MAXIMIZATION OF LAND USE THROUGH AGROFORESTRY PRACTICES IN FLOODPLAIN ECOSYSTEM OF BANGLADESH

186
30.11.10

A Dissertation

Submitted to the
Hajee Mohammad Danesh Science and Technology University, Dinajpur
In partial fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

By

MD. MAIN UDDIN MIAH

Student No. 0505019
Session: 2005

হাজী মোহাম্মদ দানেশ বিজ্ঞান ও প্রযুক্তি বিশ্ববিদ্যালয়, দিনাজপুর
গ্রন্থাগার

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BIOGRAPHICAL SKETCH

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AEZ	:	Agro-Ecological Zone
BARC	:	Bangladesh Agricultural Research Council
BRRI	:	Bangladesh Rice Research Institutre
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BCR	:	Benefit Cost Ratio
CD	:	Cow dung
cv	:	Cultivar
DAP	:	Days after planting
FAO	:	Food and Agricultural Organization
FTIP	:	Fruit tree Improvement Program
LSD	:	Least Significant Difference
LER	:	Land Equivalent Ratio
m^2	:	Square metre
MAF	:	Multistoried Agroforestry Systems
MOP	:	Muriate of Potash
MPTs	:	Multipurpose Tree Species
N	:	Nitrogen
NS	:	Non Significant
NSB	:	National Seed Board
RCBD	:	Randomized Complete Block Design
SRDI	:	Soil Resource Development Institute
RH	:	Relative Humidity
TSP	:	Triple Super phosphate
$t\ ha^{-1}$	:	Ton per hectare
DAS	:	Days After Sowing
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DMRT	:	Duncan Multiple Range Test

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Abstract

Eight field experiments were carried out at the agroforestry research farm of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during November 2005 to June 2008 to search the suitable agroforestry practices and high productive multistoried agroforestry systems. T. aman-wheat-mungbean cropping pattern was tested in black siris, guava and mango orchard and multistoried experiment were arranged with goraneem, ipil-ipil, banana, potato and onion. In this experiment, goraneem and ipil-ipil were used as the upper storied tree species and banana was middle storied; where potatoes followed by onion were the lower storied crops. The experiments for T. aman, wheat and mungbean were laid out in a split plot design with three replications. Tree species including one control plot were used as main plot and five (5) varieties of each test crops were assigned in sub plot. Varieties BR 10 (V_1), BR 11 (V_2), BRRI Dhan 33 (V_3), BRRI dhan 39 (V_4) and Sorna (local) were used for T. aman; Gourove (V_1), Sourave (V_2), Shatabdi (V_3), Kanchan (V_4) and Protiva (V_5) were used for wheat; BARI Mug 3 (V_1), BARI Mug 4 (V_2), BARI Mug 5 (V_3), BARI Mug 6 (V_4) and local varieties (V_5) were used for mungbean. Other experiments for banana, potato and onion in multistoried were arranged in single factor RCBD with three replications.The study showed that various light intensities of different tree species had pronounced effect on the morpho - physiological, yield and yield contributing characters of all tested crop varieties. Considering the yield, yield attributes, HI, LER and BCR values, BR 11 for T.aman, shatabdi for wheat and BARI Mug 6 for mungbean were found superior over other varieties in most of the treatment combinations. Hence, T. aman-wheat-mungbean cropping pattern (BR11- Shatabdi – BARI mug 6) in association with mango tree was found highly profitable and sustainable agroforestry practice followed by black siris based T. aman-wheat-mungbean cropping pattern. Guava was not found suitable at all for agroforestry practice especially for tested cropping pattern. Among the different combinations of multistoried systems, goraneem + banana + potato-onion system was found highly productive followed by ipil-ipil + banana + potato-onion, on the basis of LER and BCR. Effect of lower storey crops on the growth performance of MPTs showed that most of the system showed synergistic effect on crops and trees in the first year. In the following years lower storied crop yield reduced due to larger canopy effect but increment of trees enhanced due to lower storied crop management (fertilizer and irrigation) compared to open field. The highest boostering effect was found in goraneem followed by black siris. The soil properties almost remained unchanged. Soil p^H, calcium and magnesium were slightly increased in the soil of agroforestry systems. The study revealed that Amrapali (mango) based agroforestry using BR 11 – Shatabdi-BARI Mug 6 varieties for T. aman, wheat and mungbean, respectively was the best practice on the basis of sustainability evaluation which produced net return of Tk 5.12 lakh hectare^{-1} year^{-1} followed by goraneem based (banana + potato-onion) multistoried production system which produced Tk 3.21 lakh hectare^{-1} year^{-1}. The least production (Tk 1.12 lakh hectare^{-1} year^{-1}) was found from banana grown under ipil-ipil.

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Eight field experiments were carried out at the agroforestry research farm of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during November 2005 to June 2008 to search the suitable agroforestry practices and high productive multistoried agroforestry systems. T. aman-wheat-mungbean cropping pattern was tested in black siris, guava and mango orchard and multistoried experiment were arranged with goraneem, ipil-ipil, banana, potato and onion. In this experiment, goraneem and ipil-ipil were used as the upper storied tree species and banana was middle storied; where potatoes followed by onion were the lower storied crops. The experiments for T. aman, wheat and mungbean were laid out in a split plot design with three replications. Tree species including one control plot were used as main plot and five (5) varieties of each test crops were assigned in sub plot. Varieties BR 10 (V_1), BR 11 (V_2), BRRI Dhan 33 (V_3), BRRI dhan 39 (V_4) and Sorna (local) were used for T. aman; Gourove (V_1), Sourave (V_2), Shatabdi (V_3), Kanchan (V_4) and Protiva (V_5) were used for wheat; BARI Mug 3 (V_1), BARI Mug 4 (V_2), BARI Mug 5 (V_3), BARI Mug 6 (V_4) and local varieties (V_5) were used for mungbean. Other experiments for banana, potato and onion in multistoried were arranged in single factor RCBD with three replications.The study showed that various light intensities of different tree species had pronounced effect on the morpho - physiological, yield and yield contributing characters of all tested crop varieties. Considering the yield, yield attributes, HI, LER and BCR values, BR 11 for T.aman, shatabdi for wheat and BARI Mug 6 for mungbean were found superior over other varieties in most of the treatment combinations. Hence, T. aman-wheat-mungbean cropping pattern (BR11- Shatabdi – BARI mug 6) in association with mango tree was found highly profitable and sustainable agroforestry practice followed by black siris based T. aman-wheat-mungbean cropping pattern. Guava was not found suitable at all for agroforestry practice especially for tested cropping pattern. Among the different combinations of multistoried systems, goraneem + banana + potato-onion system was found highly productive followed by ipil-ipil + banana + potato-onion, on the basis of LER and BCR. Effect of lower storey crops on the growth performance of MPTs showed that most of the system showed synergistic effect on crops and trees in the first year. In the following years lower storied crop yield reduced due to larger canopy effect but increment of trees enhanced due to lower storied crop management (fertilizer and irrigation) compared to open field. The highest boostering effect was found in goraneem followed by black siris. The soil properties almost remained unchanged. Soil p^H, calcium and magnesium were slightly increased in the soil of agroforestry systems. The study revealed that Amrapali (mango) based agroforestry using BR 11 – Shatabdi-BARI Mug 6 varieties for T. aman, wheat and mungbean, respectively was the best practice on the basis of sustainability evaluation which produced net return of Tk 5.12 lakh hectare^{-1} year^{-1} followed by goraneem based (banana + potato-onion) multistoried production system which produced Tk 3.21 lakh hectare^{-1} year^{-1}. The least production (Tk 1.12 lakh hectare^{-1} year^{-1}) was found from banana grown under ipil-ipil.

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CHAPTER 1
INTRODUCTION

Bangladesh is an agrarian country and agriculture is the driving force for her economic growth (Anon, 2007). Although the share of this sector to its GDP has been decreasing over the last few years due to the multifold expansion of the export oriented garment sector. Yet it dominates the economy accommodating lion share of the labour force living in rural areas. More than 84% of the population living in the rural areas are this or that way dependent on this profession for their livelihoods (MoA, 2007). The economy of the domain is burdened with her increasing population. Note that the present growth rate is 1.5% (BBS, 2006) in the realm. This territory is one of the largest deltas of the orb with a total area of 147570 square kilometer. About 1045 persons live here per square kilometer (CIA, 2007) leading it the densest populated country of the planet. This expanding population is exerting immense pressure on the usable land and ultimately reducing per capita available land in an alarming rate. This availability has been declined from 0.19 in 1961 to 0.101 ha in 1992 (Iqbal *et al.,* 2002) and now the country is claimed to have the lowest per capita arable land of 0.06 hectares. Most of the area of the country is floodplain, covering about 80% of her total land, the rest 20% constitute hills and raised terraces (Abedin *et al.,* 1991). Floodplain and terraces are the major ecosystem of Bangladesh in terms of traditional farm land agroforestry systems (Miah *et al.,* 2002).

This limited land resource can not make up cereal requirements for her people. On the other hand, adequate emphasis has not been given to fruit and vegetable production, which are important sources of different vitamin and minerals. The minimum dietary recommendation of fruits per capita per day is 85 g where the availability is only 30-35 g. Again the average consumption of vegetables in Bangladesh is only 70 g per head per day including potato and sweet potato. Except tuber crops, it is only 30 g as against the recommendation of 200 g. Hence, there has been a widespread malnutrition in the country. (Miah, 2001). Identical situations prevail for pulses and oil seed too.

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Department controlled land, 0.73 million ha Unclassified State Forest (USF) under control of the District Administration and 0.27 million ha village forest land which do not have satisfactory tree cover. Only 0.84 million ha (about 5.8%) of the state forest land has good forest cover (Anon, 2005). The depletion of tree resources and poor productivity are severely threatening our food and energy security and quality of life. Therefore, with increasing population, decreasing arable land and tree resources, maintaining of food security and ecology is a formidable challenge for the country (Miah *et. al.*, 2002).

Scarcity of fuel wood has been indirectly reducing soil fertility through limiting organic matter recycling as people burn cow dung and crop residues (Douglas, 1982). The situation may continue to deteriorate further with the increase of population. Absolutely there is no scope for increasing land under agriculture or forestry alone to fulfill our national demands. Under such a critical situation, the concept of agroforestry is gaining popularity. Agroforestry, the integration of tree and crops on the same area of land, is a promising production system for maximizing yield and maintaining friendly environment (Nair, 1990). This approach may give the assurance of job facilities round the year, maximum food, fruit, fodder, fuel wood and timber production through vertical space utilization, intensive land use, friendly environment and soil sustainability. For any successful agroforestry practice, suitable tree-crop combinations and proper management practices are vital. According to Walt (1989), "Agroforestry has two dimensions. One is the way of thinking. It means looking for ways to maximize the production from the land using a mixture of wood fiber, wildlife recreation and farm crops, both plant and animal, to make the biggest buck possible consistent with keeping the land productive. The second dimension echoes the first one. It is the actual management of land according to this ethic."

Crop land Agroforestry is a production technique that integrates agricultural crops and forestry on a piece of crop land to maximize the exploitation of natural resources (land, sunlight, water etc.). By practicing these methods, farmers may get income both from agricultural and forest products. This farming technique has been expanded on a large scale for effective land use system to meet the requirements. A case study on crop land Agroforestry revealed that 46% of farmers generated cash income from felling trees and met expenses for purchase of land, bullocks, inputs for crops and supplemented

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expenses of marriage, household expenditure, and loan repayment (Chowdhury and Mahat, 1993). Crop land Agroforestry includes various multipurpose tree species, which are grown along with various annual crops like, wheat, paddies and other cash crops in farmers' lands. Trees are grown sparsely in rows in crop field. The system provides food, fodder, fuel, timber, construction materials, raw materials etc. In addition, soil conservation and improvement has been one of the most important functions of this system.

Bangladesh agriculture has been suffering from acute shortage of biomass to regenerate her soil from depletion of organic matter due to intensive cropping. The scale of reduction (0.01% $year^{-1}$) of organic matter contain in crop land is alarming. It is estimated that huge amount (9 t ha^{-1} dry matter) of organic materials would be needed to maintain the current organic matter status (Hossain *et al.,* 1997). These problems could be solved partially through the leaves litter of perennial plant species by an agroforestry system. But the problem may be addressed significantly by introducing green manuring crops in cropping patterns. A huge amount of organic matter is added into crop land from green manuring than using farmyard manure and the utilization of any other organic source (Ullah *et al.*, 2002). In every year, 1.00-13.33 ton dry matter is gained into soil from 70-80 ton fresh matter (BARC, 1997). The practice of green manuring has been shown to increase the yields of corn, small grain, cotton, beets, potatoes, sugarcane and to be successful in tobacco culture in the tropics though expected results have not always been secured in tobacco culture in the United States. In addition, there are marked residual effects from green manuring crops and all sorts of values of the residual effects must be included in considering the profits from green manuring (Pieters, 2004).

On the other hand, homestead agroforestry is an important component of the livelihood activities of rural peoples and so far, the most productive system in Bangladesh. It is defined as a land use practice involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops (particularly vegetables and spices) and invariably, livestock within the compounds of individual houses, the whole crop-tree-animal unit being intensively managed by family labour (Fernandes and Nair, 1986). It is the most complex multistoried

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production system that combines all farming components (tree, crop, livestock and occasionally fish) and provides household food security, employment and income generation opportunity to the million of households. About 70 percent fruit, 40 percent vegetable, 70 percent timber and 90 percent firewood and bamboo production of the country come from the homesteads (Miah *et al.,* 2007). The estimated per capita consumption of timber and fuel wood is only 0.01 m^3 and 0.07 m^3 respectively perhaps one of the lowest level of consumptions in the world. The supply is however, inadequate even to meet this low level of consumption. In 2002, the demand of timber and fuel wood were calculated to be 3.2 and 8.7 million m^3. The projected supply of timber and fuel wood for this period was 1.2 and 3.5 million m^3. Thus the estimated deficit stood at 62.5 and 59.7% respectively. There are 28.7 million homesteads in the country (Anon, 2009) which have enough potential to contribute more in livelihood security but our homestead production system is still unmanaged from the scientific point of view and its component combinations were not scientifically proved.

Considering the above facts, it is better to find out a high productive farm land agroforestry system which will be a sustainable land use practice and high yielding multistoried model comprising timber, fruit, vegetables and spices utilizing optimum natural resources (light, water, nutrient and vertical space)for homesteads/small land utilization. With the above in view a study was, therefore, undertaken with the following specific objectives:

1. To find out a sustainable agroforestry practice for maximizing production that results high-income generation and could be used for poverty reduction.
2. To develop a productive multistoried agroforestry model utilizing the natural resources.
3. To determine the effects of crop cultivation on the performance of MPTs.
4. To examine the changes of soil health due to such agroforestry practices.

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CHAPTER 2

REVIEW OF LITERATURE

2.1 Concept of agroforestry and fruit tree- based crop land agroforestry system

Agroforestry is an age-old and ancient practice. It is an integral part of the traditional farming system of Bangladesh. The concept of agroforestry was probably originated from the realization that trees play an important role in protecting the long range interests of agriculture and in making agriculture economically fruitful. The emergence of agroforestry was mainly influenced by the need to maximize the utilization of soil resources through the "Marriage of forestry and agriculture" (PCARRD, 1983). Agriculture and forestry were considered before as two distinct arenas but these practices are now considered as complementary to each other. This was brought about by the increasing realization that agroforestry can become an important component of ecological, social and economic development efforts.

Agroforestry is the idea of combining forestry and agriculture on the same piece of land. The basic concept of intercropping has been extended to agroforestry system. Many authors have defined agroforestry in different ways. A widely used definition given by the International Council for Research in Agroforestry (Nair, 1983) is that agroforestry is a collective name for all land use systems and practices where woody perennials are deliberately grown on the same land management unit as agricultural crop or animal in some form of spatial arrangement or temporal sequence.

From a bio-economic point of view, Harou (1983) stated that agroforestry is a combined agriculture-tree crop farming system which enables farmers or land users to make more effective use of land that may yield a higher net economic return on a sustainable basis.

From business point of view, agroforestry is an economic enterprise which aims to produce a combination of agricultural and forest crops simultaneously on the same land area.

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Saxena (1984) pointed out that agroforestry utilize the inter spaces between tree rows for intercropping with agricultural crops and this did not impair the growth and development of the trees but enabled farmers to derive extra income in addition to benefits accrued from the use of fuel and timber from trees.

Ong (1988) reported that by incorporating trees with arable crops, biomass production per unit area could be increased substantially when the roots of trees exploited water and nutrients below the shallow roots of crops and when mixed canopy intercepted more solar energy.

In traditional agroforestry systems of Bangladesh, farmers consider trees as saving and insurance against risk of crop failure or compensate low yields of crops (Akter *et al.,* 1989). Homestead gardens are common in Bangladesh where farmers take up combination of 10-15 species of fruit, ornamental and multipurpose trees with vegetables to meet their own requirement or aesthetic value (Rang *et al.,* 1990).

MacDicken and Vergara (1990) stated that agroforestry is a means of managing or using land i.e., a land use system that combines trees or shrubs with agricultural/ horticultural crops and/or livestock.

Trees are grown in the crop land, homestead, orchard not only to produce food, fruits, fodder, fuel wood or to generate cash for various purposes but also to give better living environment (Chowdhury and Satter, 1993).

One of the other potential benefits of agroforestry is the diversification of species grown on farm. Through this, and the domestication of an increasing number of tree species, it could be possible to make small-holder farming both more biologically diverse and economically rewarding. (Leaky, 1996).

Trees grown on farms for their non-timber forest products such as fruits, nuts, and spices constitute the basis for many vibrant and sustainable farming systems throughout the world. Yet, compared to other types of trees, research on horticultural and agronomic management of such trees and systems to optimize total system-yield and understand tree-crop interactions is scarce. Farmers prefer fruit-producing species to

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other trees for on-farm planting and appreciate the dual contributions of food for consumption and the potential for income generation (Dhyani *et al.,* 1996).

Fruit trees are considered advantageous because of the relatively high returns to labor resulting from low labor inputs (compared with annual crops); moreover, fruit tree-based systems also offer a more uniform distribution of income throughout the year than annual crop systems. However, the relatively "free" availability of forest-based timber and fuel wood products in some areas are seen as disincentives for growing tree species for those purposes (Hossain and Bari , 1993).

According to Solanki (1998), agroforestry can significantly contribute in increasing demand of fuel wood, fodder, cash and infrastructure in many developing countries. He also stated that agroforestry had high potential to simultaneously satisfy three important Objectives:

(i) protecting and stabilizing the ecosystems.

(ii) producing a high level output of economic goods (fuel, fodder, small timber, organic fertilizer etc).

(iii) providing stable employment, improved income and basic materials to rural populations.

A strictly scientific definition of agroforestry should stress two criteria common to all forms of agroforestry systems and separate them from other forms of land use, namely:

- the deliberate growing of woody perennials on the same unit of land as agricultural crops and/or animals, either in the form of spatial mixture or sequence;
- there must be a significant interaction (positive and/or negative) between the woody and non woody components of the system, either ecological and/or economic.

When promoting agroforestry one should then stress the potential of it to achieve certain aims, not only by making theoretical and qualitative remarks about the benefits of trees, but also more important, by providing quantitative information. These ideas were later refined through "in-house" discussions at ICRAF, and the following definition of agroforestry was suggested:

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Agroforestry is a collective name for all land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc) are deliberately used on the same land-management units as agricultural crops and/or animals, in some forms of spatial arrangements or temporal sequences. In agroforestry system there are both ecological and economic interactions among different components.

This definition implies that:

- agroforestry normally involves two or more species of plants (or plants and animals), at least one of which is a woody perennial;
- an agroforestry system always has two or more outputs;
- the cycle of an agroforestry system is always more complex, ecologically (structurally and functionally) and economically than a mono cropping system.

This definition, though not "perfect" in all respects, was increasingly used in ICRAF publications and thus achieved wide acceptability.

In the mean time, the surge of enthusiasm for defining agroforestry has been subsided. The concepts, principles and limitations of agroforestry have been articulated in several publications from ICRAF and other organizations. Thus agroforestry is no longer a "new" term. It is widely accepted as an approach to land use involving a deliberate mixture of trees with crops and/or animals. However, the question of "what is agroforestry" comes up occasionally even today (early 1990s) in many discussions and some publications. Today there is a consensus of opinion that agroforestry is practiced for a variety of objectives. It represents, as depicted in the Fig.1 an interface between agriculture and forestry and encompasses mixed land-use practices.

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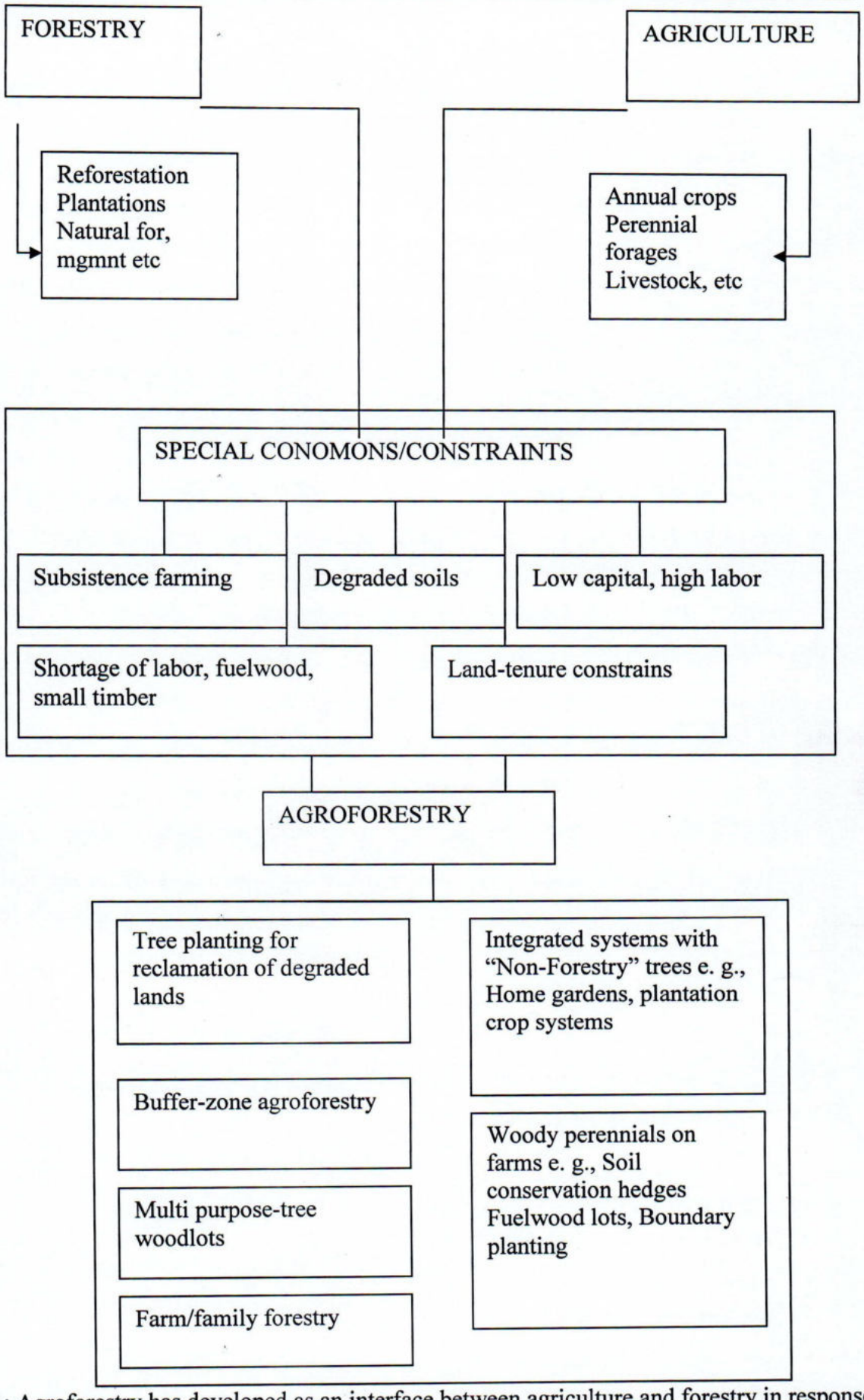
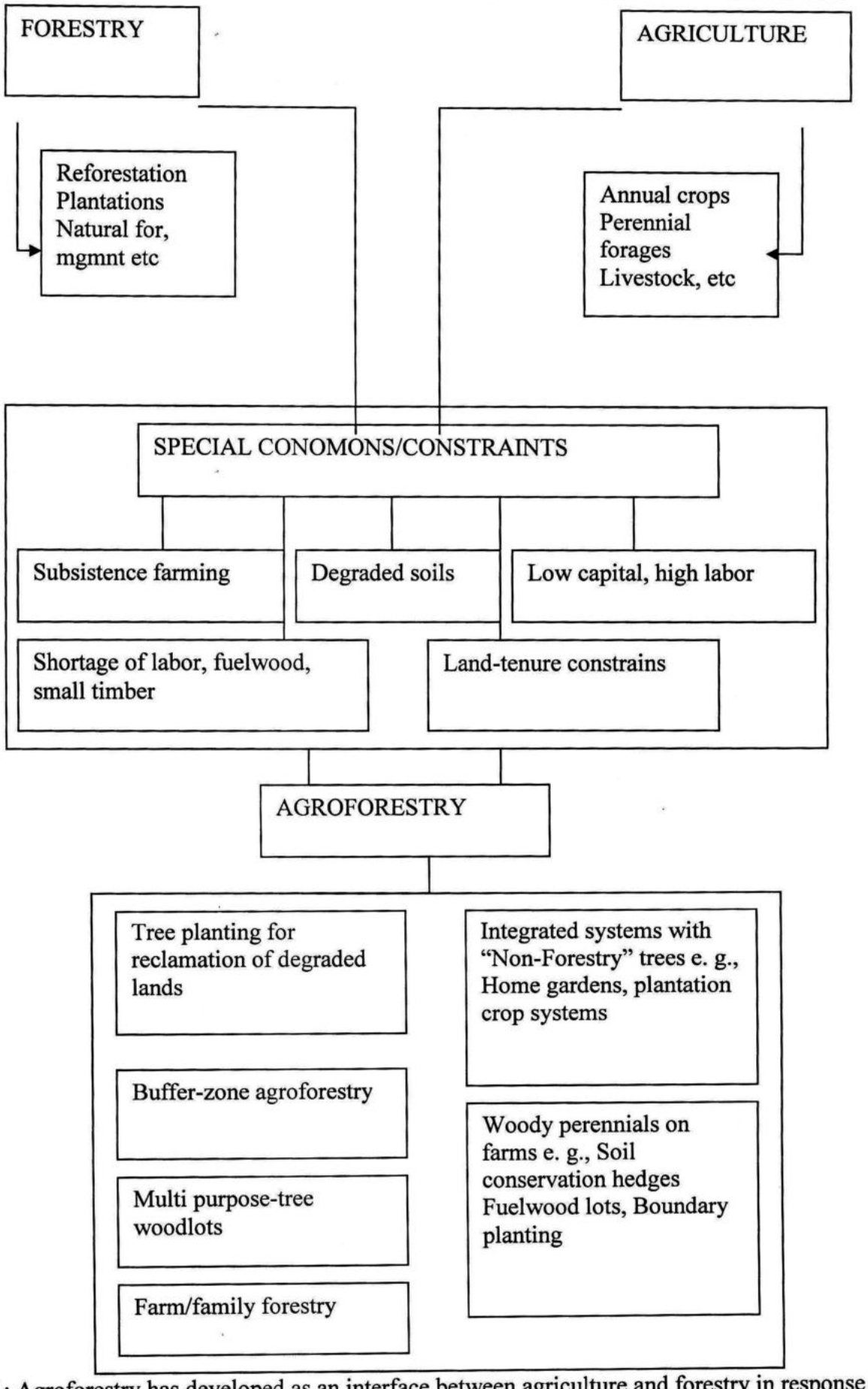


Fig. 2.1: Agroforestry has developed as an interface between agriculture and forestry in response to the special needs and conditions of tropical developing countries (source: An Introduction to Agroforestry by P.K.R. Nair,1993)



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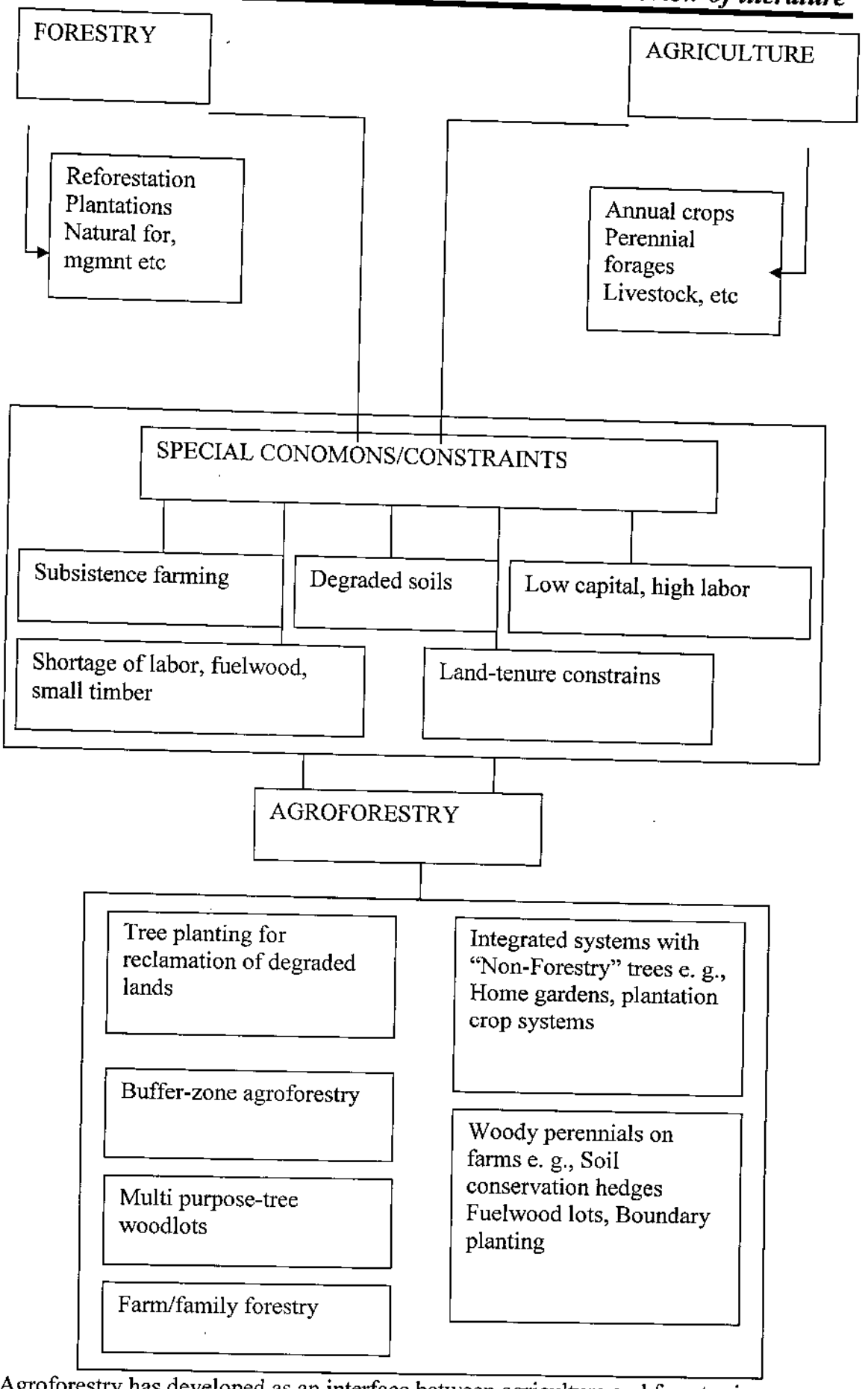

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These practices have been developed primarily in response to special needs and conditions of tropical developing countries, that have not been satisfactorily addressed in conventional agriculture or forestry. The term is used to denote practices ranging from simple forms of shifting cultivation to complex hedgerow intercropping systems; system including varying densities of tree stands ranging from widely-scattered *Faidherbia (Acacia) albida* trees in Sahelian millet fields to the high-density multistoried homegardens of the humid tropics; and systems in which trees play a predominantly service role (e.g., windbreaks) to those in which they provide the main commercial product (e. g., intercropping with plantation crops).

Additionally, there are three attributes which, theoretically, all agroforestry systems possess. Those are:

1. Productivity: Most, if not all, agroforestry systems aim to maintain or increase production (of preferred commodities) as well as productivity (of the land). Agroforestry can improve productivity in many different ways. These include: increased output of tree products, improved yields of associated crops, reduction of cropping system inputs, and increased labor efficiency.
2. Sustainability: By conserving the production potential of the resource base, mainly through the beneficial effects of woody perennials on soils, agroforestry can achieve and indefinitely maintain conservation and fertility goals.
3. Adoptability: The word "adopt" here means "accept" and it may be distinguished from another commonly used word adapt, which implies "modify" or "change". The fact that agroforestry is a relatively new word for an old set of practices means that, in some cases, agroforestry has already been accepted by the farming communities. However, the implication here is that improved or new agroforestry technologies which are introduced into new areas should also confirm to local farming practices.

These attributes are the very characteristics of all agroforestry systems which form the basis for evaluation of various agroforestry systems.

2.1.1 Agroforestry systems and practices

The words "systems" and "practices" are often used synonymously in agroforestry literature. However, some distinctions can be made between them. An agroforestry system is a specific local example of a practice; characterized by environment, plant species and their arrangement, management and socioeconomic functioning(Nair, 1993).

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Oppositely an agroforestry practice denotes a distinctive arrangement of components in space and time. Although hundreds of agroforestry systems have been recorded, they all consist of about 20 district agroforestry practices. In other words, the same or similar practices are found in various systems in different situations. It may be worthwhile to note that both the systems and the practices are known by similar names; but the systems are (or ought to be) related to the specific locality or the region where they exist, or other descriptive characteristics that are specific to it.

Another term that is also frequently used is "the agroforestry technology". It refers to an innovation or improvement, usually through scientific intervention, to either modify an existing system or practice, or develop a new one. Such technologies are often distinctly different from the existing systems/practices; so they can easily be distinguished and characterized. However, the distinction between 'systems' and 'practices' are vague, and even not very critical for understanding and improving them. Therefore, the words 'systems' and 'practices' are used synonymously in agroforestry, as they are in other forms of land uses.

2.1.2 Fruit tree based agroforestry system

The indigenous farming systems of many developing counties often include several fruit- and nut producing trees. These are common components in most home gardens and other mixed agroforestry system (Nair, 1993).

Based on a study of farmers in Dauphiné province in southeastern France, Mary *et al.* (1999) reported that farmers considered agroforestry as a significant aspect of walnut (*Juglans regia*) production. Annual crops such as maize and soybean (*Glycine max*) were frequently cropped among the growing trees. Additionally, farmers frequently grew numerous other fruits, such as apple (*Malus domestica*), currants and gooseberries (*Ribes* spp.), and grapes (*Vitis vinifera*) during the pre-production period. Mechanical harvesters and the lack of appropriate equipment for intercrops were cited as primary limitations of mixed cropping of annuals and perennials. The potential advantage of producing a high-value crop in place of often-costly ground cover management was seen as a factor in favor of mixed cropping. A combination of perverse subsidies and a need for short-term financial returns dissuade many growers from agroforestry-based management.

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Fruit-tree-based agroforestry, known locally as "*streuobst*", has been a traditional activity throughout Europe, but has declined in extent since the advent of industrial agriculture in the 1930s (Herzog, 1998). The system consists of "tall" fruit trees irregularly dispersed throughout croplands, pastures and meadows. Temperate fruits, such as *Malus, Pyrus, Prunus, Juglans* and *Castanea* spp. are the most common tree components. The development of these systems was supported by a purposeful, government-based program promoting fruit tree planting. The principal disadvantage of *streuobst* compared to intensive orchards is labor availability and currently it enjoys greater popularity where labor is a less limiting factor (Herzog, 1998).

In the northwest hills region of India, researchers reported that the returns from intercrops with temperate fruit trees were negligible but did not elaborate on whether they were unproductive or simply contributed little cash earnings to the system (Azad and Sikka, 1991). The results showed that fruit production was more profitable than comparative areas of annual crops. The farm to market link was described as the most tenuous and problematic in the production chain. Generally, growers were not able to profit from higher market value for their fruits because value was withheld at the farm gate by middlemen.In the Bhopal region of central India, fruit-tree-based systems were found to have higher benefit to cost ratio (BC ratio 2.7) than agroforestry based on non-fruit trees (BC ratio 1.8). When cash crop systems were assessed, fruit-tree-based agroforestry had BC ratios of 2.9 versus 1.8 for timber and cash crops.

Farmers preferred a fruit and fodder system incorporating *Ananas comosus* (pineapple) and *Psidium guajava* (guava) with *Morus alba* (mulberry) for sericulture over a system of *Morus* with vegetables or rice in Meghalaya in northeastern India. The fruit-tree-based system was highly profitable, but detailed economic analysis was only performed on systems preferred by forestry officials (Dhyani *et al.,* 1996). Mixed systems of *Prunus* spp. with *Lens culinaris* (lentils) and *Triticum aestivum* (wheat) showed an economic advantage compared to cropping systems without fruit (Ashour *et al.,* 1997). There, BC ratios of sole peach (1.19) and mixed peach-annual crops (1.56) were observed. Another evaluation of economic returns of *Sorghum bicolor* and *Vigna mungo,* cropped with *Psidium guajava* (guava), and alley-cropped with *Leucaena leucocephala* in Andhra Pradesh, India, showed BC ratios ranging from 1.52 for crops with *Leucaena* to 2.16 for crops with guava (Das *et al.,* 1993).

Fruit-tree-based agroforestry, known locally as "*streuobst*", has been a traditional activity throughout Europe, but has declined in extent since the advent of industrial agriculture in the 1930s (Herzog, 1998). The system consists of "tall" fruit trees irregularly dispersed throughout croplands, pastures and meadows. Temperate fruits, such as *Malus, Pyrus, Prunus, Juglans* and *Castanea* spp. are the most common tree components. The development of these systems was supported by a purposeful, government-based program promoting fruit tree planting. The principal disadvantage of *streuobst* compared to intensive orchards is labor availability and currently it enjoys greater popularity where labor is a less limiting factor (Herzog, 1998).

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Key areas of biophysical interaction including competition between fruit trees and crops grown together have not been adequately addressed. While it appears very likely that the value of fruit tree yields relative to annual crop yields are substantial to farmers, the question of the resources that are lost to crops through competition vs. resources that are non-competitively acquired remains virtually unaddressed. Without knowledge of both these aspects, it is difficult to quantify the overall merit of a mixed fruit-tree + crop system.

A study of mixed cropping of *Lens culinaris* (lentil) and *Triticum aestivum* (wheat) with *Prunus* spp. (peach) in the arid northern Sinai of Egypt, showed that seed yield and harvest index of *Lens* and *Triticum* under mixed cropping increased over those under sole cropping (Ashour *et al.,* 1997). Tillering and spike number of wheat were also increased in the mixed system. Peach yield increased marginally when grown with lentils, but not with wheat. Soil moisture was greater in the mixed annual-perennial system than in the sole crops. Several crucial experimental details of this study were not reported, for example irrigation amounts could have been limiting to sole crops.

In an intercropping study of banana with annuals in St. Lucia, The Caribbean, Rao and Ito, (1998) found that intercropping various annuals with *Musa* spp. resulted in a decrease in weight per fruit but no loss in total bunch yield. Duration to maturity of banana was prolonged with under planted annuals as compared to sole cropped bananas. The study did not report any assessment of yield differences in annuals, however, the mixed stand of banana with annuals was stated as providing greater overall yields and more uniform distribution of income.

2.2 Performances of crops in shaded condition

The performance of field crops in Agroforestry systems is influenced by the tree- shade and crop species. Low light condition by shade, during the growing season affects morphological characters and yield of crops.

Some of the research suggested that yields could be increased growing cocoa in full sun (Murray, 1953).

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The intensity of light affected the growth and development of the plants. Early growth of the plants has been accelerated, by giving high light intensity (Kudrjavcev, 1964; Binchy and Morgan, 1970).

In this region of the world full sunlight may not be required for optimal growth and development of many plants, particularly those grown in summer. Under light intensities of 20 to 50 percent of full sunshine, maximum vegetative growth is attained. The leaves reach their greatest area, the canopy attains its widest diameter and the stem its maximum height (Weaver and Clements, 1973). The root is penetrated and spreaded moderately.

Intensities higher than 50 percent sometimes causes a decrease in plant growth. This is particularly true for shade loving plants. In many cultivated crop plants maximum dry weight is obtained under full sunlight (Weaver and Clements, 1973). For best development, most plants require full sunshine, providing other factors are not limited. Rate of growth usually increases with increased light intensity up to 50 percent or more (Weaver and Clements, 1973).

It has been reported that shading reduced leaf number, leaf area and thickness of dry bean (Crookston *et al.,* 1975). They also reported 38% decrease in photosynthesis per unit area of shaded leaves.

Shading produced taller tomato plants with longer internodes (Thomas and Teoh, 1983).

Plant grown in low light levels was found to be apically dominant than those grown in high light environment resulting taller plant under shades (Hillman, 1984).

Alley cropping agroforestry systems have been emerged as a sound technology where tree leaves are periodically pruned to prevent shading the companion crops (Kang *et al.,* 1984).

Sharma and Tiware (1992) reported that the effects of shading after heading reduced ear, calm and root dry weight and reduced grain yield more than shading before heading.

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An experiment was conducted by Mc. Master *et al.* (1987) on wheat who reported that the effect of shading decreased the number and weight of grain /spikelet, decreased most at the lower central portion of the ear, decreased in the upper half and basal portion of the ear despite high ear sink activity and increasing ear life.

The partial shading (45-50% of normal light) at 15 days after transplanting reduced grain yield of rice by 73% because of reduction in number of panicles per plant (51.50%), number of grain per panicle (16.70%) and increase in number of unfilled spikelets (41.10%) in 25 rice cultivars (Jadhav, 1987).

Rao and Mittra (1988) observed that shading by taller species usually reduced the photosynthetically active radiation that regulates photosynthesis, dry matter production and yield of crop.

The shading was responsible for suppression of maize yield while in the shorter second season where rains ended abruptly, moisture competition was the main factor causing the drastically low yield (Singh *et al.,* 1989).

Anderson *et al.* (1993) determined that shade increased plant height, decreased tiller and panicle number hill^{-1}, grains panicle^{-1} and grain yield. reported that leaf senescence was delayed under shaded conditions, which might prolong the reproductive phase i.e. life cycle and reduced root growth. However shading increased leaf length.

Islam *et al.* (1993) conducted an experiment with mungbean under three levels of shades and reported that there were almost no differences between full sun (control) and 15 percent shading for all the plant parameters. However, the growth attributes and yield of mungbean were decreased with further increase of shade level.

Islam *et al.* (1993) also reported that dry matter production of mungbean is influenced by the imposition of shading. Mungbean has some tolerance to shade but high level of shade drastically reduced its dry matter production.

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In addition to providing shade, the trees may also benefit the understoried component from hydraulically lifted water. Sharif (1993) reported that shading in agroforestry influenced nutrient uptake.

Miah *et al.* (1995) reported that shading reduced the photosynthetic capacity of plants. Unlike water and nutrients, light cannot be captured and stored for later use in the way that other natural resources are managed. Leonardi (1996) reported that shading (60% light reduction) reduced vegetative and fruit growth but increased plant height. Shading also reduced chlorophyll content, stomatal density, transpiration rate and photosynthetic rate. Yield of peppers decreased with increasing amount of shade levels.

Studies in New Zealand have indicated that the American ginseng can be successfully grown under *Pinus radiata* with the best growth under a tree stand of 130 stems/ha (Follett, 1997).

Miah *et al.* (1999) found that the tallest onion plants under 25 percent PAR level and the shortest ones under that the 100 percent PAR level.

Araki *et al.* (1999) conducted an experiment with four shading treatments (0, 30, 45 and 60% shading) in Japan and reported that spinach growth was the best under 45 % shading ratio in June, August and September and under 60% ratio in June. Nitrate content was the highest under 45% shading.

Ravi *et al.* (2001) determined the effect of partial shade on the yield and yield attributes of wheat cultivar intercropped with sissoo tree under shallow water table conditions in Uttaranchal India. Net radiation, yield and yield attributes were recorded below tree canopies and in control. The net radiation available during grain filling and maturity staged varied from 70-75 and 58-77% of the control, respectively during the crop-growing period. Grain yield and biological yield decreased below tree canopies and ranged from 71.58 - 88.90 and 69.29 - 79% at the control one , respectively. Higher harvest index and yield attributes were observed in the treatment set below tree canopies compared to the control one.

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Satish *et al.* (2003) conducted an experiment and studied the relative performance of wheat cultivars in fields having different shading intensity brought by Eucalyptus. Grain yield decreased significantly with the increase in shade duration due to Eucalyptus plantation on the eastern side of the wheat field. Photosynthetic rate and specific leaf weight of wheat also decreased significantly with the increase in shade duration. However, chlorophyll-a, chlorophyll-b and total chlorophyll content per unit leaf fresh weight increased with increased shade duration.

Miah *et al.* (2007) reported that significantly the highest plant height of egg plant was found under moderate shade of eucalyptus with cane based agroforestry systems while the shortest plant was observed in the control plot.

2.3 Tree- crop Interaction

Khan and Aslam (1974) studied the effect of single sissoo (*Dalbergia sissoo*) tree on the yield of wheat. Both the tree and the crops were raised under irrigated condition. Yield was recorded from plots within a quadrate of $1m^2$. The quadrates were taken at a distance of 3, 4.5 and 6m from the base of tree. One quadrate was taken from the center of the field, that is, well away from the influence of trees involved. The grain yield showed a decrease of 30.88, 23.6 and 12.7% at the distance of 3, 4.5 and 6m, respectively as compared to the open field. . He also found that the yield of wheat in association with *Dalbergia sissoo* was significantly higher than those of *Eucalyptus camaldulensis, Populus deltoides* and *Bombax ceiba.*

Scott (1987) summarized the important findings of tree crop interaction in agroforestry as:

1. Tree in close proximity depressed crop yield
2. These effect varied with crops and tree species
3. Farmers are prepared to raise the tree species if those are fast growing and have good market value.

He also investigated that the rows of *Inga edulis* reduced rice yield by 50% compared with those in rows farthest away. A follow up research was designed to observe the effect of *Inga edulis* on upland rice yield. It was known that *Inga edulis* had a pronounced effect in reducing rice yield by 50% up to 2.5m away; beyond that, yield was similar to those in rows 6m away.

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Satish *et al.* (2003) conducted an experiment and studied the relative performance of wheat cultivars in fields having different shading intensity brought by Eucalyptus. Grain yield decreased significantly with the increase in shade duration due to Eucalyptus plantation on the eastern side of the wheat field. Photosynthetic rate and specific leaf weight of wheat also decreased significantly with the increase in shade duration. However, chlorophyll-a, chlorophyll-b and total chlorophyll content per unit leaf fresh weight increased with increased shade duration.

Miah *et al.* (2007) reported that significantly the highest plant height of egg plant was found under moderate shade of eucalyptus with cane based agroforestry systems while the shortest plant was observed in the control plot.

2.3 Tree- crop Interaction

Khan and Aslam (1974) studied the effect of single sissoo (*Dalbergia sissoo*) tree on the yield of wheat. Both the tree and the crops were raised under irrigated condition. Yield was recorded from plots within a quadrate of $1m^2$. The quadrates were taken at a distance of 3, 4.5 and 6m from the base of tree. One quadrate was taken from the center of the field, that is, well away from the influence of trees involved. The grain yield showed a decrease of 30.88, 23.6 and 12.7% at the distance of 3, 4.5 and 6m, respectively as compared to the open field. . He also found that the yield of wheat in association with *Dalbergia sissoo* was significantly higher than those of *Eucalyptus camaldulensis, Populus deltoides* and *Bombax ceiba.*

Scott (1987) summarized the important findings of tree crop interaction in agroforestry as:

1. Tree in close proximity depressed crop yield
2. These effect varied with crops and tree species
3. Farmers are prepared to raise the tree species if those are fast growing and have good market value.

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Dhukia *et al.*(1988) observed that in the rabi season of 1984-87, four fodder crops (*Trifolium alexandrium*, oats, *Vicia faba* and *Trifolium foenum-graecum)* and 2 field crops (*Triticum aestivum* and *Cicer arietinum*) were grown under *Dalbergia sissoo* and *Albizia lebbeck.* Among the fodder crops the highest fresh fodder and dry matter yields under both plantations were given by *Trifolium alexandrium* follower by oats. The yields decreased less than 4 years old trees compared with those of less than 3 years old trees. Wheat gave higher yields than *Cicer arietinum* under both plantations. Yields of all crops under the *Dalbergia sissoo* plantation were higher than under the *Albizia lebbeck* plantation.

Hazra and Tripathi (1989) reported that four oat cultivars were grown under the canopy of different trees and in open plots of a suitable cultivar for cultivation under an Agroforestry system. Cvs. OL-189 and OL-125 gave the highest fodder yields under different trees. The average yields were 95% under *Albizia lebbeck*, 90% under *Hardwickia binarta*, 88% under *Acacia nilotica*, and 74% under *Melia azedarach*, compared to the open plot yields. The PAR received under the 4 tree canopies was 90, 87, 80 and 63%, respectively showing its suitability for cultivation in agroforestry system especially under *A. lebbeck.*

Lal (1989) showed that, over a period of six years (12 cropping season), the relative rates of decline in the status of nitrogen, pH, and exchangeable bases of the soil were much less under alley cropping than under the non alley cropped (continuous cropping without trees) control plots. These studies also implied a possible nutrient cycling capability of *Leucaena leucocephala* hedgerows, as there was evidence of a slight increase in soil pH and exchangeable bases during the third and fourth years after the establishment of these hedgerows. Very few studies have been carried out on the effect of alley cropping on other soil properties.

Basri *et al.* (1990) observed that hedgerow trees competed for nutrients and light with upland rice crops to a significant extent. The competition was most severe in the 2-3 rice rows closed in the hedgerows where yields were reduced by 50-70% compared to those in the center of the alley.

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Garrity *et al.* (1992) observed that in an alley cropping system yield depression of upland rice was obtained in the zone near the hedgerows although plant height did not affect much. Results of three-year trial indicated that *Gliricidia sepium* exhibited the lowest yield depression on upland rice in rows near the hedges.

Studies at ICRAF's research filed with *Leucaena leucocephala* and maize showed that total maize yield under improved trees were only 50% of the sole maize yield, which increased to 80% due to pruning (Ong *et al.*, 1992) indicating the benefits of pruning in reducing tree-crop competition.

Puri and Bangarwa (1993) studied wheat yield in Agroforestry system. They collected data on crop yield from each tree species at different distances (1, 3, 5 and 7m) and in 4 directions (east, west, north and south) from the tree bases and control (no tree). The results indicated that *Azadirachta indica* and *Prosopis cineraria* did not make any significant difference to wheat yield, while *Acacia nilotica* reduced yield by 4-30%. But reduction was only up to a distance of 3m. In general, the effect of trees on wheat yield was observed up to 3m distances and there was little effect from 3 to 5m distances, and almost no effect at 7m distance. In all the tree species, the wheat yield was maximum reduced on the north side of trees and had almost no effect in the southern direction.

Kang *et al.* (1984) observed the influences of various economic tree species on growth and yield of rabi sorghum. Sorghum was grown in strips on the upstream side of *Dalbergia sisso, Tectona grandis, Casuarina euisetifolia, Acacia auriculiformis, A. nilotica, Albizia lebbek, Eucalyptus tereticoenis, Acacia catechu and Leucaena leucocephala*. Reductions in stover yields compared to the control were 75.7-97.1% at 0-1.35 m and 0-58.1% at 9.45-10.8 m from the trees. He also determined the influence of boundary planting of *Acacia nilotica* on the growth and yield of associated wheat (*Triticum aestivum)* crop under irrigated conditions. The results indicated that close proximity to trees adversely affected tillers m^{-2}, grains $spike^{-1}$ and 1000-grain weight, but grain yield was slightly lowest near the largest trees.

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reduction in soil P^H and K and an increase in organic matter. Shading effects could be minimized by proper orientation of rows, side or top pruning of trees in the outer of plots, having larger plots for crops and isolating sole-crop plots from tree plot.

Hocking and Islam (1997) Traditional management of trees in crop fields resulted 20-50% loss in yield of the under crops, mainly through competition for light. In Bangladesh, competition for water is important only in the post monsoon season and only in areas where there is no irrigation. Farmers knew that tree cause losses of under crops, but they nevertheless raised valuable trees in their fields for compensation tree products. For most trees, the depressing effects on the yield of rice were extended up to 4 m distance from the tree. There was no adverse effect on crop beyond 4 m distance from the trees. Of the total 73 farmers managed trees, the impact on yield was limited up to 2-3 m distance for 63 trees and 3-4 m for 33 trees. That impact was rather positive for 22 trees beginning at 2-3 m and 13 trees at 3-4 m distance from trees. All naturally-growing trees in crop fields had yield depressing effects up to 4 m away from the trees.

2.4 Crop yield under agroforestry system

Nayak and Murty (1980) reported that fifty per cent shading during ear formation and milking stages of rice decreased yield by 48 and 18%, respectively and yield reduction of rice occured by 47, 57 and 74 per cent in 75, 50 and 25 per cent of normal light.

Jadhav (1987) reported that partial shading (45-50% of normal light) at 15 days after transplanting reduced grain yield of rice by 73% because of reduction in number of panicles plant $^{-1}$(51.5%), number of grains panicle $^{-1}$ (16.7%) in 25 rice cultivars.

Verma and Warsi (1999) mentioned that pre-flowering shading (50% shade) resulted in reduced leaf area, tiller number and spikelets panicle^{-1}, whereas post- flowering shading reduced filled spikelets fraction and weight in rice.

Lal (1989) evaluated the growth and yield of maize and cowpea grown in association with single row hedge of *Gliricidia sepium* and *Leucaena leucocephala* in a tropical Alfisol. He observed that maize growth and yield were suppressed only in the vicinity

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Akber *et al.* (1990) reported that wheat yield under different tree species (Eucalyptus, Mulberry, Siris, Ipil-ipil) did not show any significant difference as compared to the control yield.

The influence of *Acacia nilotica* on the growth and yield of associated wheat crop under irrigated conditions in India was examined by Sharma and Tiware (1992).The authors reported that the tree line negatively affected all crop parameters like yield in the vicinity of trees and concluded that as the distance from the tree line was increased the growth and yield of wheat also increased.

Nazir *et al.* (1993) conducted a trial in Pakistan where wheat was sown parallel to *Dalbergia sissoo* trees at distance giving 0.2, 3, 4, 5, 6, 7, and 8 hour to shade/ day. Increasing duration at shading decreased plant height, number of fertile tillers unit^{-1} area, number of grains spike^{-1}, 1000-grain weight, grain protein content and percentage DM and grain yield. Yield was 2.99, 2.96, 2.11, 2.57, 2.4, 2.12, 164 and 1.32 t /ha with 0.2, 3, 4, 5, 6, 7 and 8 hrs of shade /day, respectively.

Jaing *et al.* (1994) reported that tree crown had no profound effect on the number of effective spikelets and grains of wheat but that affected total grain yield and 1000-grain weight, with the size of the effect on crop, depending on the distance from the trees.

Nandal *et al.* (1999) grew 5 wheat cultivars under Sissoo trees. In their experiment grain yield, dry matter yield, leaf area index, spiklets m^{-1}, grain spike $^{-1}$ and test weight were reduced under the tree canopy compared to the crops growing in the open place.

Pandey *et al.* (1999) reported that rice yield was positively related to distance from the trees. Impact of trees was maximum up to 2m distance from the tree, crop yield reduced by 44% and declined with increasing the distance (to 14% reduction at 8 m). There was an increased relationship between the percentage decrease in the parameters and the distance indicating that the greater the distance the smaller the effect of the tree.

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Samsuzzaman *et al.* (2002) carried out three studies in Bangladesh to find out the effects of tree species on crops and alternative management practices for better system productivity. From the first experiment the highest yields of mustard (0.788 t/ha) and rice (2.89 t ha^{-1}) were obtained under *Albizia lebbeck* trees and *Acacia nilotica*, respectively. The second experiment indicated that the lower reduction in yield of adjacent crop occurred with wider tree spacing. The third experiment showed that root and shoot pruning increased the grain yield of wheat by 22%. The highest increase in the yield of rice (27%) and radish (72%) were obtained due to pruning of *Acacia nilotica* for two and three times a year, respectively. Pruning of *Albizia lebbeck* three times a year contributed to the highest increase in rice (50%) and radish (35%) yields.

An experiment was conducted by Roy *et al.* (2005) from which they reported that grain and straw yields of wheat were significantly influenced by tree species. The highest grain (3.27 t ha^{-1}) and straw yield (3.82 t ha^{-1}) were obtained from plots with *M. azedarach* and lowest grain (2.57 t ha^{-1}) and straw (2.87 t ha^{-1}) yields were obtained from the plot with *Albizia lebbeck.*

2.5 Concept and production of multistoried agroforestry systems

The multistoried / multilayered Agroforestry system is found in the tropical and subtropical regions of the world but a majority of them are in the lowland humid tropics. The population density enjoying the system is generally high as there are 3-5 layered plants arranged in different architectures. It can be characterized by high species diversities and usually diverse production activities. All multilayered homestead agroforestry system contains some kind of fruit crops and many of the trees produce fruits or other forms of food. However, there are also several secondary outputs from the system.

In general, all home gardens consist of a herbaceous layer near the ground, a tree layer at upper levels and intermediate layers between the twos. The lower layer can usually be partitioned into two: the lower most one (less than 1 m height) dominated by different vegetable and medicinal plants and the second layer (1-3m height) being composed of food plants such as cassava, banana, papaya, yam, and so on. The upper tree layer can also be divided in two consisting of emergent, fully grown timber and

Samsuzzaman *et al.* (2002) carried out three studies in Bangladesh to find out the effects of tree species on crops and alternative management practices for better system productivity. From the first experiment the highest yields of mustard (0.788 t/ha) and rice (2.89 t ha^{-1}) were obtained under *Albizia lebbeck* trees and *Acacia nilotica*, respectively. The second experiment indicated that the lower reduction in yield of adjacent crop occurred with wider tree spacing. The third experiment showed that root and shoot pruning increased the grain yield of wheat by 22%. The highest increase in the yield of rice (27%) and radish (72%) were obtained due to pruning of *Acacia nilotica* for two and three times a year, respectively. Pruning of *Albizia lebbeck* three times a year contributed to the highest increase in rice (50%) and radish (35%) yields.

An experiment was conducted by Roy *et al.* (2005) from which they reported that grain and straw yields of wheat were significantly influenced by tree species. The highest grain (3.27 t ha^{-1}) and straw yield (3.82 t ha^{-1}) were obtained from plots with *M. azedarach* and lowest grain (2.57 t ha^{-1}) and straw (2.87 t ha^{-1}) yields were obtained from the plot with *Albizia lebbeck.*

2.5 Concept and production of multistoried agroforestry systems

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fruit trees occupying the uppermost layer of over 25 m height, and medium sized trees of 10-20 m occupying the next lower layer. The intermediate layer of 3-10 m height is dominated by various fruit trees, some of which would continue to grow taller. This layered structure is never static; the pool of replacement species results in a productive structure, which is always dynamic while the overall structures and functions of the system are maintained for along period.

Vergara (1982) defined agroforestry as a system of combining agricultural and tree crops of various longevity (ranging from annual, biennial and perennial plants), arranged either temporally (crop rotation) or spatially (intercropping) to maximize and sustain agricultural production.

Harou (1983) pointed out that agroforestry is a combined agriculture-tree crop farming system, which enables a farmers or land user to make more effective use of his/her land that may yield a higher net economic return on a sustainable basis.

Michon (1983) reported from an analysis of the structure of the *Pekarangan* in the Citarum watershed in West Java, a five-layered canopy structure. The lowest layer of 1-2 m height contained 14% of the total canopy volume; the second, third, fourth and fifth layer contained 9, 25, 36 and 16% of the total canopy volume respectively and the height was 1-2, 2-5, 5-10 and greater than 10 m.

According to Saxena (1984) agroforestry utilizes the inter space between tree - rows for intercropping with agricultural crops and this does not impair the growth and development of the trees but enable farmers to derive extra income in addition to benefits accrued from the uses of firewood and timber from trees.

According to Shankarnarya (1984), trees in agroforestry systems conserve soil moisture, increase atmospheric humidity and improve soil fertility. The process is enhanced by tree canopy cover, which moderates microclimates and enhances organic matter accumulation, microbial activities and mineralization.

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The chagga homegardens (Fernendes *et al.*, 1984) are essentially a commercial system based on Arabica coffee, which formed third stratum, second layer was constituted by banana and the ground layer was dominated, in terms of total volume, over the others.

Fernandes and Nair (1986) reported that in an average the homestead agroforestry system produce 15 –20 % of the total fuel wood requirements of the local households.

The West African component farms (Okafor and Fernandes, 1987) are characterized by four-layer canopy dominated by a large number of tall indigenous fruit trees. An architectural analysis of the canopy revealed a relatively higher percentage of canopy distribution in the upper strata.

Nair (1987) stated that an agroforestry system can play an important role in improving soil fertility by: (i) increasing organic matter content of soil through addition of leaf litter, pruning and other biomass, (ii) efficient nutrient recycling within the system, (iii) biological nitrogen fixation in case of leguminous shrubs and trees and (iv) possible complementary interactions among associated species due to differences in canopy structure, root system and active zone of water and nutrient absorption.

According to Ong (1988), incorporating trees with arable crops, biomass production per unit area could be increased substantially when the roots of trees exploit water and nutrients below the shallow roots of crops and a mixed canopy intercepts more solar energy.

Acacia nilotica, Phoenix sylvestris, Artocarpus heterophyllus and *Borasus flabellifer* are the major tree species grown haphazardly with little or no management in the crop fields for fruit, fuel, timber, juice and building materials (Abedin *et al.,* 1991).

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MacDicken and Vergara (1990) stated that agroforestry is a means of managing or using land (i.e. a land use system) that combines trees or shrubs with agricultural/horticultural crops and/or livestock.

In China, cultivation of medicinal plants is an age-old practice under the name of 'silvo-medicinal' system. In northeast China, ginseng (*Panax ginseng*) and other medicinal plants are grown in pine (*Pinus* spp.) forests; in Central China, many medicinal plants are planted with *Paulownia tomentosa* and in southern China medicinal herbs are often planted in bamboo (*Bambusa* spp.) and Chinese fir (*Cunninghamia lanceolata*) forests (Zou and Sanford 1990).

According to Rang *et al.* (1990), homestead gardens are common in Bangladesh where farmers take up a combination of 10-15 species of fruits, ornamental and multipurpose trees along with vegetables to meet up their own diversified needs.

In Yunnan province, China, traditional 'Dai and Jinuo' agroforestry systems involve the medicinal crop *Amomum villosum* in the forest areas cleared of undergrowth (Pierre, 1991).

Yantashath *et al.* (1992) stated that fast growing multipurpose tree species in agroforestry play an important role through providing food, fuel wood, timber, fodder, green manure, soil and environment conservation.

In Bangladesh, it has been estimated that thirty thousand hectares of our homesteads provide 80% of total fruits and 85 % of fuel wood and timber (Rahim, 1994).

Bhatia and Singh (1994) stated that the agroforestry in India plays an important role in increasing biomass production, maintaining soil fertility and improving soil and averting risk.

Groot and Sourmare (1995) observed that decomposition of tree roots and the substances of the root exudes greatly enhance soil organic matter and thereby soil fertility. Lateral roots of tree may reduce loss of nutrients from the soil by recycling

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According to Miah *et al.* (1995), agroforestry system that incorporates a range of tree and crop species offers much more scope for useful management of light interception and distribution than monoculture forests and agricultural crops.

Homestead Agroforestry plays a very important role in Bangladesh economy. Income from home gardens ranges from 26 to 47% of the total family expenses (Millat-e-Mostofa, 1997).

Solanki (1998) stated that agroforestry can significantly contribute in increasing fuel wood, fodder, cash income and infrastructure in many developing countries. He also stated that agroforestry has high potential to simultaneously satisfy three important objectives: (i) protecting and stabilizing the ecosystems, (ii) producing a high level of output of economic goods (fuel, fodder, small timber, organic fertilizer, etc.) and (iii) providing stable employment, improved income and household materials to rural populations.

American ginseng (*Panax quinquefolium*), a medicinal herb exported to China from the United States and Canada, is grown as an understorey in red maple (*Acerrubrum*) forests (Nadeau *et al.*, 1999) or deciduous hardwoods such as black walnut (*Juglans nigra*) and sugar maple (*Acer saccharum*) instead of growing under artificial shade with considerable expense (Hill and Buck, 2000). Indeed, cultivation of ginseng and several other medicinal plants in the forests is a common growing form of forest farming practice of agroforestry in North America.

2.6 Effect of light on plant growth and development

Crop growth and development will depend on the available light: how much light is captured and how efficiently it is used to create dry matter. Again, for crops it is fairly easy to measure the interception of light over a season and to interpret the effects of that on growth and yield. In agroforestry, the capture of light by any one plant component is highly dependent on the species being used and on the design and layout of the various plant components (The ratio of cover of trees to crops, and the ways

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Optimal level of light is essential for normal structures and necessary physiological functions of all green plant (Leopold, 1964).

Okigbo and Geenland (1976) and Okigbo (1980) identified more efficient use of light resource by plants of different heights and canopy structures as one of the advantage to be gained by growing crops in mixed stands.

Alvim (1977) cited a good example of an interaction between light and nutrients in the case of cacao. While pod production of cacao is maximum under conditions of high soil fertility and low shade. Plants under nutrient stress yield more under shade than in the open.

Nayak *et al.* (1979) reported that translocation is enhanced under slightly reduced light (70% of normal light), but further reduction in light (below 70% of normal light) affect translocation due to limitation in energy supply.

Nayak and Murty (1980) observed that yield reduction of rice by 47, 57 and 74 percent in 75, 50 and 25 percent of normal light, respectively. That was mostly due to impaired dry matter production, panicle number and grains per panicle.

Cannell (1983) reported that crops differed in their responses to poor nutrition, competition for light or water and may either be reduced or amplified by a shortage of nutrients.

Investigation on light interception and competition in agroforestry systems are generally scarce. Verinumble and Okali (1985) showed that competition for light was a more critical factor than root competition for intercropped maize between teak trees (*Tectona grandis*) in Nigeria.

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According to Salisbury and Ross (1986), in dark or at very low light level the green plants become etiolated with maximum elongation of internodes. The stem becomes soft and weak with degeneration of xylem and differentiation of too much parenchyma. Different spectra have different effects on plants. Plants attain maximum height under red light. In blue and violet rays, the plants become healthy in structural and functional.

Interaction among the trees and solar geometry produce the particular solar climate of tree/crop systems. These interaction and effects include interception of radiation by tree stands of various densities, effect of canopy structure, effect of latitude and time of year on solar paths, shade from single crown and spectral quality of sun light under partial shade (Reifsnyder, 1987).

The potential benefits as a result of combining field crops with trees are so obvious from consideration of the waste of light resources as experienced in orchard and tree crop orientations (Jackson, 1987).

Neumann and Pietrowics (1989) studied competition in an agroforestry combination of *Grevillea robusta,* maize, and beans in Rwanda. They reported that the shade cast by *Grevillea robusta* appeared more important than other effects of the trees. While the availability of light may be the most limiting factor in many situations, particularly those with relatively fertile soils and adequate water availability, the relative importance of light would decrease in semiarid conditions as well as on sites with low fertile soils.

Basri *et al.* (1990) found that incorporating prunnings increased upland rice yield by 25-30% on a fill area basis. Root + shoot prunings of trees was found better in increasing crop yield compared to other pruning managements due to reduction of above ground competition (light) by shoot pruning and below ground competition (water and nutrients) by root pruning.

The yield advantage of conventional intercropping is explained in terms of improved capture of utilization of growth resources (Willy *et al.*, 1986). The resource capture by agroforestry systems would probably be greater than in sole crops (Ong *et al.,* 1991).

According to Salisbury and Ross (1986), in dark or at very low light level the green plants become etiolated with maximum elongation of internodes. The stem becomes soft and weak with degeneration of xylem and differentiation of too much parenchyma. Different spectra have different effects on plants. Plants attain maximum height under red light. In blue and violet rays, the plants become healthy in structural and functional.

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Limiting light (shade) is obviously the most important factor causing poor performance of understorey crops. The key to the development of compatible tree crop combination in agroforestry is greater light interception by understorey crops. In India, it is widely believed that shading by trees is responsible for poor yields of associated crops (Ong *et al.*, 1992).

Agroforestry system that incorporate a range of tree crop species offer much more scope for useful management of light interception and distribution than do monoculture forests and agricultural crops (Miah *et al.*, 1995).

The higher amount of light transmitted through *Gliricidia sepium* species may be due to its small and thin leaflets as well as poor branching habit (Miah, 1993).

Miah *et al.* (1995) reported that the mean light availability on crop rows decreased as they approached the tree rows across the alleys. The rate of decrease was greater in unpruned alleys than in the pruned one. Rice and mungbean yields decreased more in unpruned conditions (13 kg ha^{-1}) than in the pruned one (9 kg ha^{-1}).

The severity of competition in agroforestry system, ultimately the crop yield, is dependent on the partitioning of resources, primarily of light and water between tress and crops (Howard *et al.,* 1995).

In agroforestry, multistrata canopies offer scope for regulating the light distribution between the plant components and also of using the available light more efficiently over all (Wallace, 1996).

Light demanding understorey species (e.g., *Echinacea* sp.) may be intercropped initially to provide early returns from plantations and after canopy closure, shade tolerant species such as ginseng and goldenseal can be intercropped (Teel and Buck, 2002).

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2.7 Economic output from agroforestry systems

Agroforestry system has been recognized as a promising approach to addressing land use problems of rainfed farming systems in the tropics. Nonetheless, the lack of appropriate methodologies for evaluating the various types of agroforestry systems – both indigenous and improved - has been a serious impediment to the realistic assessment of their merits. Definite criteria that can be employed in evaluations and which can convincingly assess the merits and advantages of an agroforestry system in comparison with another agroforestry system or other land-use systems are needed.

According to Rachie (1983), the factors to be considered during selection of woody legumes for intercropping with annuals in the low land tropics are : i) ease to establish from seeds or seedlings, ii) rapid growth and high productivity of foliage and wood, iii) limited maximum size, iv) good coppicing ability, v) effective nutrient recycling ability, especially di-nitrogen fixation, vi) multiple uses - food, fodder, firewood, construction materials and other products and services, vii) minimal competition with shallow rooted annual crops, viii) small leaflets readily detached when dried and quickly decomposed when used as fertilizer, ix) good tolerance for draught, low fertility and other, x) freedom from pests and diseases and finally, xi) ease of control of eventual elimination.

According to Kang *et al.* (1984), a substantial improvement of crop yield in agroforestry systems was reported where tree prunings were used as mulch or green manure.

Gupta (1986) listed a number of indigenous understorey herbs and shrubs that can be produced as a part of forest farming or in new forest plantations to improve economic returns from forests in India.

Akter *et al.* (1990) reported that in the recent years public interest in planting trees in croplands has increased greatly in the southwest region of Bangladesh. In addition to planting traditional species farmer of the area have started organized planting of a fast growing species *Dalbergia sisso* in croplands. One of the reasons behind such practice was to avoid the risk of total crop failure. They also reported that wheat yield under

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different tree species (Mulberry, siris, Ipil-ipil) did not show any significant difference as compared to control yield.

The forest is thinned to give 30 to 40% shade and seedlings or cuttings are planted, which produce an average dried fruit yield of 375 kg/ha/annum (Zhou, 1993).

The severity of competition in agroforestry system-ultimately crop yield is dependent on the partitioning of resources, primarily of light and water between trees and crops (Howard *et al.,* 1995).

A farmers' cooperative in the northern lowlands of Costa Rica has successfully demonstrated cultivation of the medicinal herb 'raicilla' (*Cephaelis ipecacuanha*) in natural forests for export to the Netherlands and Germany (Hager and Otterstedt, 1996).

An experiment was carried out by Ahmed (2005) to investigate the performance of medicinal and spice plants grown under different agroforestry systems. The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. In the open condition, medicinal and spice plants received 100% sunlight; while guava and coconut based agroforestry system and, lemon and coconut based agroforestry system allowed, 65-70 and 34-45% sunlight respectively. The result revealed that the highest plant growth and the best yield contributing characteristics of *Aloe vera* was found in guava and coconut based agroforestry system. But the highest dry matter of leaves was found in the open condition.

Hossain *et al.* (2005) carried out an experiment to evaluate the performance of Indian spinach (*Basella alba*) grown under Eucalyptus *(Eucalyptus camaldulensis*) in different orientations from May to August, 2003 at the Bangladesh Agricultural University Campus, Mymensingh. The treatments involved different orientations: north, south, east and west for each of the tree. The experiment was conducted in RCBD design with three replications. The fresh yields produced in south, west, east and north orientations were remarkably lower than that of open field. The dry matter yields were 52.74, 56.41, 58.14 and 59.80 percent less respectively in compared to open field.

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2.8 Green manuring crops in agroforestry and its impact on soil health

In a pot trial, 15N tracing was used to investigate the dynamics of N in a grain-grain-green manure rotation, a farming system widely practiced in recent years in Ningxia (Xiong and Chen 1993). Spring wheat was intercropped with maize, and Vicia sativa was grown as the green manuring crop after wheat was harvested. The amount of N take by the plants when spring wheat and maize were grown together in the same pot accounted for 15.88% (0.716 g/pot) of the applied fertilizer N whereas N uptake by V. *Sativa* was only 0.009 g/pot. The beneficial effects of green manuring crop after wheat and the problems involving 15 N labeling by biological methods are also noted.

Sharma and Das (1994) observed that intermediate deep water conditions (0-50cm) at Cuttack, Orissa during 1990-91, rice cv. Gayatri and dhaincha (*S. aculeata*) were either mixed-sown in different arrangements (parallel lines and mixed broadcasting) in dry soil by the end of May or rice seedlings were transplanted in plots grown with pure dhaincha after the accumulation of water in the field by mid-July. Incorporation of dhaincha 48 and 54 days after sowing added 60.8-65.2 and 72.9-76.9 kg N/ha in the mixed stands compared to 81.3 and 85.1 kg N/ha in the pure stand in 1990 and 1991, respectively. Although the growth of rice sown simultaneously with dhaincha was affected initially due to the more after the incorporation of green manure following an increase in inter-row spacings.

Sharma *et al.* (1995) stated that sesbania green manuring and mungbean residue increased grain yield of rice by 0.4 and 0.3 t/ha, respectively and of spring wheat by 0.6 and 0.6 t/ha. Sesbania green manure and mungbean residue substituted for 43 and 30 kg N/ha in rice and subsequently gave a beneficial effect in spring wheat equal to the residual effect of 89 and 112 kg N/ha applied to rice, respectively. Mungbean residue remaining after the picking of pods, contributed similar amount of N as *Sesbania* green manuring to rice-wheat cropping system but, additionally gave seed yields of 0.5 – 1.3 t/ha.

Rahman *et al.* (1995) conducted a field experiment with a newly released variety of mungbean (Kanti) grown under varying population densities at different dates of sowing to evaluate yield performance in relation to various growth parameters. There i was scope to increase the grain yield of mungbean for September sown crop with

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higher population densities. Although the crop growth rate (CGR) and total dry matter plant^{-1} was higher with the lowest population density, but the leaf area index (LAI) was higher with the highest plant population in case of August sown crop. Total dry matter per unit area and leaf area indices showed strong positive significant correlations with grain yield, while crop growth rate showed an inverse relationship irrespective of spacing and dates of sowing. Relative growth rate (RGR) and net assimilation rates were maximum at 20 and 40 days after emergence of the crop in all the treatments.

Saneoka *et al.* (1995) stated that for the elucidation of the effects of salt stress on whole plant growth and crop productivity the knowledge of root characteristics with respect to soil physical and chemical environments is essential. Additionally, specific informations on the variation in root distribution both in space and time have been sought as an input information in computer simulation models for the reclamation of salt-affected soils.

Fakir (1997) observed that two contrasting rooting patterns in pigeonpea were stable over several seasons and generations indecating that the rooting patterns might be genetically heritable.

Fakir *et al.* (1998) gave information on dry matter (DM) partitioning into root system in pigeonpea. This study was conducted to compare DM production and partitioning in four contrasting pigeon pea genotypes.

Rao and Ito (1998) carried out a comparative study of the root system morphologies and of some physiological parameters at initial growth stages of three legumes: pigeon pea, chickpea and groundnut and three cereals : sorghum, pearl millet and maize. Considerable differences were observed for all the root morphological traits among the species. The root respiration rate significantly correlated with the N uptake. The legumes showed a higher efficiency of N uptake in terms of respiratory requirement. The transpiration rate showed a significant association with total N concentration of shoot, indicating the transpiration might be partly related to nitrogen flow and accumulation in shoot in case of nitrate nitrogen as a sole nitrogen source. Morphological and physiological characteristic of the root systems using rather simple indices were found to be better criteria for describing functional differences among crop species.

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higher population densities. Although the crop growth rate (CGR) and total dry matter plant^{-1} was higher with the lowest population density, but the leaf area index (LAI) was higher with the highest plant population in case of August sown crop. Total dry matter per unit area and leaf area indices showed strong positive significant correlations with grain yield, while crop growth rate showed an inverse relationship irrespective of spacing and dates of sowing. Relative growth rate (RGR) and net assimilation rates were maximum at 20 and 40 days after emergence of the crop in all the treatments.

Saneoka *et al.* (1995) stated that for the elucidation of the effects of salt stress on whole plant growth and crop productivity the knowledge of root characteristics with respect to soil physical and chemical environments is essential. Additionally, specific informations on the variation in root distribution both in space and time have been sought as an input information in computer simulation models for the reclamation of salt-affected soils.

Fakir (1997) observed that two contrasting rooting patterns in pigeonpea were stable over several seasons and generations indecating that the rooting patterns might be genetically heritable.

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A trial was conducted at Akola, Maharashtra in the 1991-92 to 1995-96 kharif [monsoon] seasons to assess the effects of NPK fertilizer and application of 5 t glyricidia [gliricidia sp.] green manure/ha on rice cv. SKL-7 yield and soil fertility. Averaged rice yield was 2.84 and 3.04 t/ha without and with green manure, respectively, while recommended NPK (100:50:50 kg N:P:K ha^{-1}) gave a yield of 3.52t. Green manuring decreased soil bulk density, and increased water holding capacity, pH, organic carbon content, and available N, P and K (Turkhede *et al.,* 1998).

Das *et al.* (1999) studied the effects of elevated CO_2 (600±50μII^{-1}) on growth, rate of photosynthesis, respiration and yield parameters of mungbean after 25 and 50 days of CO_2 exposure (25 and 50 DAT). Increasing atmospheric CO_2 directly stimulated photosynthesis and plant growth. High CO_2 treatment caused increase in leaf number, leaf area and dry weight of mungbean plants at both stages. Similarly, plant height and shoot dry weight also showed significant increase due to elevated CO_2. The enhancement in all the morphological parameters was more at 25 DAT compared to the later stage. It showed that early vegetative stages of mungbean are more responsive to high CO_2. The rate of photosynthesis was higher at both the stages but the rate of respiration was reduced due to elevated CO_2. Mungbean plants grown under elevated condition also produced statistically higher yield than ambient plants.

Singh and Singh (1999) simulated differential salt profiles in potted soil to study their effects on root growth and grain yield of wheat cv K8804. The root length, root volume and root surface area were greatly decreased under saline (ECe 15.2 ds/m) as well as sodic (ESP55, pH 9.6) soil conditions. In a vertically variable profile with top soil, normal, and lower one saline, the root penetration was poor compared to the one having top soil normal with lower one sodic. However, root growth differences were not so prominent when normal/saline or normal/sodic soil variations were in the lateral plane. The biomass was positively correlated with root dry weight which in turn, was dependent on the soil chemical environment. The yield loss under entirely saline or sodic soil was nearly 70% of the normal one. Finally, it was concluded that the salinity of simulated sub-soil was more detrimental to plant growth than the sodicity of similar zone.

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Haris *et al.* (1999) carried out a 2 year field experiment in New Delhi, India, where green manure of sunnhemp (*Crotalaria juncea*), dhaincha (*Sesbania aculeata*) and cowpeas (*Vigna unguiculata*) were grown in kaharif and given 0 or 60 kg P/ha, and were followed by rabi crops of wheat, cv. Kundan, gram (*Cicer arietinum*) cv. BG-209 or mustard (*Brassica juncea*) cv.Bio-727 given 0 or 30 kg P/ha. Soil available N was greatest following sunnhemp, succeeded by dhaincha, and after gram, followed by mustard. However, P decreased the available N.

A field experiment was conducted during 1998-99 in Mosonmagyarovar, Hungary, to determine the total biomass production (tonnes/ha), dry matter content (%) and dry matter yield (tonnes/ha) of some spring sown green manure crops namely Phacelia, oilradish, fenugreek and the mixture of those species (Phacelia/oilradish and Phacelia/fenugreek). The highest biomass production values of 34.60-41.30 tonnes/ha were obtained under Phacelia/oilradish mixture. Statistical analyses proved significant effects in all cases except in the Phacelia/oilradish mixture. The dry matter content of purely sown Phacelia showed the highest values during the entire experiment period. The total dry matter yield at harvest was found highest in the phacelia/oilradish mixture (Casavajda, 2002).

A field experiment was conducted in an 18-year-old coconut orchard at Konark, Orissa, India, during kharif of 1994 and 1995 to assess the performance of cowpea, green gram, horsegram (*Macrotyloma uniflorum*) and dhaincha (Sesbania), with littoral sandy soil. Results revealed that the plant heights of different green manuring crops differed significantly in both the years. Maximum plant height (63.45 cm) was observed in dhaincha followed by cowpea at 45 days after sowing. Leaf number plant^{-1} at the time of incorporation was highest (22.05) in horesgram and lowest (12.05) in dhaincha. Root nodulation also varied significantly in both the years with dhaincha as the highest one (139.43). Biomass production was highest in cowpea (7.23) followed by green gram (6.0) and horsegram (5.72 kg). The highest dry matter contents in both the years were found in dhaincha followed by greengram and horsegram. The results indicated that cowpea, greengram, and horsegram could be successfully grown as green manuring crops in coconut basin with littoral sandy soils (Sahoo *et al.*, 2002).

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Sharda and Ratan (2003) reviewed that soil erosion is a major cause of land degradation in India. Out of the 329 M ha geographical area of the country, 187.9 M ha is affected by various types of land degradation problems. Water erosion alone constitutes an area of 148.9 M ha resulting in an annual loss of 5333 M t of fertile soil equivalent to 16.4 t ha/year. The magnitude of soil loss is much higher in Shiwalik Hills (>80 t/ha); ravine and shifting cultivation areas (>40 t ha); and black soils and Western Ghat region (20-30 t/ha). Soil erosion depleted soil depth, fertility, organic matter, groundwater table and consequently crop productivity. The off-site effects included reduction in carrying capacity of reservoirs, meandering of rivers and drainage channels due to sedimentation, occurrence of floods, loss biodiversity and impairment of water quality. Agronomical measures such as contour farming, strip and mixed cropping, intercropping, cover management, mulching, green manure, use of crop residues, crop geometry, tillage, etc., were adequate up to 4% slope to minimize erosion losses and achieved higher productivity. However, those measures needed to be supplemented with mechanical measures like levelling and bunding, bench terracing, trenching, etc. on higher slopes. Vegetative measures such as grass barriers and agroforestry were cost effective and could minimize erosion loses and enhance productivity. The input-use-efficiency of basic resources of soil, water and nutrients could be significantly improved by adopting appropriate erosion control measures for sustained productivity and farmers' profitability.

Fawaz *et al.* (2003) carried out two field experiments on dhaincha (*Sesbaina aculeata*) and sorghum (*Sorghum bicolor*) grown in monocropping and intercropping systems under non-saline and saline conditions in Syria to evalaute dry matter production, total nitrogen (N) yield, land equivalent ratio (LER), soil N uptake and N_2-fixation using the 15N isotope dilution method. The first experiment was conducted under non-saline conditions, three different combinations of *Sesbania* (ses) and sorghum (sor) were investigated in the intercropping system (2 ses : 1 sor; 1 ses : 1 sor and 1 ses : 2 sor, row ratio). In the second experiment, only one combination (1 ses : 1 sor, row ratio) was tested under saline conditions. Results of the first experiment showed that dry matter yield of sole sorghum was higher than the sole *Sesbania*, and was similar to that produced by the intercropping treatments. In the both experiments, percentages of N_2 fixed by the *Sesbania* in the intercropping systems were considerably enhanced relative to the sole cropping of *Sesbania*.

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Parvin *et al.* (2005) studied the decomposition patterns of two contrasting green manures viz. water hyacinth (*Eichhornia crassipes*) and mimosa (*Mimosa invisa*) in an incubation experiment at the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh during May to July, 2003. The highest decomposition rate was observed in mimosa at day 2 and water hyacinth at day 10. The decomposition of mimosa was approximately two times higher than water hyacinth. After 50 days of incubation, a total of 32 and 49% of the added C were respired from water hyacinth and mimosa, respectively. Both the rates and total decomposition of the green manures were also found to be related to their nutrient status (C:N:P:S ratios).

On the basis of review discussed above, it can be concluded that the agroforestry practices have enough potentiality to sustain soil health, intensification of land use and maximization of production. Introducing legume crop in the cropping pattern in agroforestry practices will be more helpful for maintaining soil sustainability. There is a few alternative rather than multistoried agroforestry system for maximizing vertical space utilization, diversified production and high income generation. Hence, screening of varieties of wheat, mungbean and T. aman for fruit tree based agroforestry practices and selection of component crops for different storied in multistoried agroforestry system will be justified.

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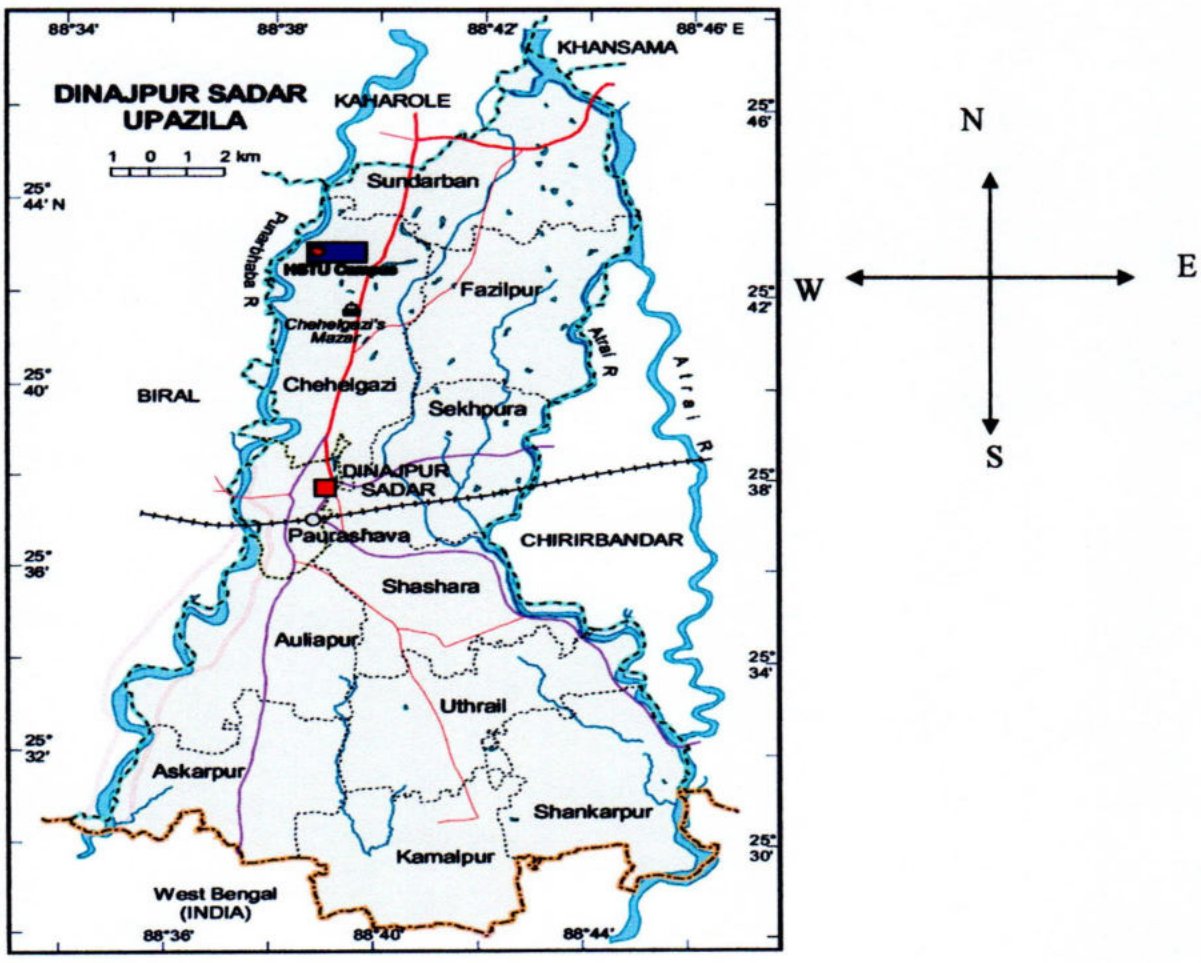
CHAPTER 3
MATERIALS AND METHODS

This episode deals with the materials and methodology used in conducting the experiment. The location of the experiment, materials used, and methodology followed in different operations during the experimentation as well as in data collection have been described in the following subheads:

3.1 Experimental site

3.1.1 Location of the study

A series of experiments were conducted at the Agroforestry Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The experimental site is situated under the Sadar Upazila and located at $25^0$39' N latitude and $88^0$41' E longitude having an elevation of 37.58 m.



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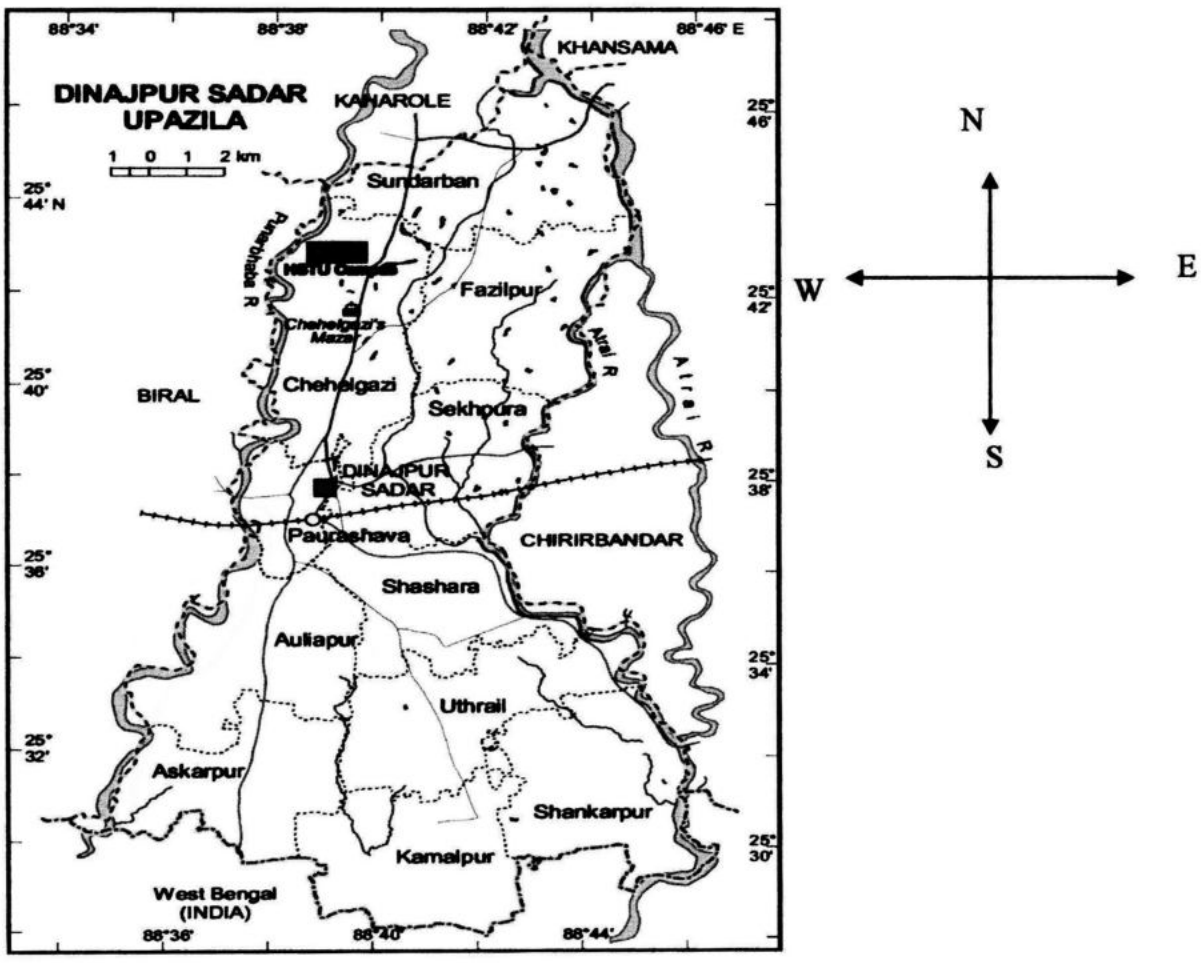

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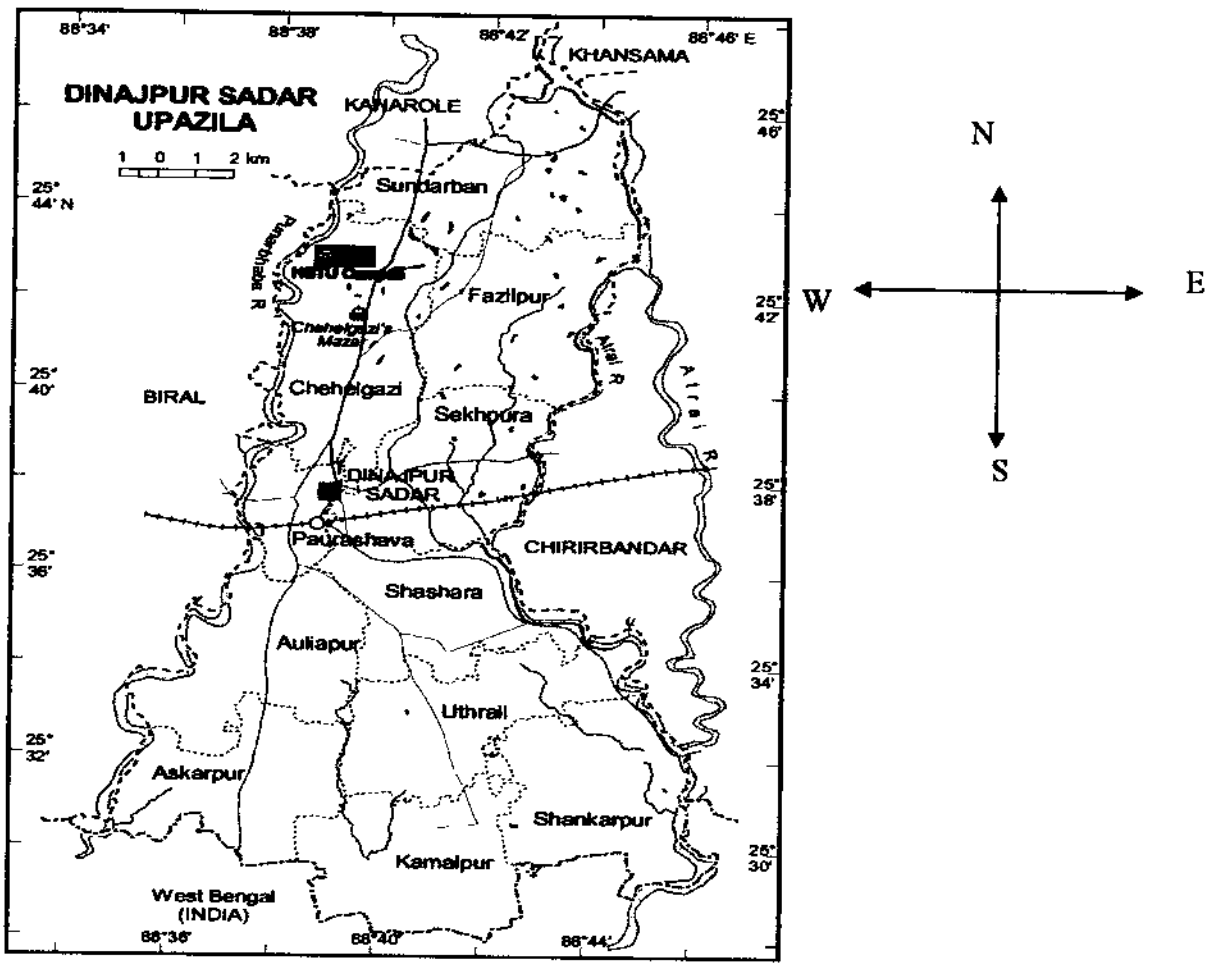

3.1.2 Soil characteristics

The experimental site is situated in a medium high land belonging to the Old Himalayan Piedmont Plain (AEZ No. 01). The rain water did not stay there. Irrigation facilities and drainage were well developed. The soil texture was sandy loam with 65% sand, 30% silt and 5% clay. pH of the soil was 5.1 and CEC 8.07 me/100g soil. The structure of the soil was fine and the organic matter content was 1.06%. The soil possesses the following amounts of other elements -

Name of the element	Amount
Sodium (Na)	0.06 me /100 g soil
Calcium (Ca)	1.30 me /100 g soil
Magnesium (Mg)	0.40 me /100 g soil
Potassium (K)	0.26me/100 g soil
Total nitrogen	0.103%
Phosphorus (P)	24.0 µg/g soil
Sulfur (S)	3.2 µg/g soil
Boron (B)	0.27µg/g soil
Iron (Fe)	5.30µg/g soil
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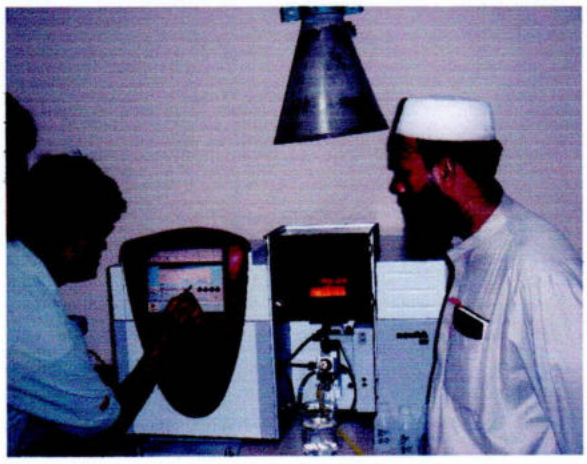
The soil sample was analyzed at the Soil Resource Development Institute (SRDI), Dinajpur before plantation of tree species for the experiment to know the soil health status.



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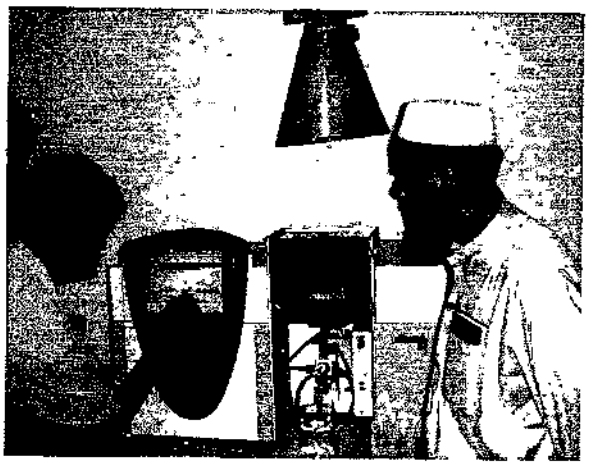

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3.1.3 Climate and weather

The experimental site is situated under the tropical climate characterized by heavy rainfall during May to August and scanty rainfall during the rest period of the year (Figure 3.1 and 3.2). Information regarding meteorological data i.e, monthly maximum and minimum temperatures, relative humidity (%), sunshine (hr) and light intensity (lux) recorded during the study period are presented (Figure 3. 1, 2, 3 and 4).

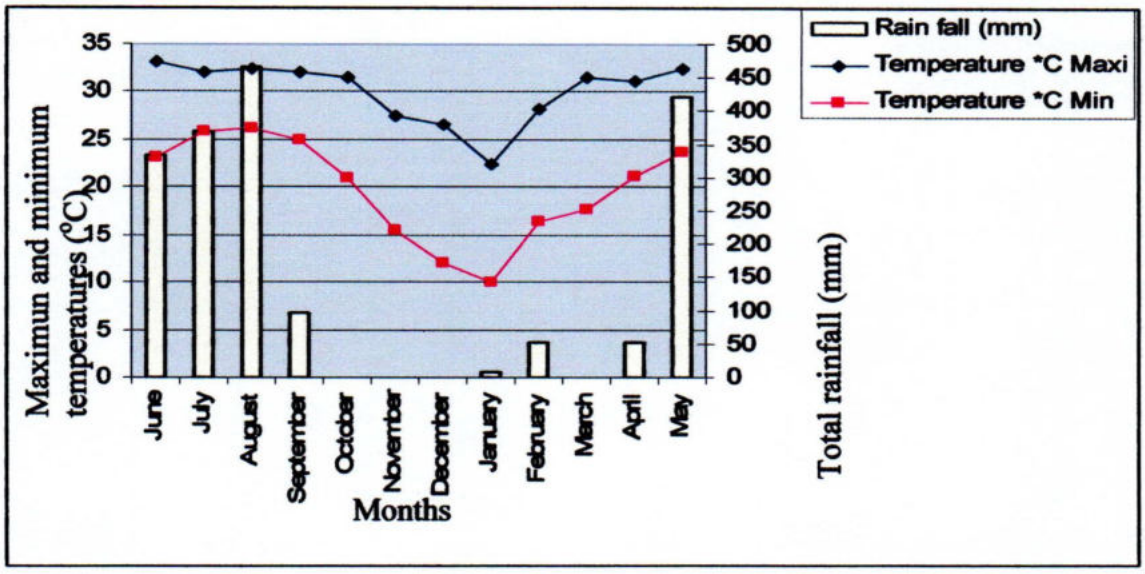
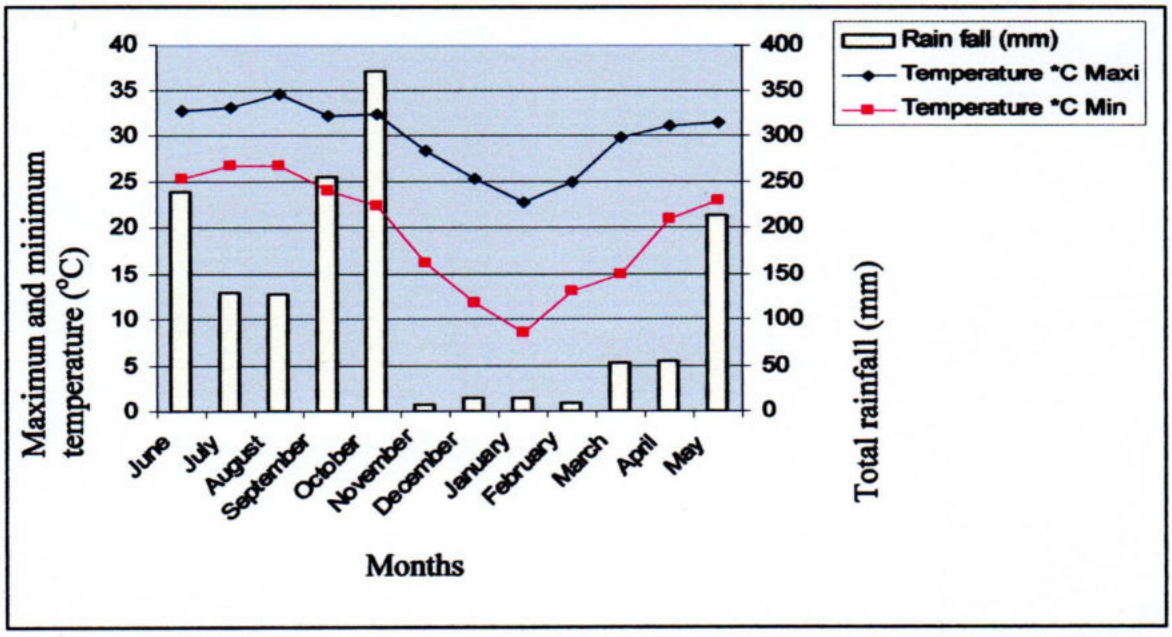


Fig 3.1: Monthly mean maximum and minimum temperatures, and total rainfall of the year 2006- 07



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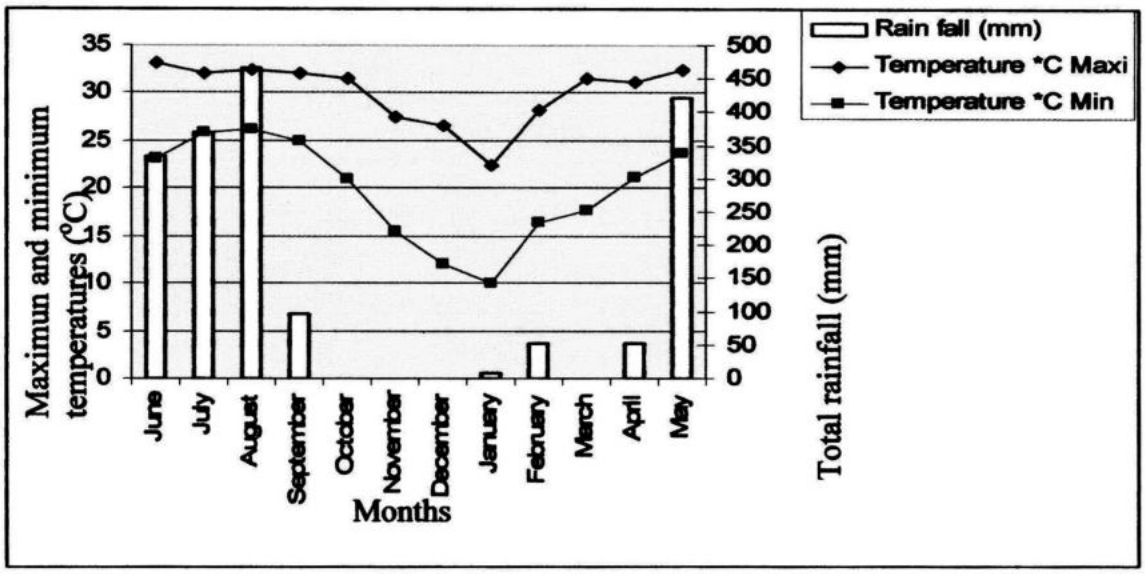

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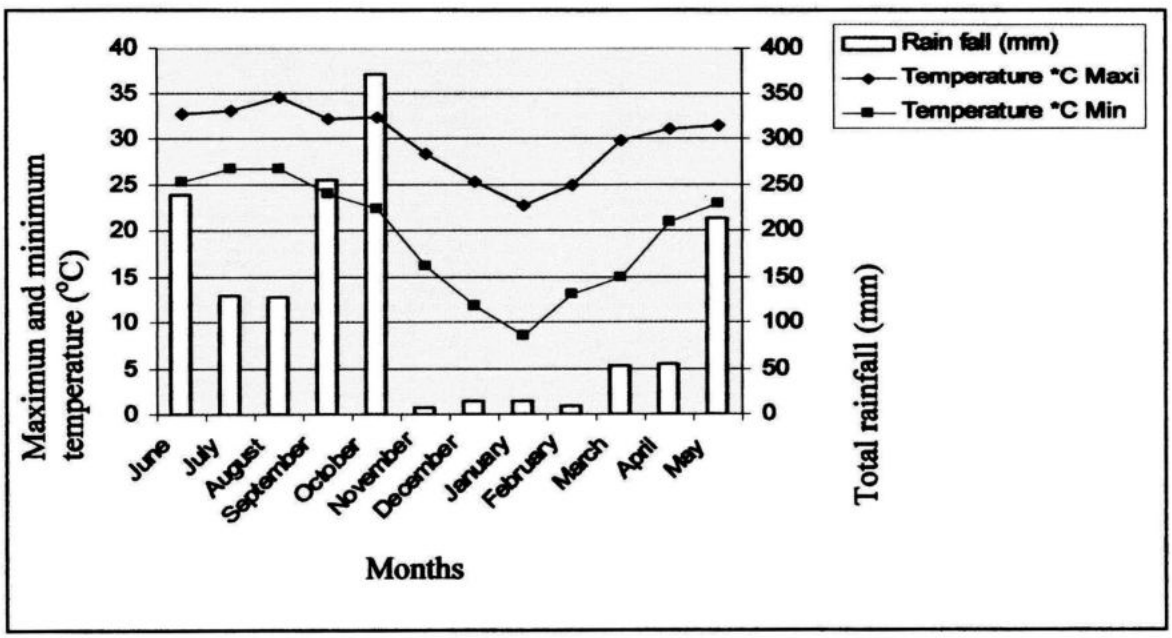

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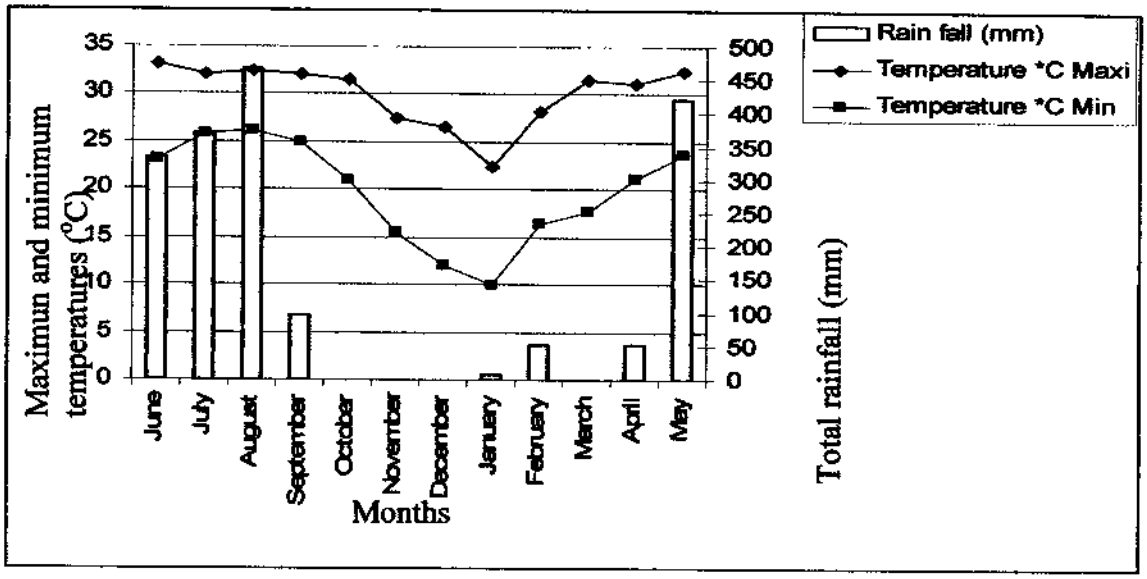

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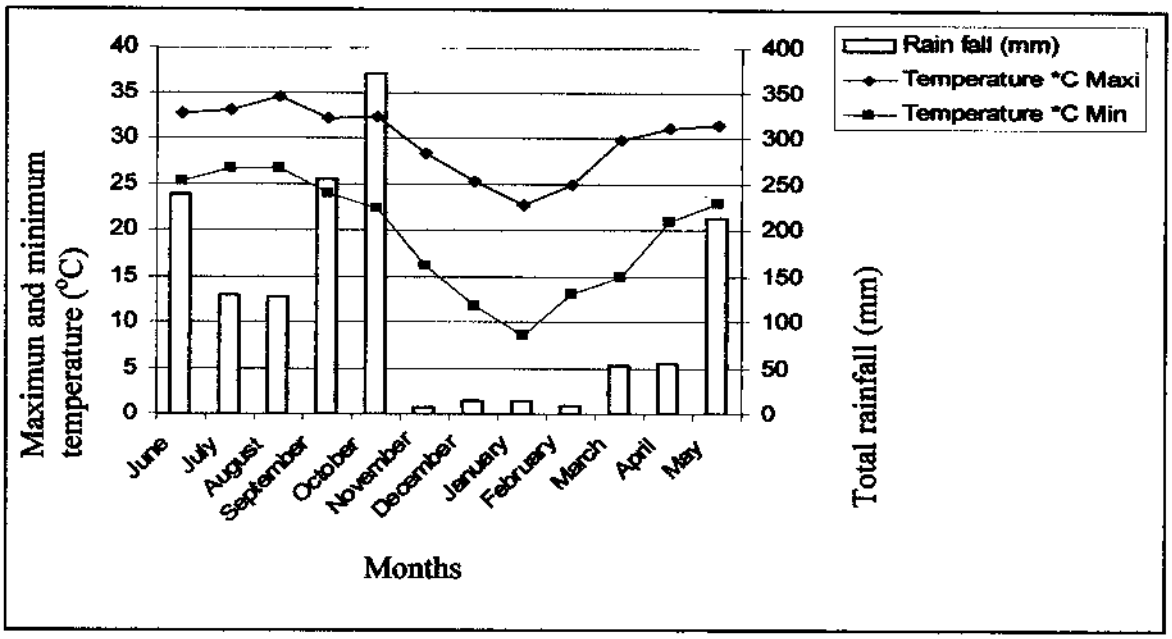

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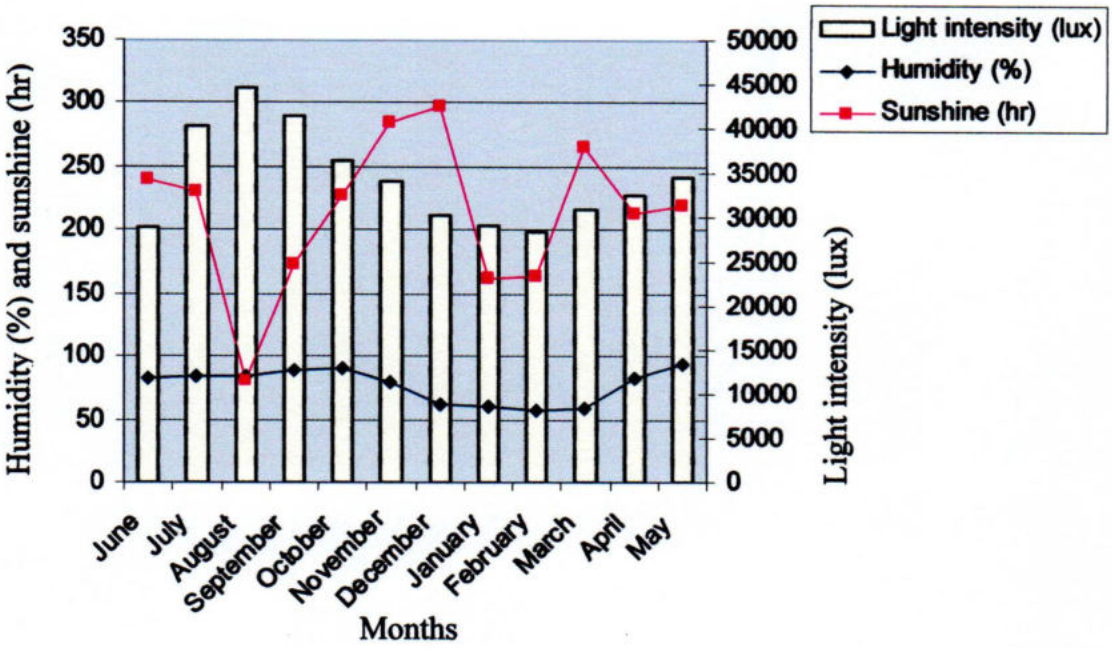

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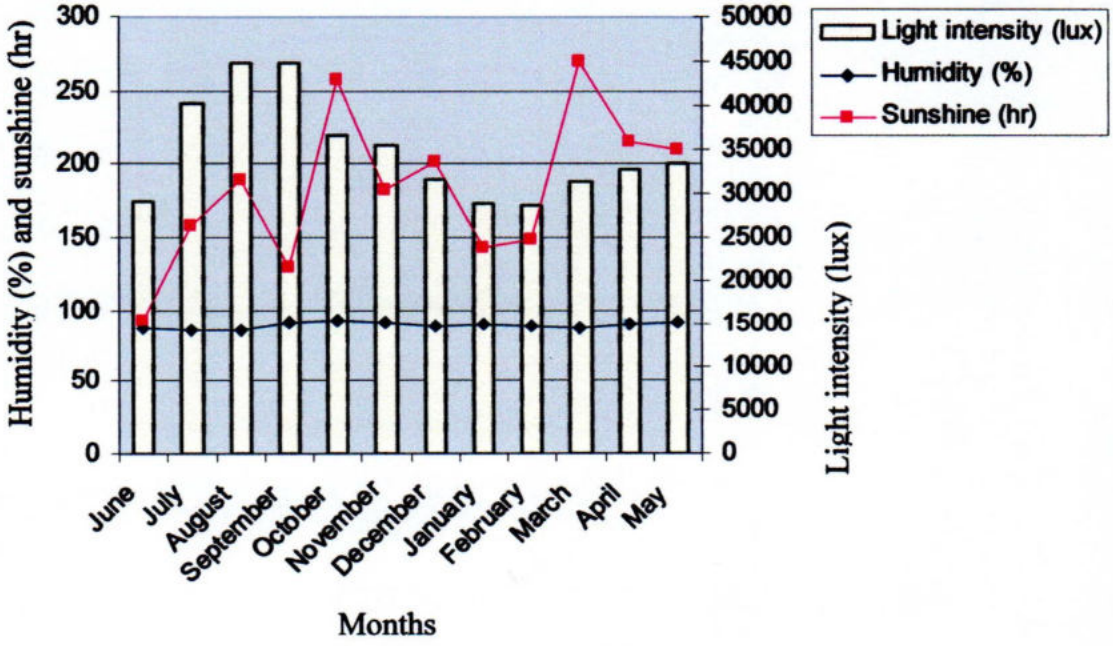
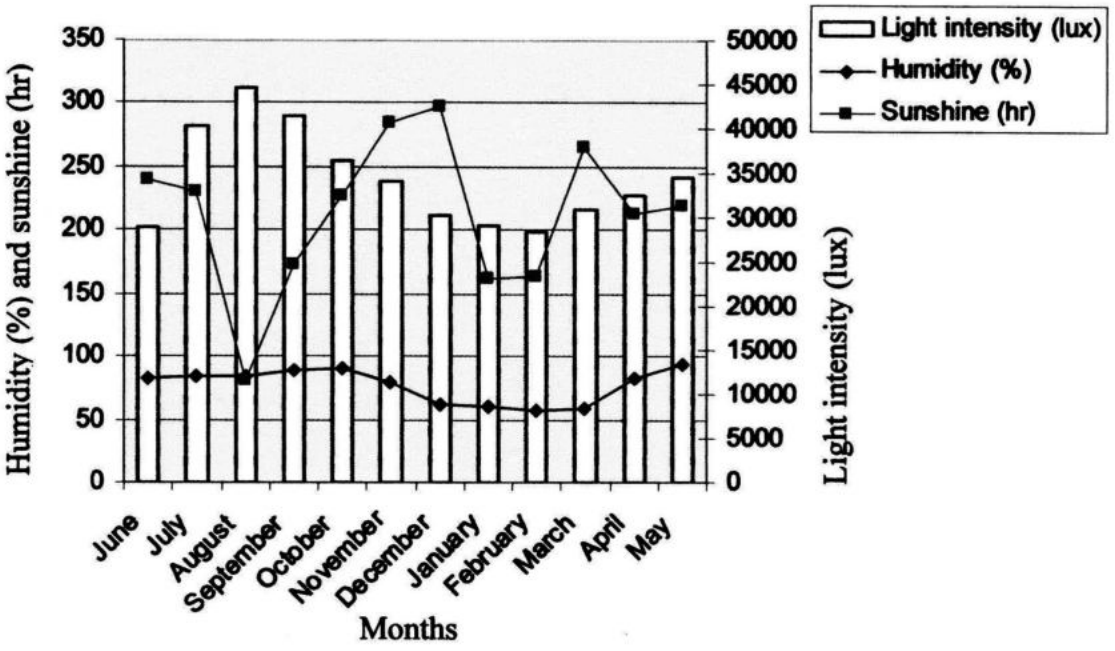


Fig 3.4: Monthly average humidity (%), light intensity (lux) and total sunshine (hr) in 2007- 08.



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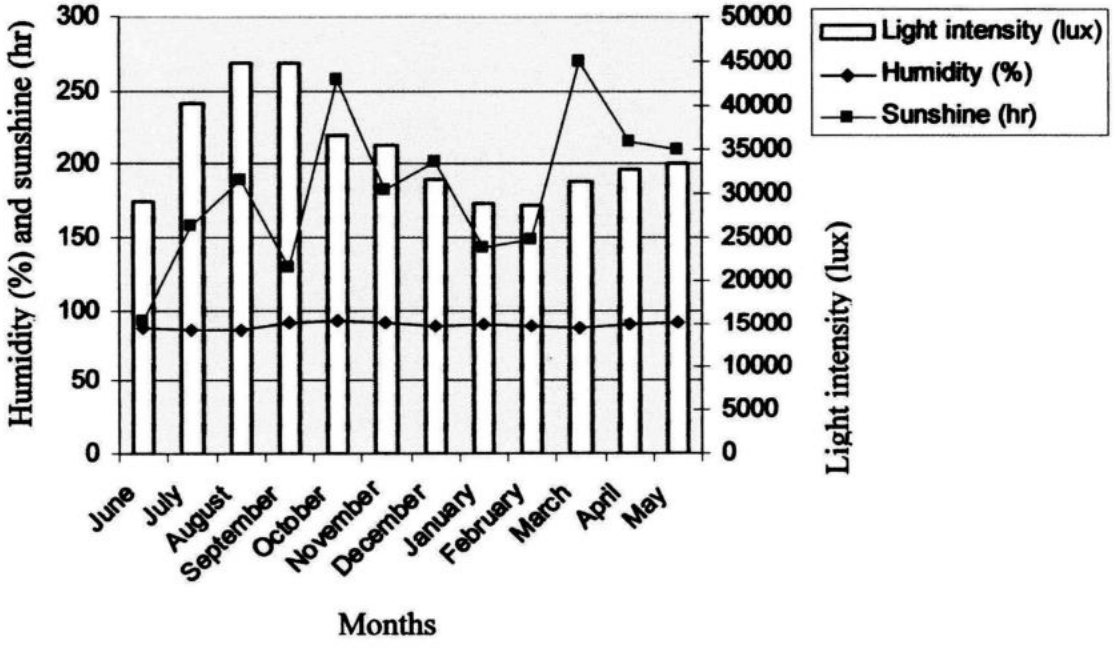

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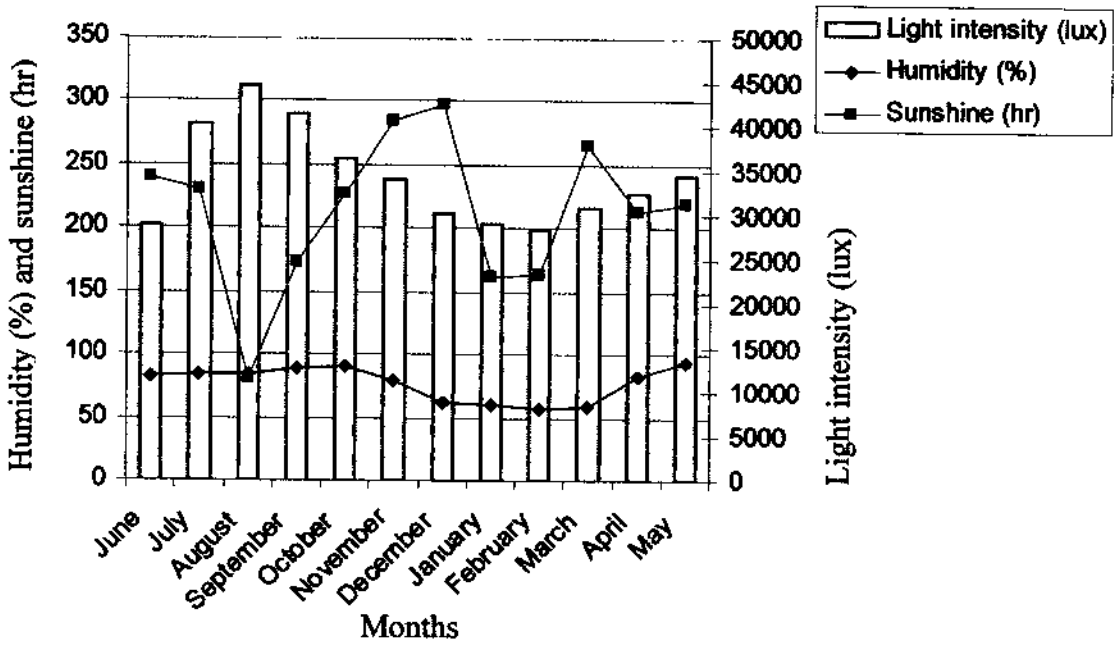

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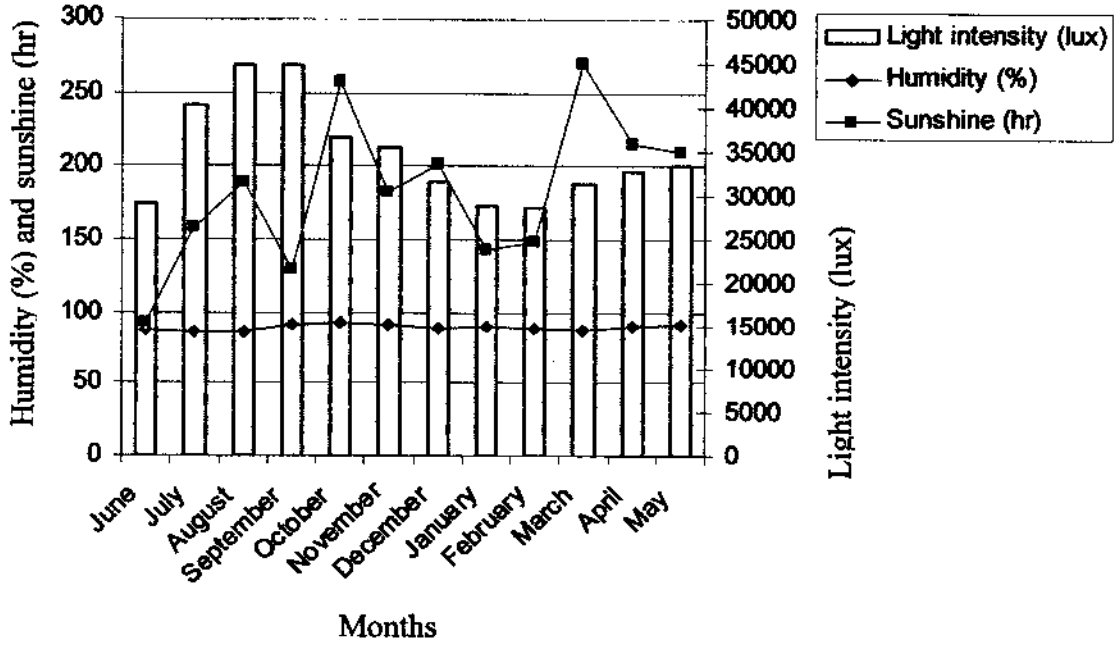

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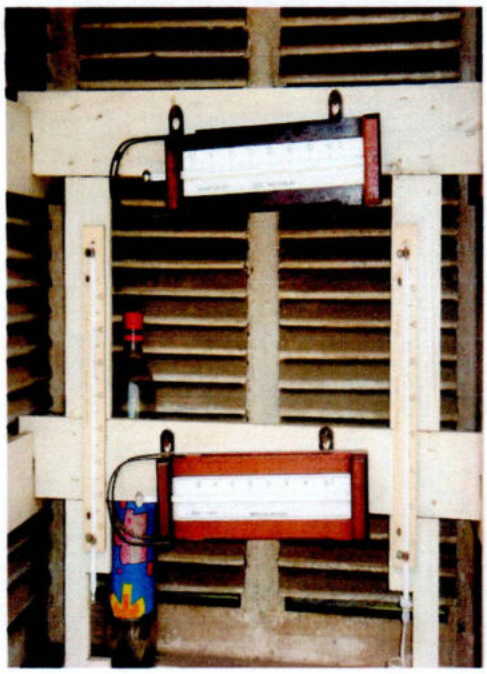
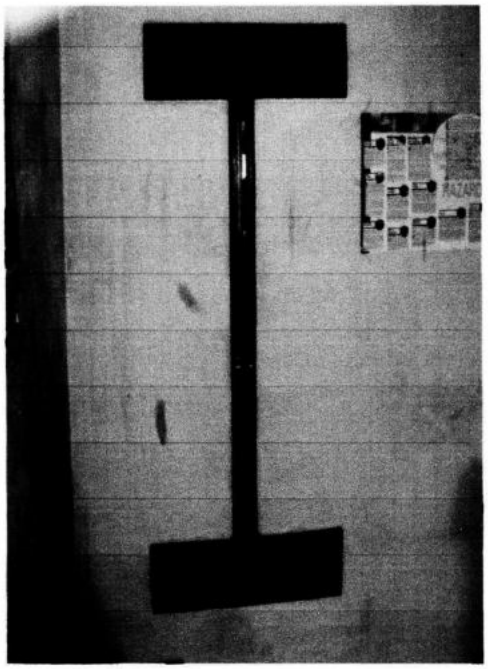


Plate 3.3: Thermometer used for measuring maximum and minimum temperature

Plate 3.4: Rain gauge used for measuring rainfall

Plate 3.5: Sunshine recorder



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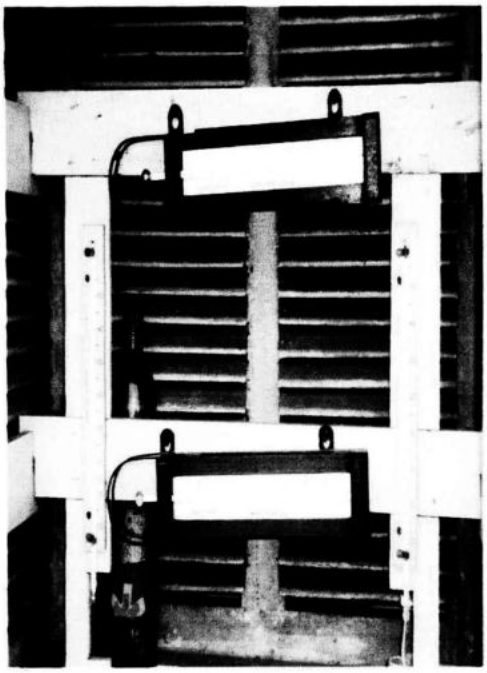

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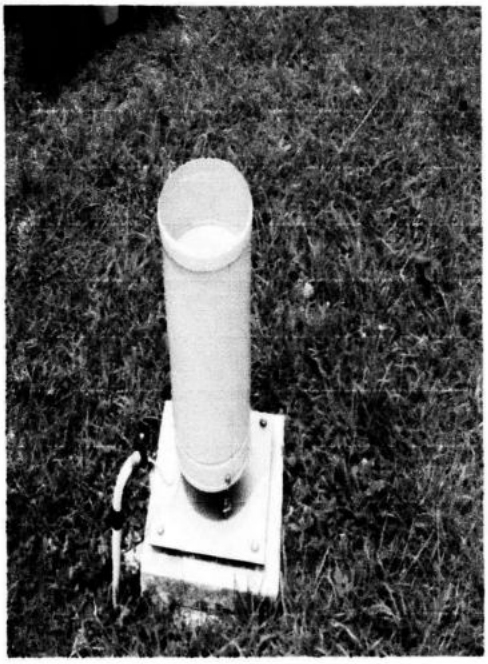

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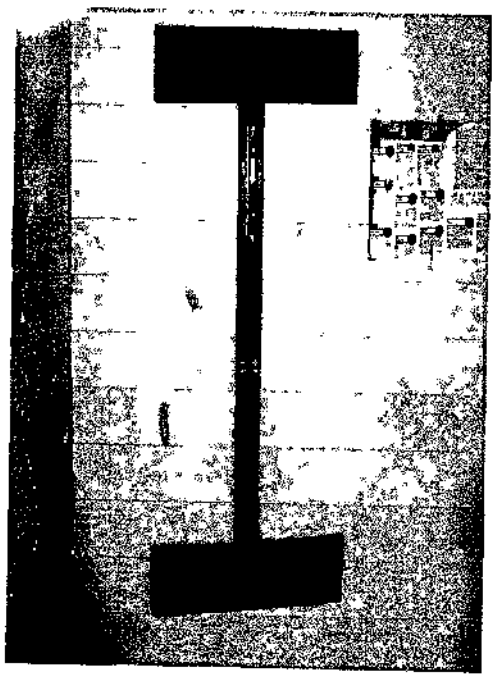

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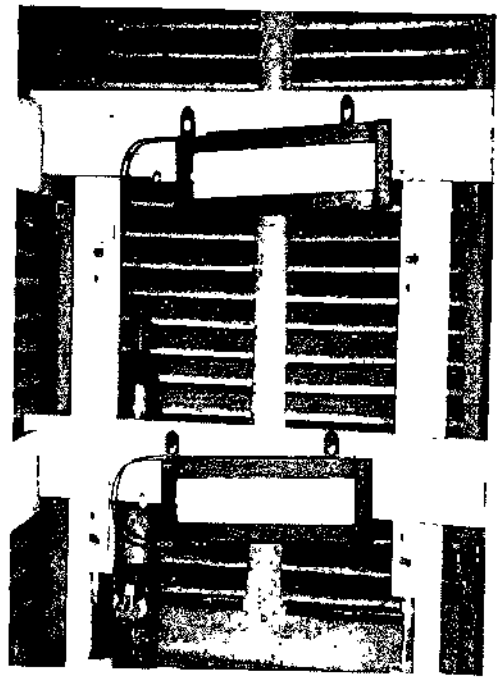

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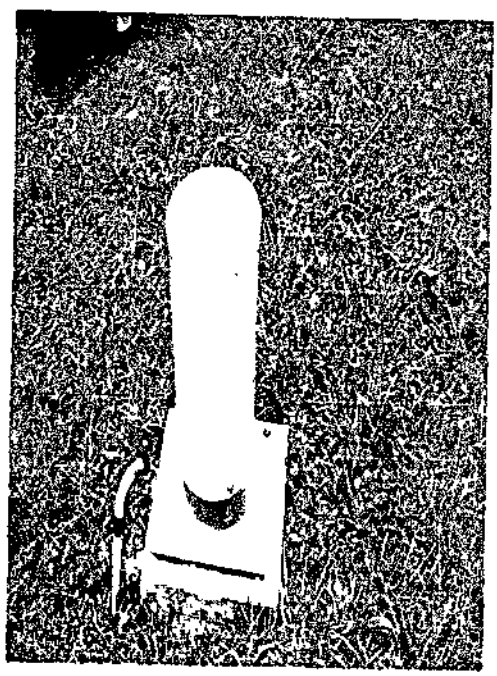

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3.2 Experimental techniques

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MPTs Establishment Year (2004)

Establishment of five MPTs for conducting the targeted agroforestry research

Experimental Year-1 (2006-2007)

Experiment # 1 : Performance of Transplanted aman in Agroforestry Systems

Experiment # 2 : Performance of Wheat in Agroforestry Systems

Experiment # 3 : Performance of Mungbean in Agroforestry Systems

Experiment # 4: Performance of Banana as the Middle Storey Crop in Agroforestry Systems

Experiment # 5: Performance of Potato as the Lower Storey Crop in Multistoried Agroforestry Systems

Experiment # 6: Performance of Onion as the Lower Storey Crop in Multistoried Agroforestry Systems

Experiment # 7: Effect of Lower Storied Crops on the Performance of MPTs

Experiment # 8: Effect of Different Agroforestry Practices on the Soil Properties

Experimental Year-2(2007-2008)

All the experiments of the year-1 were repeated in the year-2

Detail experimental procedures and other relevant activities of each of the experiments are described in the following sections.

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Experiment # 4: Performance of Banana as the Middle Storey Crop in Agroforestry Systems

Experiment # 5: Performance of Potato as the Lower Storey Crop in Multistoried Agroforestry Systems

Experiment # 6: Performance of Onion as the Lower Storey Crop in Multistoried Agroforestry Systems

Experiment # 7: Effect of Lower Storied Crops on the Performance of MPTs

Experiment # 8: Effect of Different Agroforestry Practices on the Soil Properties

Experimental Year-2(2007-2008)

All the experiments of the year-1 were repeated in the year-2

Detail experimental procedures and other relevant activities of each of the experiments are described in the following sections.

3.2.1. Establishment of five MPTs for agroforestry practice

Five Multipurpose Tree Species (MPTs) namely, black siris, guava, mango, gora neem and ipil ipil were established in five separate blocks in the experimental field in July 2004. The saplings were collected considering same height and base girth for individual species. The trees were planted maintaining 3 m x 3 m spacing in the block and blocks were separated by 5 m from each other. For black siris, guava and mango, 20 trees were planted in the block maintaining 4 replications. Each replication posses 5 trees which were used for 5 varieties of each lower storied crop (wheat, mungbean, T. aman). There was also a controlled block for lower storied crop containing 20 plots of 3 m x 3 m size. Gora neem and ipil ipil were used for multistoried experiment where banana was used as middle storied crop planted in the middle of 2 tree species. The alleys were used for lower storied crops (potato followed by onion).

3.2.1.1 Descriptions of the selected MPTs

Silvanfeatures/Phenological characteristics of MPTs are more important in association with crops for agroforestry practices. The descriptions of silvanfeaturs of selected MPTs are given below-

Black siris (*Albizia lebbeck*): It is a large, handsome deciduous tree with spreading crown. Leaves bi-pinnate, leaf rachis 7-15 cm, usually with an oval gland at the base ; pinnae usually 2-5 pairs,5-20 cm long often with glands between the leaflets; leaflets 3-10 pairs, 2.5-3.0 x 1.5-2.0 cm, oblong. Flowers greenish-white in pedunculate heads. Fruit a pod, 15-30 x 3-4 cm, pale, shiny, yellowish-brown, alternately depressed on either side of the seeds. The root system is largely superficial. It is nearly leafless in part of the year (Gupta, 1993). Leafless condition was found in the cold season, Flowering time: May-June, Fruiting time: December- February.

Guava (*Psidium guajava*): This is a popular fruits in Bangladesh. A small to medium tree, 5.8-6.2 m. in height, branching heavy with dense foliage, tendency to produce long shoots (Bose, *et. al.* 2004). Leaves simple, opposite, 10-12 x 5-7 cm, elliptic-oblong, usually acuminate, sub glabrous above, pubescent beneath with prominent veins, petiole about 0.5 cm. Flowers white, about 4 cm across,1-3 flowered on axillary peduncles. Fruit a globose or pyriform berry, 5 cm long or more; seeds usually many, very hard. Flowering time April-June, Fruiting time: June -September.

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Mango (*Mangifera indica*): Mango is one of the major fruit of Bangladesh. It is a middle sized to large ever green tree with thick, rough, nearly black bark. Leaves alternate, 7-30 cm long, oblong-lanceolate, crowded near the end of the branches, petiole 2-4 cm long. Flowers small with large peduncles. Fruit a drupe, 5-15 cm long, ripen mango consists of a lot of vitamin A. We can get fruit within only one year after plantation of one year aged grafted mango sapling. The test variety (Amrapaly) is one of the finest Indian mango cultivar. It is annual quick growing in nature. Fruits are very attractive, medium elongated in shaped. The test is superb, with an excellent sugar acid blend (Bose *et. al.* 2004). Flowering time: February-March; Fruiting time: April-June.

Goraneem (*Melia azedarach*) It is usually a small or middle- sized fast growing and deciduous tree species. Leaves bi-pinnate, very often tri-pinnate, leaflets 2.5-5.0 x .6-2.5 cm, somewhat obliquely ovate, unequally serrate. Flowers lilac-blue, in numerous axillaries cymes formed in to panicles. Fruit a drupe, 1.2-1.6 cm across, globosely, yellow when ripe. Leaves fall during the cold season and reappear during the months of March and April. Flowering time: March-May; Fruiting time : December to January. Goraneem is a short durated tree species and can be harvested with 6-8 years (Bose *et. al.* 2004).

Ipil-ipil (*Leucaena leucocephala*): It is fast growing deciduous tree species. Its bark brownish, smooth. Leaves feathery, bi-pinnate, pinnae 4-8 pairs, 5-9 cm long, leaflets 10-26 pairs, linear, oblong to lanceolate, 10x3 mm. flowers small,yellowish-creamy in globose heads.Fruits straight, flat pods growing in large bunches. Flowering time:March-April and August-october;Fruiting:almost round the year.Its leaves and pods are widely used as palatable fodder as it is grown for protein bank. It is a member of leguminosae family and can fixes nitrogen. Its deep root system helps in nutrient recycling, leaflets of the tree are small and easily decomposable (Bose *et. al.* 2004).

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3.1 Growth of the trees over time for transplanted aman-wheat-mungbean cropping pattern during the study period

		Growth of trees							
Tree	**Growth parameter**	**Initial**	**Before planting t-aman**	**Before sowing wheat**	**Before sowing mung bean**	**Before planting t-aman**	**Before sowing wheat**	**Before sowing mung bean**	**Before planting t-aman**
		10/7/2005	15/7/2006	15/11/2006	25/3/2007	15/7/2007	15/11/2007	25/3/2008	15/7/2008
Black siris	Plant height (m)	1.0	2.76	4.05	4.25	5.20	6.25	7.60	8.30
	Base girth (cm)	4.0	7.5	15.4	19.0	25.5	40.2	46.1	52.0
	Canopy dia. (cm)	15	100	125	125	150	295	300	320
Guava	Plant height (m)	1.0	1.45	1.75	1.96	2.20	3.10	3.70	4.00
	Base girth (cm)	4.4	8.6	12.5	14.3	18.5	25.0	28.0	32.0
	Canopy dia. (cm)	18.0	95.0	112.5	122.5	180.9	259.5	320.0	375.0
Mango	Plant height (m)	1.0	1.30	1.68	1.91	2.05	2.70	3.10	3.30
	Base girth (cm)	4.1	7.5	15.8	17.8	19.0	26.0	32.0	34.2
	Canopy dia. (cm)	20.0	80.0	102.6	108.7	113.5	230.0	280.0	286.5

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		Growth of trees							
Tree	**Growth parameter**	**Initial**	**Before planting t-aman**	**Before sowing wheat**	**Before sowing mung bean**	**Before planting t-aman**	**Before sowing wheat**	**Before sowing mung bean**	**Before planting t-aman**
		10/7/2005	15/7/2006	15/11/2006	25/3/2007	15/7/2007	15/11/2007	25/3/2008	15/7/2008
Black siris	Plant height (m)	1.0	2.76	4.05	4.25	5.20	6.25	7.60	8.30
	Base girth (cm)	4.0	7.5	15.4	19.0	25.5	40.2	46.1	52.0
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Guava	Plant height (m)	1.0	1.45	1.75	1.96	2.20	3.10	3.70	4.00
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		Growth of trees							
Tree	**Growth parameter**	**Initial**	**Before planting t-aman**	**Before sowing wheat**	**Before sowing mung bean**	**Before planting t-aman**	**Before sowing wheat**	**Before sowing mung bean**	**Before planting t-aman**
		10/7/2005	15/7/2006	15/11/2006	25/3/2007	15/7/2007	15/11/2007	25/3/2008	15/7/2008
Black siris	Plant height (m)	1.0	2.76	4.05	4.25	5.20	6.25	7.60	8.30
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Plate 3.6: Sowing the structural view for wheat-mung bean-T. aman experiment

Plate 3.7: Structural view of banana based multistoried production system

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Plate 3.7: Structural view of banana based multistoried production system

Plate 3.6: Sowing the structural view for wheat-mung bean-T. aman experiment

Plate 3.7: Structural view of banana based multistoried production system

Table 3.2. Growth of trees over time in banana based multistoried cropping system during the study period

Treatment	15/7/05				15/7/06				15/7/07				15/7/08			
	Plant height (m)	Base girth (cm)	Girth at breast height (cm)	Volume (cm^3)	Plant height (m)	Base girth (cm)	Girth at breast height (cm)	Volume (cm^3)	Plant height (m)	Base girth (cm)	Girth at breast height (cm)	Volume (cm^3)	Plant height (m)	Base girth (cm)	Girth at breast height (cm)	Volume (cm^3)
Goraneem(control)	1.3	5.1	00	89.56	4.3	15	10	2579.01	6.4	30	26	15289.95	8.0	43	36	39414.9
Goraneem+Banana	1.3	5.1	00	89.56	4.5	20	11	4778.11	6.65	38	27	25557.7	8.55	52	44	61548.30
Goraneem+Banana +Potato+Onion	1.3	5.2	00	116.42	4.6	23	15	6470.07	7.05	44	35	36375.95	9.0	59	51	83322.63
Goraneem +Potato-+nion	1.3	5.0	00	87.36	4.45	16	10	3038.29	6.55	33	25	18956.11	8.1	53	42	60584.18
Ipil-ipil (control)	1.5	3.5	1.5	49.39	4.8	12	10	1838.64	7.25	25	17	12058.50	9.0	44	40	46437.39
Ipil-ipil +Banana	1.56	3.55	1.6	53.22	4.9	13	11	2204.58	7.3	24	19	11185.07	9.1	40	34	38771.23
Ipil-ipil + Banana + Potato + Onion	1.5	3.45	1.5	47.64	5.0	14	11	2587.41	7.4	27	24	14366.73	9.2	43	40	45327.14
Ipil-ipil + Potato + Onion	1.45	3.47	1.55	46.05	4.7	14	10	2432.17	7.0	27	21	13590.15	9.0	44	39	46437.39

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Treatment	15/7/05				15/7/06				15/7/07				15/7/08			
	Plant height (m)	Base girth (cm)	Girth at breast height (cm)	Volume (cm^3)	Plant height (m)	Base girth (cm)	Girth at breast height (cm)	Volume (cm^3)	Plant height (m)	Base girth (cm)	Girth at breast height (cm)	Volume (cm^3)	Plant height (m)	Base girth (cm)	Girth at breast height (cm)	Volume (cm^3)
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3.2.2 Experiment # 1: Performance of Transplanted aman in the Agroforestry System

3.2.2.1 Objectives

Production of *transplanted aman* under different MPTs was evaluated with the following objectives-

1. To select the suitable *transplanted aman* varieties for *T. aman* -Wheat-Mung bean cropping pattern in Agroforestry system.
2. To characterize the growth and yield of the T.aman rice in partial shade provided by MPTs.
3. To estimate the interaction effects between crop and the used five tree species

3.2.2.2 Design

The experiment was conducted following Split plot design with four replications.

3.2.2.3 Treatments

Factor A: Agroforestry tree species

T_1 = Open field (control)

T_2 = Black siris

T_3 = Guava and

T_4 = Mango

Factor B: Rice varieties

V_1 = BR 10 (Progoti)

V_2 = BR 11 (Mukta)

V_3 = BRRI dhan33

V_4 = BRRI dhan39 and

V_5 = Sorna (local variety)

Description of the rice varieties

Rice (*Oryza sativa* L.) was used in this study. Five transplanted aman rice varieties i.e. BR10, BR11, BRRI dhan33, BRRI dhan39 and Sorna were used as test crops. These are briefly described below.

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Production of *transplanted aman* under different MPTs was evaluated with the following objectives-

1. To select the suitable *transplanted aman* varieties for *T. aman* -Wheat-Mung bean cropping pattern in Agroforestry system.
2. To characterize the growth and yield of the T.aman rice in partial shade provided by MPTs.
3. To estimate the interaction effects between crop and the used five tree species

3.2.2.2 Design

The experiment was conducted following Split plot design with four replications.

3.2.2.3 Treatments

Factor A: Agroforestry tree species

T_1 = Open field (control)

T_2 = Black siris

T_3 = Guava and

T_4 = Mango

Factor B: Rice varieties

V_1 = BR 10 (Progoti)

V_2 = BR 11 (Mukta)

V_3 = BRRI dhan33

V_4 = BRRI dhan39 and

V_5 = Sorna (local variety)

Description of the rice varieties

Rice (*Oryza sativa* L.) was used in this study. Five transplanted aman rice varieties i.e. BR10, BR11, BRRI dhan33, BRRI dhan39 and Sorna were used as test crops. These are briefly described below.

3.2.2 Experiment # 1: Performance of Transplanted aman in the Agroforestry System

3.2.2.1 Objectives

Production of *transplanted aman* under different MPTs was evaluated with the following objectives-

1. To select the suitable *transplanted aman* varieties for *T. aman* -Wheat-Mung bean cropping pattern in Agroforestry system.
2. To characterize the growth and yield of the T.aman rice in partial shade provided by MPTs.
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V_4 = BRRI dhan39 and

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Description of the rice varieties

Rice (*Oryza sativa* L.) was used in this study. Five transplanted aman rice varieties i.e. BR10, BR11, BRRI dhan33, BRRI dhan39 and Sorna were used as test crops. These are briefly described below.

BR10 (Progoti): The popular name of this rice is Progoti. Bangladesh Rice Research Institute (BRRI) invented BR10 through hybridization between IR20 and IR5-114-3-1. The breeding line number of this rice is BR51-46-6-HR65. This variety is easily recognized as the ear stayed under the flag leaf during flowering and end edge of flag leaf suddenly becomes sharp. It is a late variety. Progoti has achieved goodwill in the world as it included in the list of optimum yielding in the international competition. The yield potential of this variety is 6.5 t ha^{-1} and maturities in 150 days.

BR11 (Mukta): BRRI invents BR11 making hybridization between IR20 and IR5-47-2. The breeding line number of this rice is BR52-87-1-HR88. The popular name of this rice is Mukta. The ears were stayed over flag leaf during flowering and easily recognized by everybody. This variety is equally popular throughout the country. The yield potential of this variety is 6.5 t ha^{-1} and days of maturity 145.

BRRI dhan33: It has been invented making hybridization between BG388 and BG367-4. The breeding line number of BRRI Dhan33 is BG850-2 which collected from Srilanka. It is very early transplanted Aman variety. It takes only 118 days on maturity for harvest. The yield potential of this variety is 4.5 t ha^{-1}.

BRRI dhan39: This rice has been invented by making hybridization among BR1185-2B-56-2-1-1, R1674-28-3-1-1and BR2558-7-3-2-2. the breeding line number of this variety is BR5969-3-2. The stem is strong so it dose not fall down. The flag leaf of this variety is more wide and erect than other varieties. The yield potential of this variety is 4.5 t $ha-^{1}$ and days of maturity 122.

Sorna: It is an Indian variety grown in northern region of Bangladesh it is now-a-days a popular variety. It is also a late transplanted aman variety. It is most probably sheath blight disease susceptible in the early stage of transplanting. The yield potential of this variety is 4.00 t $ha-^{1}$ and days of maturity 150.

3.2.2.4 Layout of the experimental plots

The experiment was laid out following the split plot design with four replications. Three agroforestry tree species with one control plot of the factor-A were used as the main plots (for main effects) and five T. aman varieties of factor-B were used in the

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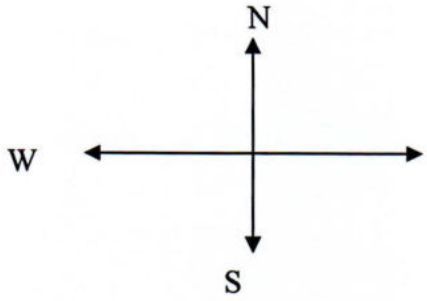
sub plots (for varietals effects). The plot size was 2.5 × 2.5 m. Adjacent plots and neighboring blocks were separated by 0.5 and 5.0 m, respectively.

Layout of the experimental plot:

Plot size: 2.25 m× 2.25 m

No. of replication: 4

Total number of plots: 80



Mango species

R_1	BR11	BRRI dhan 33	BR10	Sorna	BRRI dhan 39	R_3	Sorna	BRRI dhan 39	BR11	BRRI dhan 33	BR10
R_2	Sorna	BRRI dhan 39	BR11	BR10	BRRI dhan 33	R_4	BR10	BR11	BRRI dhan 33	Sorna	BRRI dhan 39

Guava species

R_1	BRRI dhan 39	BR11	BRRI ddhan 33	Sorna	BR10	R_3	BRRI dhan 39	Sorna	BR10	BRRI dhan 33	BR11
R_2	BRRI dhan 33	Sorna	BR10	BR11	BRRI dhan 39	R_4	BR11	BRRI dhan 33	BRRI dhan 39	Sorna	BR10

Black siris species

R_1	BR10	BRRI dhan 33	Sorna	BR11	BRRI dhan 39	R_3	BR11	BR10	Sorna	BRRI dhan 33	BRRI dhan 39
R_2	BR11	BRRI dhan 39	Sorna	BR10	BRRI dhan 33	R_4	Sorna	BRRI dhan 39	BR10	BR11	BRRI dhan 33

Open field

R_1	BR10	BRRI dhan 33	BR11	BRRI dhan 39	Sorna	R_3	BRRI dhan 33	BR10	BR11	Sorna	BRRI dhan 39
R_2	BRRI dhan 33	BR11	BRRI dhan 39	Sorna	BR10	R_4	BR11	BRRI dhan 33	BRRI dhan 39	BR10	Sorna

sub plots (for varietals effects). The plot size was 2.5 × 2.5 m. Adjacent plots and neighboring blocks were separated by 0.5 and 5.0 m, respectively.

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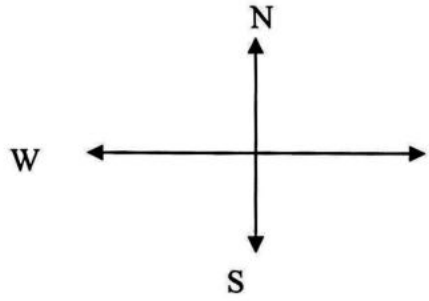
Plot size: 2.25 m× 2.25 m

No. of replication: 4

Total number of plots: 80



Mango species

R_1	BR11	BRRI dhan 33	BR10	Sorna	BRRI dhan 39	R_3	Sorna	BRRI dhan 39	BR11	BRRI dhan 33	BR10
R_2	Sorna	BRRI dhan 39	BR11	BR10	BRRI dhan 33	R_4	BR10	BR11	BRRI dhan 33	Sorna	BRRI dhan 39

Guava species

R_1	BRRI dhan 39	BR11	BRRI ddhan 33	Sorna	BR10	R_3	BRRI dhan 39	Sorna	BR10	BRRI dhan 33	BR11
R_2	BRRI dhan 33	Sorna	BR10	BR11	BRRI dhan 39	R_4	BR11	BRRI dhan 33	BRRI dhan 39	Sorna	BR10

Black siris species

R_1	BR10	BRRI dhan 33	Sorna	BR11	BRRI dhan 39	R_3	BR11	BR10	Sorna	BRRI dhan 33	BRRI dhan 39
R_2	BR11	BRRI dhan 39	Sorna	BR10	BRRI dhan 33	R_4	Sorna	BRRI dhan 39	BR10	BR11	BRRI dhan 33

Open field

R_1	BR10	BRRI dhan 33	BR11	BRRI dhan 39	Sorna	R_3	BRRI dhan 33	BR10	BR11	Sorna	BRRI dhan 39
R_2	BRRI dhan 33	BR11	BRRI dhan 39	Sorna	BR10	R_4	BR11	BRRI dhan 33	BRRI dhan 39	BR10	Sorna

sub plots (for varietals effects). The plot size was 2.5 × 2.5 m. Adjacent plots and neighboring blocks were separated by 0.5 and 5.0 m, respectively.

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Plot size: 2.25 m× 2.25 m

No. of replication: 4

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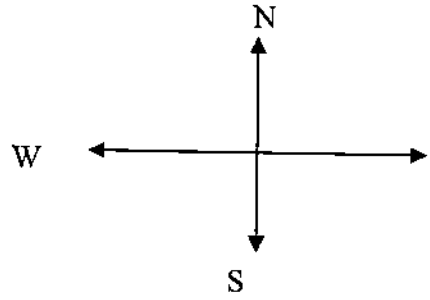

Mango species

R_1	BR11	BRRI dhan 33	BR10	Sorna	BRRI dhan 39	R_3	Sorna	BRRI dhan 39	BR11	BRRI dhan 33	BR10
R_2	Sorna	BRRI dhan 39	BR11	BR10	BRRI dhan 33	R_4	BR10	BR11	BRRI dhan 33	Sorna	BRRI dhan 39

Guava species

R_1	BRRI dhan 39	BR11	BRRI ddhan 33	Sorna	BR10	R_3	BRRI dhan 39	Sorna	BR10	BRRI dhan 33	BR11
R_2	BRRI dhan 33	Sorna	BR10	BR11	BRRI dhan 39	R_4	BR11	BRRI dhan 33	BRRI dhan 39	Sorna	BR10

Black siris species

R_1	BR10	BRRI dhan 33	Sorna	BR11	BRRI dhan 39	R_3	BR11	BR10	Sorna	BRRI dhan 33	BRRI dhan 39
R_2	BR11	BRRI dhan 39	Sorna	BR10	BRRI dhan 33	R_4	Sorna	BRRI dhan 39	BR10	BR11	BRRI dhan 33

Open field

R_1	BR10	BRRI dhan 33	BR11	BRRI dhan 39	Sorna	R_3	BRRI dhan 33	BR10	BR11	Sorna	BRRI dhan 39
R_2	BRRI dhan 33	BR11	BRRI dhan 39	Sorna	BR10	R_4	BR11	BRRI dhan 33	BRRI dhan 39	BR10	Sorna

3.2.2.5 Crop establishment and cultural practices

The methods of crop establishment and cultural practices followed for conducting the experiments are discussed bellow-

Raising seedlings: The seedlings were raised in the seedbed in traditional way. Seeds of each variety were sown on 10 June in both the experimental years at separate seedbed. Sowing was done at the rate of 20-30 kg seeds ha^{-1}.

Land Preparation: The experimental field was opened with a power tiller on 4 July 2006. Thereafter, the land was spaded several times followed by laddering to obtain good tilth. All weeds and rubbishes were removed from the field and then left exposed to solarization for several days before the land was finally prepared for seedling transplanting. The unit plot (containing a tree species at the middle) was leveled before transplanting. Levee was made around each plot for proper fertilization and water management. The same procedure was followed for all the experiments.

Fertilizers application: The unit plots were uniformly fertilized following the IPNS (Integrated plant nutrient system) method. The fertilizer doses were applied in the field according to the recommendation of SRDI, Dinajpur.

Name of fertilizer	Recommended dose (kg ha^{-1})	
	2006	2007
Urea	227.5	114.00
TSP	13.75	13.75
MP	68.75	68.75
Gypsum	21.25	10.0
Dollochone	500	00.0

Sulfur was applied as per experimental specification through Gypsum. One-third of urea and the entire amount of other fertilizers were applied as basal dose at the time of final land preparation. The individual plot was spaded and fertilizers were incorporated before transplanting of seedlings. The remaining two-third of urea was top dressed in two equal splits at early tillering and late tillering stages after weeding and followed by irrigation.

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Date of seedling transplanting: Thirty five to thirty seven days old seedlings were transplanted in the main field with a distance of 15 x 25 cm. The transplanting date was 15 July 2006 for the first year and 17 July 2007 for the second year.

Intercultural operations: Intercultural operations such as weeding and irrigation were done uniformly in each plot. Weeding was done two times at 15 and 45 DATs. The field was irrigated as needed. Plant protection measures such as insecticide or fungicide application were done as per need.

Harvesting, threshing and weighing: The crop was harvested at different dates at maturity in October - November, 2006 and 2007. The harvested crops were threshed plot-wise and grain yield was recorded plot-wise on 14% moisture basis and converted in to ton /ha.

3.2.2.6 Sampling and data collection

The recommended procedures were followed to collect the data for growth, yield and yield attributes. For collecting data, (except yield) eight hills were (2 from each orientation) randomly selected from each plot. The following parameters were recorded from the selected hills.

- Plant height (cm)
- Number of tillers hill^{-1}
- Fresh weight of straw plant^{-1} (g)
- Dry weight of straw plant^{-1} (g)
- Length of panicle (cm)
- Number of grains panicle^{-1}
- Number of sterile spikelets panicle^{-1}
- 1000 grain weight (g)
- Grain yield (t ha^{-1})
- Harvest index (HI)
- Land equivalent ratio (LER)
- Benefit cost ratio (BCR)

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- Number of tillers $hill^{-1}$
- Fresh weight of straw $plant^{-1}$ (g)
- Dry weight of straw $plant^{-1}$ (g)
- Length of panicle (cm)
- Number of grains $panicle^{-1}$
- Number of sterile spikelets $panicle^{-1}$
- 1000 grain weight (g)
- Grain yield (t ha^{-1})
- Harvest index (HI)
- Land equivalent ratio (LER)
- Benefit cost ratio (BCR)

Procedure of data recording

A brief outline of the data recording procedures is given below-

Plant height: The plant height was measured from the ground level to the top of flag leaf at 30, 45, 60 and 75 DATs.

Number of tillers hill^{-1}: All the tillers of sample hills were counted. It includes both bearing and none bearing tillers and the average value was taken. It was counted from the selected hills at 30, 45 and 60 DAT.

Fresh weight of straw hill^{-1}: The straw obtained from the harvested crops was recorded plot wise and then sun dried. Finally, straw yields were recorded and the values were converted to t ha^{-1}.

Dry weight of straw hill^{-1}: Sun dried straw per hill was kept into oven at a constant temperature of 102±3 °C for 24 hours. The oven-dried straw was cooled down in desiccators for 6 hours and weighted by a digital electric balance and expressed in gram.

Length of panicle: The length was recorded from the basal node of the rachis up to the apex of each panicle. All the panicles of the said hills were measured and the average of which was considered as length of panicle.

Number of grains panicle^{-1}: Presence of any food material in the spikelets was considered as grain and total number of grains present panicle^{-1} form the sample hills were counted and averaged.

Number of sterile spikelets panicle^{-1}: The spikelets with no food material inside were considered as sterile or unfilled grain, and such grain present in each panicle were counted.

1000 grain weight: One thousand cleaned dried grains (14% moisture content) were counted from each seed stock obtained from sample hill of each plot and weighed by using an electric balance and expressed in gram (g).

Procedure of data recording

A brief outline of the data recording procedures is given below-

Plant height: The plant height was measured from the ground level to the top of flag leaf at 30, 45, 60 and 75 DATs.

Number of tillers hill^{-1}: All the tillers of sample hills were counted. It includes both bearing and none bearing tillers and the average value was taken. It was counted from the selected hills at 30, 45 and 60 DAT.

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Number of sterile spikelets panicle^{-1}: The spikelets with no food material inside were considered as sterile or unfilled grain, and such grain present in each panicle were counted.

1000 grain weight: One thousand cleaned dried grains (14% moisture content) were counted from each seed stock obtained from sample hill of each plot and weighed by using an electric balance and expressed in gram (g).

Grain yield: The harvested crops were threshed and grain yield was recorded plot-wise on 14% moisture basis. The weight of grain was recorded in kg $plot^{-1}$. The grain yield was later expressed in ton/ha.

Straw yield: The straw obtained from the harvested plots were dried and weighed. The moisture content of the straw was determined by drying samples in an oven at 72 ^{0}C for 72 hours. Straw yields were then adjusted to 14% moisture content and converted into t ha^{-1}.

Biological yield: The grain and straw yields are altogether regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield

3.2.3 Experiment # 2: Performance of Wheat in the Agroforestry System

3.2.3.1 Objectives:

1. To select suitable wheat varieties for the transplanted aman -wheat-mung bean cropping pattern in Agroforestry system
2. To characterize the growth and yield of the wheat varieties in partial shade provided by MPTs.
3. To estimate the interaction effects between crop and tree species.

3.2.3.2 Design

The experiment was conducted following Split Plot Design with four replications.

3.2.3.3Treatment

Factor A: Agroforestry tree species mentioned in experiment # 1

T_1 = Open field (control),

T_2 = Black siris,

T_3 = Guava, and

T_4 = Mango

Factor B: Wheat varieties-

V_1 = Gourave (BARI Gam 20),

V_2 = Shourave (BARI Gam 19)

V_3 = Shatabdi (BARI Gam 21)

V_4 = Kanchan and

V_5 = Protiva

Grain yield: The harvested crops were threshed and grain yield was recorded plot-wise on 14% moisture basis. The weight of grain was recorded in kg $plot^{-1}$. The grain yield was later expressed in ton/ha.

Straw yield: The straw obtained from the harvested plots were dried and weighed. The moisture content of the straw was determined by drying samples in an oven at 72 ^{0}C for 72 hours. Straw yields were then adjusted to 14% moisture content and converted into t ha^{-1}.

Biological yield: The grain and straw yields are altogether regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield

3.2.3 Experiment # 2: Performance of Wheat in the Agroforestry System

3.2.3.1 Objectives:

1. To select suitable wheat varieties for the transplanted aman -wheat-mung bean cropping pattern in Agroforestry system
2. To characterize the growth and yield of the wheat varieties in partial shade provided by MPTs.
3. To estimate the interaction effects between crop and tree species.

3.2.3.2 Design

The experiment was conducted following Split Plot Design with four replications.

3.2.3.3Treatment

Factor A: Agroforestry tree species mentioned in experiment # 1

T_1 = Open field (control),

T_2 = Black siris,

T_3 = Guava, and

T_4 = Mango

Factor B: Wheat varieties-

V_1 = Gourave (BARI Gam 20),

V_2 = Shourave (BARI Gam 19)

V_3 = Shatabdi (BARI Gam 21)

V_4 = Kanchan and

V_5 = Protiva

Grain yield: The harvested crops were threshed and grain yield was recorded plot-wise on 14% moisture basis. The weight of grain was recorded in kg $plot^{-1}$. The grain yield was later expressed in ton/ha.

Straw yield: The straw obtained from the harvested plots were dried and weighed. The moisture content of the straw was determined by drying samples in an oven at 72 ^{0}C for 72 hours. Straw yields were then adjusted to 14% moisture content and converted into t ha^{-1}.

Biological yield: The grain and straw yields are altogether regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield

3.2.3 Experiment # 2: Performance of Wheat in the Agroforestry System

3.2.3.1 Objectives:

1. To select suitable wheat varieties for the transplanted aman -wheat-mung bean cropping pattern in Agroforestry system
2. To characterize the growth and yield of the wheat varieties in partial shade provided by MPTs.
3. To estimate the interaction effects between crop and tree species.

3.2.3.2 Design

The experiment was conducted following Split Plot Design with four replications.

3.2.3.3Treatment

Factor A: Agroforestry tree species mentioned in experiment # 1

T_1 = Open field (control),

T_2 = Black siris,

T_3 = Guava, and

T_4 = Mango

Factor B: Wheat varieties-

V_1 = Gourave (BARI Gam 20),

V_2 = Shourave (BARI Gam 19)

V_3 = Shatabdi (BARI Gam 21)

V_4 = Kanchan and

V_5 = Protiva

Description of the experiential materials

The above five modern wheat (*Triticum aestivum* L.) varieties were used as the experimental crops. These are briefly described below.

Shatabdi (BARI Gam 21): This variety was developed by BARI and it was released in 2000.It is a high yielding modern variety. The variety attains a height of 90-100cm. Number of tillers per hill is 6-7. Flag leaf is erect. It takes 65-68 days to heading and 104-112 days to complete its life cycle. Its 1000-grain wt. is 46-48gm and yield is 3.5-5 t ha^{-1}.

Shourave (BARI Gam 19): It was developed by BARI and released in 1998 (BARI Gam 19). This variety attains a height of 90-100cm. It takes 60-67 days to heading. Number of tiller per hill is 5-6. It also takes 102-110 days to complete its life cycle. The variety Shourave yield is 3.5-4.5 t ha^{-1}.

Gourave (BARI Gam 20) It was developed by BARI and released in 1998. This variety attains a height of 90-102cm and takes 102-108 day to complete its life cycle. The number of tillers $hill^{-1}$ is 5-6; leaves are deep green in colour. Flag leaf is erect, narrow and slightly curled. It takes 60-65 days to heading. This variety is temperature tolerant and resistant to leaf spot disease and the yield is 4.5-5.0 t ha^{-1}.

Kanchan: Kanchan was developed by BARI and released in 1983. It is a semi dwarf and popular variety. This variety attains a height of 90-100 cm. Number of tillers $hill^{-1}$ is 6-7. Flag leaf is erect. It takes 60-68 days to heading and 106-112days to complete its life cycle. It is susceptible to leaf rust disease. The yield of this variety is 3.5-4.0 t ha^{-1}.

Protiva: Protiva was developed by BARI and released in 1993. This variety attains a height of 85-95cm and gives 6-7 tillers $hill^{-1}$. Flag leaf of this variety is erect. It takes 60-70 days to heading and 105-110 days to complete its life cycle. It is resistant to leaf rust and leaf spot disease. The yield of variety protiva is 3.4-4.5 t ha^{-1}.

3.2.3.4 Layout and duration of the experiment

The experiment was laid out following split plot design with two factorial arrangements with four replications for each treatment. Layout of the experiment was similar to that of first one, only *T. aman* varieties were replaced by the wheat varieties. The duration of the experiments was from 15 November 2006 to 15 March 2007 for first year and from 15 November 2007 to 15 March 2008 for second year.

Description of the experiential materials

The above five modern wheat (*Triticum aestivum* L.) varieties were used as the experimental crops. These are briefly described below.

Shatabdi (BARI Gam 21): This variety was developed by BARI and it was released in 2000.It is a high yielding modern variety. The variety attains a height of 90-100cm. Number of tillers per hill is 6-7. Flag leaf is erect. It takes 65-68 days to heading and 104-112 days to complete its life cycle. Its 1000-grain wt. is 46-48gm and yield is 3.5-5 t ha^{-1}.

Shourave (BARI Gam 19): It was developed by BARI and released in 1998 (BARI Gam 19). This variety attains a height of 90-100cm. It takes 60-67 days to heading. Number of tiller per hill is 5-6. It also takes 102-110 days to complete its life cycle. The variety Shourave yield is 3.5-4.5 t ha^{-1}.

Gourave (BARI Gam 20) It was developed by BARI and released in 1998. This variety attains a height of 90-102cm and takes 102-108 day to complete its life cycle. The number of tillers $hill^{-1}$ is 5-6; leaves are deep green in colour. Flag leaf is erect, narrow and slightly curled. It takes 60-65 days to heading. This variety is temperature tolerant and resistant to leaf spot disease and the yield is 4.5-5.0 t ha^{-1}.

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3.2.3.5 Crop establishment and cultural practices

The crop establishment methods and cultural practices that followed for conducting experiments are discussed below:

Land Preparation: The experimental field was opened by spading on 4 November 2006. Several spading followed by laddering was done to obtain a good tilth. All the weeds and other major rubbishes were removed from the field and then left exposed to natural weathering for several days before the land was finally prepared for seed sowing. Each unit plot was prepared properly using a spade before sowing.

Fertilizer Application: The following fertilizer doses were applied in the field according to SRDI soil analysis report (IPNS):

Name of Fertilizer	Recommended doses (kg ha^{-1})	
	2006-07	2007-08
Urea	303.25	300.00
TSP	28.75	28.75
MOP	141.25	141.25
Gypsum	35.00	20.00
Boric acid	2.72	00.00

Sulfur was applied as per experimental specification through Gypsum. One-third of urea and entire amount of other fertilizers were applied as basal dose at the time of final land preparation. The individual plot was spaded and fertilizers were incorporated before sowing. The remaining two-third of urea was top dressed in two equal splits at early tillering and late tillering stages after weeding followed by irrigation.

Sowing of seed: Seeds were sown on 15 November. Sowing was done at the rate of 120 kg ha^{-1}. Seeds were sown continuously in lines and were covered by soil with the help of hand. The lines were 20 cm apart, making 12 rows per plot.

Intercultural operation: Intercultural operations such as weeding thinning and irrigation were given uniformly in each plot. Weeding was done two times on 20 and 50 days after sowing (DAS). At time of first weeding, thinning was done to maintain 5cm distance from plant to plant. The field was irrigated after first weeding and the second at 50 DAS. Plant protection measure such as insecticide or fungicide spray was not required, as the crop was free from any insect or disease attack.

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Harvesting, threshing and weighing: The crop was harvested on 15 March in both the years. The harvested crops were threshed plot-wise and grain yield was recorded plot-wise on 14% moisture basis and converted to ton /ha.

3.2.3.6 Sampling and data recording

The recommended procedures were followed to collect the data for growth, yield and yield attributes. For collecting data, (except yield) eight hills were (2 from each orientation) randomly selected from each plot. The following parameters were recorded from the selected hills.

- Plant height hill^{-1}
- Number of tillers hill^{-1}
- Number of spikelets hill^{-1}
- Length of spikes hill^{-1}
- Number of grains hill^{-1}
- Grain weight hill^{-1}
- 1000 grain weight
- Straw yield
- Grain yield
- Harvest index (HI)
- Land equivalent ratio (LER)
- Benefit cost ratio (BCR)

Procedure of data recording: A brief outline of the data recording procedure is given below:

Plant height: The plant height was measured from the ground level to the top of Spike. From each plot 8 hills were measured and averaged.

Number of tillers: Number of tillers was counted from the selected hills at 30, 45 and 60 DAS.

Number of spike: Number of spikes was counted from the hills, which has at least one visible, spike.

Length of spike: Spike length was recorded from the basal node of the rachis to the apex of each spike.

Number of grain : Ten spikes were randomly collected from each sample and grains were counted. Then average of 8 samples was taken.

Grain weight: Grain obtained from each plot were dried and weighed carefully.

Harvesting, threshing and weighing: The crop was harvested on 15 March in both the years. The harvested crops were threshed plot-wise and grain yield was recorded plot-wise on 14% moisture basis and converted to ton /ha.

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- Grain yield
- Harvest index (HI)
- Land equivalent ratio (LER)
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Procedure of data recording: A brief outline of the data recording procedure is given below:

Plant height: The plant height was measured from the ground level to the top of Spike. From each plot 8 hills were measured and averaged.

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Length of spike: Spike length was recorded from the basal node of the rachis to the apex of each spike.

Number of grain : Ten spikes were randomly collected from each sample and grains were counted. Then average of 8 samples was taken.

Grain weight: Grain obtained from each plot were dried and weighed carefully.

1000 grain weight: Thousand grains were randomly selected from each seed stock obtained from in each plot and it was dried in an oven up to 14% moisture content. Then weight was taken on an electric balance.

Grain yield: The grain was threshed from the plants cleaned, dried and weighed. The yield of grain in t /ha was adjusted to 14% moisture content.

3.2.4 Experiment # 3: Performance of Mung bean in the Agroforestry System

3.2.4.1Objectives

1. To select the suitable mungbean varieties in wheat-mung bean- t. aman cropping pattern in Agroforestry system
2. To characterize the growth and yield of the mung bean varieties in partial shade provided by MPTs.
3. To estimate the interaction effects between crop and tree species.

3.2.4.2 Design

Split plot design with four replications.

3.2.4.3 Treatment

Factor A: Agroforestry tree species mentioned in experiment # 1

T_1 = Open field (control)

T_2 = Black siris

T_3 = Guava and

T_4 = Mango

Factor B: Mungbean varieties

V_1 = BARI Mug 3 (Progati)

V_2 = BARI Mug 4 (Rupsa)

V_3 = BARI Mug 5(Taiwan)

V_4= BARI Mug 6 and

V_5= Local variety

Description of the experimental materials

BARI Mung 3 (Progati): BARI Mung 3 or progati is derived from hybridization. It is recommended in 1996 for farmer's practices. Plant height is 50-55 cm. seed is smooth

1000 grain weight: Thousand grains were randomly selected from each seed stock obtained from in each plot and it was dried in an oven up to 14% moisture content. Then weight was taken on an electric balance.

Grain yield: The grain was threshed from the plants cleaned, dried and weighed. The yield of grain in t /ha was adjusted to 14% moisture content.

3.2.4 Experiment # 3: Performance of Mung bean in the Agroforestry System

3.2.4.1Objectives

1. To select the suitable mungbean varieties in wheat-mung bean- t. aman cropping pattern in Agroforestry system
2. To characterize the growth and yield of the mung bean varieties in partial shade provided by MPTs.
3. To estimate the interaction effects between crop and tree species.

3.2.4.2 Design

Split plot design with four replications.

3.2.4.3 Treatment

Factor A: Agroforestry tree species mentioned in experiment # 1

T_1 = Open field (control)

T_2 = Black siris

T_3 = Guava and

T_4 = Mango

Factor B: Mungbean varieties

V_1 = BARI Mug 3 (Progati)

V_2 = BARI Mug 4 (Rupsa)

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Description of the experimental materials

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1000 grain weight: Thousand grains were randomly selected from each seed stock obtained from in each plot and it was dried in an oven up to 14% moisture content. Then weight was taken on an electric balance.

Grain yield: The grain was threshed from the plants cleaned, dried and weighed. The yield of grain in t /ha was adjusted to 14% moisture content.

3.2.4 Experiment # 3: Performance of Mung bean in the Agroforestry System

3.2.4.1Objectives

1. To select the suitable mungbean varieties in wheat-mung bean- t. aman cropping pattern in Agroforestry system
2. To characterize the growth and yield of the mung bean varieties in partial shade provided by MPTs.
3. To estimate the interaction effects between crop and tree species.

3.2.4.2 Design

Split plot design with four replications.

3.2.4.3 Treatment

Factor A: Agroforestry tree species mentioned in experiment # 1

T_1 = Open field (control)

T_2 = Black siris

T_3 = Guava and

T_4 = Mango

Factor B: Mungbean varieties

V_1 = BARI Mug 3 (Progati)

V_2 = BARI Mug 4 (Rupsa)

V_3 = BARI Mug 5(Taiwan)

V_4= BARI Mug 6 and

V_5= Local variety

Description of the experimental materials

BARI Mung 3 (Progati): BARI Mung 3 or progati is derived from hybridization. It is recommended in 1996 for farmer's practices. Plant height is 50-55 cm. seed is smooth

and brownish green color. Thousand seed weight is 28-29 g. As a day neutral variety, it can be cultivated in Kharif-1, kharif-2 and in late rabi also. Protein content is 19-21%, total life cycle is 60-65 days. Seed yield is 1.0-1.1 t ha^{-1}. The variety is susceptible to yellow mosaic virus and *Cercospora* diseases.

BARI Mung 4 (Rupsa): BARI Mung 4 or Rupsa is a hybrid variety. The variety is recommended in 1996 for cultivation. Plant height is 50-55cm, seed is smooth and green color. Thousand seed weight is 28-32g. It is also day neutral variety and cultivated round the year. Protein content is 21-24%, total life cycle is 60-65 days. Seed yield is 1.2-1.4 t ha^{-1}. The variety is also yellow mosaic virus and cercospora diseases susceptible

BARI Mung 5 (Taiwan): BARI mung 5 or Taiwan is recommended in 1997 for cultivation. Bari mung 5 is a high yielding variety. Leaf, fruit and seed of this plant is very much larger than other variety. The color of seed is deep green. Thousand seed weight is 40-42 g.The special character of this variety is that the fruit ripen at same time. Protein content is 20-22%. Total life cycle is 60-65 days. Seed yield is 1.2-1.5 t ha^{-1}. The variety is also yellow mosaic virus and cercospora diseases susceptible.

BARI Mung 6 : BARI mung 6 is the latest high yielding mung variety. Pulse research centre, BARI collects many lines of mung from AVRDC in 1998.From 3 years regional trial (2000-2002) NM-94 line was found superior among the lines and previous varieties released by BARI. NSB reregistered it as BARI Mung-6 due to its higher yield, disease remittance power and maturity habit of all the pods come at the same time. The plant height is 40-45 cm. color of seed is deep green, thousand seed weight is 51-52 g. it can be seeded up to first week of April. The variety is registrant to yellow mosaic virus and leaf spot diseases. Total lifecycle is 55-58 days, yield is 1.5-1.6 t ha^{-1}.

Local Variety: Locally used mung variety was collected from the farmer of the village adjacent to the University. This variety is very dwarf. Yield potential is very poor. Farmers produce this variety both for fodder and grain.

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Local Variety: Locally used mung variety was collected from the farmer of the village adjacent to the University. This variety is very dwarf. Yield potential is very poor. Farmers produce this variety both for fodder and grain.

and brownish green color. Thousand seed weight is 28-29 g. As a day neutral variety, it can be cultivated in Kharif-1, kharif-2 and in late rabi also. Protein content is 19-21%, total life cycle is 60-65 days. Seed yield is 1.0-1.1 t ha^{-1}. The variety is susceptible to yellow mosaic virus and *Cercospora* diseases.

BARI Mung 4 (Rupsa): BARI Mung 4 or Rupsa is a hybrid variety. The variety is recommended in 1996 for cultivation. Plant height is 50-55cm, seed is smooth and green color. Thousand seed weight is 28-32g. It is also day neutral variety and cultivated round the year. Protein content is 21-24%, total life cycle is 60-65 days. Seed yield is 1.2-1.4 t ha^{-1}. The variety is also yellow mosaic virus and cercospora diseases susceptible

BARI Mung 5 (Taiwan): BARI mung 5 or Taiwan is recommended in 1997 for cultivation. Bari mung 5 is a high yielding variety. Leaf, fruit and seed of this plant is very much larger than other variety. The color of seed is deep green. Thousand seed weight is 40-42 g.The special character of this variety is that the fruit ripen at same time. Protein content is 20-22%. Total life cycle is 60-65 days. Seed yield is 1.2-1.5 t ha^{-1}. The variety is also yellow mosaic virus and cercospora diseases susceptible.

BARI Mung 6 : BARI mung 6 is the latest high yielding mung variety. Pulse research centre, BARI collects many lines of mung from AVRDC in 1998.From 3 years regional trial (2000-2002) NM-94 line was found superior among the lines and previous varieties released by BARI. NSB reregistered it as BARI Mung-6 due to its higher yield, disease remittance power and maturity habit of all the pods come at the same time. The plant height is 40-45 cm. color of seed is deep green, thousand seed weight is 51-52 g. it can be seeded up to first week of April. The variety is registrant to yellow mosaic virus and leaf spot diseases. Total lifecycle is 55-58 days, yield is 1.5-1.6 t ha^{-1}.

Local Variety: Locally used mung variety was collected from the farmer of the village adjacent to the University. This variety is very dwarf. Yield potential is very poor. Farmers produce this variety both for fodder and grain.

3.2.4.4 Layout and duration of the experiment

The experiment was conducted in the same field of same layout as in the experiment-1&2, within 10 days of wheat harvesting; five mung bean varieties were sown. The duration of the experiments was 25 March to 1 June 2007 and 2008.

3.2.4.5 Crop establishment and cultural practices

The establishment methods of mung bean varieties and its cultural practices that followed for conducting the experiment are discussed below:

Land preparation: The land was opened just after harvest of wheat, and then prepared thoroughly by spading to obtain a good tilth. The weeds and stubbles were removed from the field and bigger clods were broken into smaller pieces.

Fertilizer application: The following fertilizer doses were applied in the field according to SRDI soil analysis report (IPNS).

Name of Fertilizers	Recommended doses (kg ha^{-1})	
	2007	2008
Urea	45.50	45.50
TSP	28.75	28.75
MoP	56.25	56.25
Gypsum	43.75	30.00
Boric acid	3.71	00.00

The entire fertilizers and cow dung were applied as basal dose at the time of final land preparation.

Sowing of seed: Seeds were sown on 25 March. Sowing was done at the rate of 80 kg ha^{-1}. Seeds were sown continuously in lines and were covered by soil with the help of hand. The lines were 20 cm apart.

Intercultural operation: Weeding was done periodically whenever necessary. Thinning was done twice once just after emergence and another at 20 DAS. Finally 5 cm plant to plant distance was maintained. One flood irrigation was done just after final thinning. The excess rain water was drained out through side canal of the plot.

Pest and disease control: No pesticides were used to control the insect pest and diseases as there were no out break of pest and diseases.

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The entire fertilizers and cow dung were applied as basal dose at the time of final land preparation.

Sowing of seed: Seeds were sown on 25 March. Sowing was done at the rate of 80 kg ha^{-1}. Seeds were sown continuously in lines and were covered by soil with the help of hand. The lines were 20 cm apart.

Intercultural operation: Weeding was done periodically whenever necessary. Thinning was done twice once just after emergence and another at 20 DAS. Finally 5 cm plant to plant distance was maintained. One flood irrigation was done just after final thinning. The excess rain water was drained out through side canal of the plot.

Pest and disease control: No pesticides were used to control the insect pest and diseases as there were no out break of pest and diseases.

Harvesting: Mature pods were plucked by hand time to time and final plucking was done at 65 DAS. After final plucking of pods rest of the biomass were incorporated in the soil.

3.2.4.6 Sampling and data collection

The data were collected at two times, first one was at 30 days after sowing (DAS) and last one was at 65 DAS (at the time of final harvest). The following parameters were recorded

- Plant height
- Incorporate biomass ha^{-1}
- Pod length
- Number of pods $plant^{-1}$
- Number of seeds pod^{-1}
- 1000-seed weight
- Yield (t ha^{-1})
- Harvest index (HI)
- Land equivalent ratio (LER)
- Benefit cost ratio (BCR)

Data collection procedure: For data collection, 10 representative sample plants were selected and dug out carefully with parts of their root systems which was washed with a jet of water to remove adhering soil particles keeping the root portion of each individual plant in a sieve. The plants were divided into root; shoot and root nodule and the said data were collected at 30 DAS. The similar procedure was followed at 65 DAS including yield contributing characters. For yield parameter, mature pods were collected time to time from the plants which were selected previously for BARI mung 3, BARI mung 4 and local variety. All pods of BARI mung 5 and BARI mung 6 were harvested at 65 DAS (more than 80% pods were matured at that time).

Harvesting: Mature pods were plucked by hand time to time and final plucking was done at 65 DAS. After final plucking of pods rest of the biomass were incorporated in the soil.

3.2.4.6 Sampling and data collection

The data were collected at two times, first one was at 30 days after sowing (DAS) and last one was at 65 DAS (at the time of final harvest). The following parameters were recorded

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Harvesting: Mature pods were plucked by hand time to time and final plucking was done at 65 DAS. After final plucking of pods rest of the biomass were incorporated in the soil.

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The data were collected at two times, first one was at 30 days after sowing (DAS) and last one was at 65 DAS (at the time of final harvest). The following parameters were recorded

- Plant height
- Incorporate biomass ha^{-1}
- Pod length
- Number of pods $plant^{-1}$
- Number of seeds pod^{-1}
- 1000-seed weight
- Yield (t ha^{-1})
- Harvest index (HI)
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- Benefit cost ratio (BCR)

Data collection procedure: For data collection. 10 representative sample plants were selected and dug out carefully with parts of their root systems which was washed with a jet of water to remove adhering soil particles keeping the root portion of each individual plant in a sieve. The plants were divided into root; shoot and root nodule and the said data were collected at 30 DAS. The similar procedure was followed at 65 DAS including yield contributing characters. For yield parameter, mature pods were collected time to time from the plants which were selected previously for BARI mung 3, BARI mung 4 and local variety. All pods of BARI mung 5 and BARI mung 6 were harvested at 65 DAS (more than 80% pods were matured at that time).

3.2.5 Experiment # 4: Performance of Banana in Different Agroforestry Systems

3.2.5.1 Objectives

1. To characterize morphological behavior of banana in partial shade conditions provided by different MPTs.
2. To determine the yield and yield attributes of banana in partial shade conditions provided by different MPTs.
3. To estimate the benefit in terms of per unit area.

3.2.5.2 Design

Single factor Randomized Complete Block Design (RCBD) with four replications.

3.2.5.3 Treatment

T_1 = Banana

T_2 = Banana + Potato + onion

T_3 = Banana + Ipil-ipil

T_4 = Banana + Ghora neem

T_5 = Banana + Ipil-ipil + Potato + onion

T_6 = Banana + Ghora neem + Potato +onion

3.2.5.4 Crop establishment and cultural practices

The banana (Amrita Shagor) suckers were used as planting materials which were planted on 1st October 2005 at the middle of each upper storey tree line. The upper storey tree species were established in July 2004 maintaining 3 x 3 m spacing. So, the spacing of banana was also 3 x 3 m, which means the upper storey tree and middle storey banana plants ware established alternately in the same line maintaining 1.5 m distance from each other. The sucker of banana were planted in the pits measuring 0.4 x 0.4 x 0.4 m.

Fertilizer application: The following fertilizer and manure doses were applied in the field according to SRDI soil analysis report (IPNS):

Name of Fertilizers	Recommended doses (kg plant^{-1})	
	2005-06	2006-07
Urea	0.5	0.5
TSP	0.5	0.5
MoP	0.5	0.5
Gypsum	0.1	0.1
Cow dung	5.0	5.0
Boric acid	2.5 g/plant	0.0

3.2.5 Experiment # 4: Performance of Banana in Different Agroforestry Systems

3.2.5.1 Objectives

1. To characterize morphological behavior of banana in partial shade conditions provided by different MPTs.
2. To determine the yield and yield attributes of banana in partial shade conditions provided by different MPTs.
3. To estimate the benefit in terms of per unit area.

3.2.5.2 Design

Single factor Randomized Complete Block Design (RCBD) with four replications.

3.2.5.3 Treatment

T_1 = Banana

T_2 = Banana + Potato + onion

T_3 = Banana + Ipil-ipil

T_4 = Banana + Ghora neem

T_5 = Banana + Ipil-ipil + Potato + onion

T_6 = Banana + Ghora neem + Potato + onion

3.2.5.4 Crop establishment and cultural practices

The banana (Amrita Shagor) suckers were used as planting materials which were planted on 1st October 2005 at the middle of each upper storey tree line. The upper storey tree species were established in July 2004 maintaining 3 x 3 m spacing. So, the spacing of banana was also 3 x 3 m, which means the upper storey tree and middle storey banana plants ware established alternately in the same line maintaining 1.5 m distance from each other. The sucker of banana were planted in the pits measuring 0.4 x 0.4 x 0.4 m.

Fertilizer application: The following fertilizer and manure doses were applied in the field according to SRDI soil analysis report (IPNS):

Name of Fertilizers	Recommended doses (kg plant^{-1})	
	2005-06	2006-07
Urea	0.5	0.5
TSP	0.5	0.5
MoP	0.5	0.5
Gypsum	0.1	0.1
Cow dung	5.0	5.0
Boric acid	2.5 g/plant	0.0

3.2.5 Experiment # 4: Performance of Banana in Different Agroforestry Systems

3.2.5.1 Objectives

1. To characterize morphological behavior of banana in partial shade conditions provided by different MPTs.
2. To determine the yield and yield attributes of banana in partial shade conditions provided by different MPTs.
3. To estimate the benefit in terms of per unit area.

3.2.5.2 Design

Single factor Randomized Complete Block Design (RCBD) with four replications.

3.2.5.3 Treatment

T_1 = Banana

T_2 = Banana + Potato + onion

T_3 = Banana + Ipil-ipil

T_4 = Banana + Ghora neem

T_5 = Banana + Ipil-ipil + Potato + onion

T_6 = Banana + Ghora neem + Potato + onion

3.2.5.4 Crop establishment and cultural practices

The banana (Amrita Shagor) suckers were used as planting materials which were planted on 1st October 2005 at the middle of each upper storey tree line. The upper storey tree species were established in July 2004 maintaining 3 x 3 m spacing. So, the spacing of banana was also 3 x 3 m, which means the upper storey tree and middle storey banana plants ware established alternately in the same line maintaining 1.5 m distance from each other. The sucker of banana were planted in the pits measuring 0.4 x 0.4 x 0.4 m.

Fertilizer application: The following fertilizer and manure doses were applied in the field according to SRDI soil analysis report (IPNS):

Name of Fertilizers	Recommended doses (kg plant^{-1})	
	2005-06	2006-07
Urea	0.5	0.5
TSP	0.5	0.5
MoP	0.5	0.5
Gypsum	0.1	0.1
Cow dung	5.0	5.0
Boric acid	2.5 g/plant	0.0

Weeding was done whenever necessary, no irrigation was applied only for banana. The water irrigated for potato and onion produced in the alley was supplemented for banana. All dead leaves of the sucker were pruned regularly. Sticking was done by bamboo stalk for each plant when bunch became larger. Harvesting of ripe banana was completed at 31 October in both the year. Remaining the best sucker of each plant all other sucker and mother plant ware removed carefully at the end of total harvesting. Second year (2006-2007) cultivation was made as raton cultivation and similar intercultural practice were done.

3.2.5.5 Sampling and data collection

Data were collected from 4 representing plants of each treatment. These were plant height, base girth, number of leaves, leaf length, leaf breadth, number of hands per bunch, number of finger per hand, finger size, weight per finger, yield per plant and yield ton per hectare. All these data were statistically analyzed to asses the levels of significance of the treatments. Finally, the means were compared by Duncan Multiple Range Test (DMRT) at 1% and 5% levels of probability.

3.2.6 Experiment # 5: Performance of Potato as the Lower Storey Crop in Multistoried Agroforestry System

3.2.6.1 Objectives

1. To characterize morphological behavior of potato in partial shade conditions provided by banana and / or different MPTs.
2. To determine the yield and yield attributes of potato in partial shade conditions provided by banana and / or different MPTs.
3. To estimate the benefit in terms of per unit area.

3.2.6.2 Design: Single factor Experiment in RCBD with four replications.

3.2.6.3 Treatment

T_1 = Potato

T_2 = Potato + Banana

T_3 = Potato +Ipil-ipil

T_4 = Potato + Ghora neem

T_5 = Potato + Banana+ Ipil-ipil

T_6 = Potato + Banana + Ghora neem

Weeding was done whenever necessary, no irrigation was applied only for banana. The water irrigated for potato and onion produced in the alley was supplemented for banana. All dead leaves of the sucker were pruned regularly. Sticking was done by bamboo stalk for each plant when bunch became larger. Harvesting of ripe banana was completed at 31 October in both the year. Remaining the best sucker of each plant all other sucker and mother plant ware removed carefully at the end of total harvesting. Second year (2006-2007) cultivation was made as raton cultivation and similar intercultural practice were done.

3.2.5.5 Sampling and data collection

Data were collected from 4 representing plants of each treatment. These were plant height, base girth, number of leaves, leaf length, leaf breadth, number of hands per bunch, number of finger per hand, finger size, weight per finger, yield per plant and yield ton per hectare. All these data were statistically analyzed to asses the levels of significance of the treatments. Finally, the means were compared by Duncan Multiple Range Test (DMRT) at 1% and 5% levels of probability.

3.2.6 Experiment # 5: Performance of Potato as the Lower Storey Crop in Multistoried Agroforestry System

3.2.6.1 Objectives

1. To characterize morphological behavior of potato in partial shade conditions provided by banana and / or different MPTs.
2. To determine the yield and yield attributes of potato in partial shade conditions provided by banana and / or different MPTs.
3. To estimate the benefit in terms of per unit area.

3.2.6.2 Design: Single factor Experiment in RCBD with four replications.

3.2.6.3 Treatment

T_1 = Potato

T_2 = Potato + Banana

T_3 = Potato +Ipil-ipil

T_4 = Potato + Ghora neem

T_5 = Potato + Banana+ Ipil-ipil

T_6 = Potato + Banana + Ghora neem

Weeding was done whenever necessary, no irrigation was applied only for banana. The water irrigated for potato and onion produced in the alley was supplemented for banana. All dead leaves of the sucker were pruned regularly. Sticking was done by bamboo stalk for each plant when bunch became larger. Harvesting of ripe banana was completed at 31 October in both the year. Remaining the best sucker of each plant all other sucker and mother plant ware removed carefully at the end of total harvesting. Second year (2006-2007) cultivation was made as raton cultivation and similar intercultural practice were done.

3.2.5.5 Sampling and data collection

Data were collected from 4 representing plants of each treatment. These were plant height, base girth, number of leaves, leaf length, leaf breadth, number of hands per bunch, number of finger per hand, finger size, weight per finger, yield per plant and yield ton per hectare. All these data were statistically analyzed to asses the levels of significance of the treatments. Finally, the means were compared by Duncan Multiple Range Test (DMRT) at 1% and 5% levels of probability.

3.2.6 Experiment # 5: Performance of Potato as the Lower Storey Crop in Multistoried Agroforestry System

3.2.6.1 Objectives

1. To characterize morphological behavior of potato in partial shade conditions provided by banana and / or different MPTs.
2. To determine the yield and yield attributes of potato in partial shade conditions provided by banana and / or different MPTs.
3. To estimate the benefit in terms of per unit area.

3.2.6.2 Design: Single factor Experiment in RCBD with four replications.

3.2.6.3 Treatment

T_1 = Potato

T_2 = Potato + Banana

T_3 = Potato +Ipil-ipil

T_4 = Potato + Ghora neem

T_5 = Potato + Banana+ Ipil-ipil

T_6 = Potato + Banana + Ghora neem

3.2.6.4 Crop establishment and cultural practices

The potato (Cardinal) tubers were planted on 5 November 2005 in the alleys (space between two lines of trees). The alley was 3 m wide and thus the unit plot size was 3 m x 3 m. The soil of each plot was well spaded and obtained a good tilth (as required for potato cultivation) before the date of tuber plantation. fifty cm line to line distance and twenty cm tuber to tuber distance were maintained.

Fertilizer application: The following fertilizer and manure doses were applied in the field according to SRDI soil analysis report (IPNS):

Name of Fertilizers and manure	Recommended doses (kg ha^{-1})	
	2005-06	2006-07
Urea	330	330.0
TSP	27.5	27.5
MoP	45	45.0
Gypsum	72.5	50.0
Cow dung	8000	8000
Boric acid	1.25	0.0

Weeding, earthling up and irrigation was done whenever necessary. Harvesting of potato tuber was done at 25 January, in both the year. Second year (2006-2007) cultivation was made with similar intercultural practices.

3.2.6.5 Sampling and data collection

Data were collected, from 10 randomly selected plants (two from each line) for each plot. These were plant height, number of tiller $hill^{-1}$, number of tuber $hill^{-1}$, tuber weight or tuber yield $hill^{-1}$ and yield t ha^{-1}. Date of first emergence and 80% emergence were recorded. All these data were statistically analyzed to asses the levels of significance of the treatments. Finally, the means were compared by Duncan Multiple Range Test (DMRT) at 1% and 5% levels of probability.

3.2.6.4 Crop establishment and cultural practices

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3.2.7 Experiment # 6: Performance of Onion as the Lower Storey Crop in Multistoried Agroforestry System

3.2.7 .1 Objectives

1. To characterize morphological behavior of onion in partial shade conditions provided by banana and / or different MPTs.
2. To determine the yield and yield attributes of onion in partial shade conditions provided by banana and / or different MPTs.
3. To estimate the benefit in terms of per unit area.

3.2.7.2 Design: Single factor Experiment in RCBD with four replications.

3.2.7.3 Treatment

T_1 = Onion

T_2 = Onion + Banana

T_3 = Onion +Ipil-ipil

T_4 = Onion + Ghora neem

T_5 = Onion + Banana+ Ipil-ipil

T_6 = Onion + Banana + Ghora neem

3.2.7.4 Crop establishment and cultural practices

The onion (BARI Piaz 2) was produced by seedling to bulb method. Onion seedlings ware collected from the BADC farm, Dinajpur. Seedlings were planted on 31th January 2006 in the alleys (space between two lines of trees) just seven days after potato harvest. The unit plot size was 3 x 3 m. The soil of each plot was well pulverized at the time of potato harvesting so ploughing cost was negligible. After applying fertilizer the soil was just need to leveling to planting onion seedlings. 20 cm line to line distance and 10 cm seedling to seedling distance were maintained.

3.2.7 Experiment # 6: Performance of Onion as the Lower Storey Crop in Multistoried Agroforestry System

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3. To estimate the benefit in terms of per unit area.

3.2.7.2 Design: Single factor Experiment in RCBD with four replications.

3.2.7.3 Treatment

T_1 = Onion

T_2 = Onion + Banana

T_3 = Onion +Ipil-ipil

T_4 = Onion + Ghora neem

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3.2.7.2 Design: Single factor Experiment in RCBD with four replications.

3.2.7.3 Treatment

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T_2 = Onion + Banana

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T_4 = Onion + Ghora neem

T_5 = Onion + Banana+ Ipil-ipil

T_6 = Onion + Banana + Ghora neem

3.2.7.4 Crop establishment and cultural practices

The onion (BARI Piaz 2) was produced by seedling to bulb method. Onion seedlings ware collected from the BADC farm, Dinajpur. Seedlings were planted on 31th January 2006 in the alleys (space between two lines of trees) just seven days after potato harvest. The unit plot size was 3 x 3 m. The soil of each plot was well pulverized at the time of potato harvesting so ploughing cost was negligible. After applying fertilizer the soil was just need to leveling to planting onion seedlings. 20 cm line to line distance and 10 cm seedling to seedling distance were maintained.

Fertilizer application: The following fertilizer and manure doses were applied in the field according to SRDI soil analysis report (IPNS):

Name of Fertilizers and manures	Recommended doses (kg ha^{-1})	
	2006	2007
Urea	220	220.00
TSP	40	40.00
MoP	41.25	41.25
Gypsum	150	150.00
Cow dung	7000	7000
Boric acid	2.5	00.00

Weeding and irrigation was done whenever necessary. Harvesting of onion bulb was done at 25 April, in both the years. Second year (2007) cultivation was done in the same way.

3.2.7.5 Sampling and data collection

Data were collected at the time of final harvest from 10 randomly selected plants for each plot. These were plant height, number of leaf $plant^{-1}$, leaf dry weight, bulb diameter, bulb fresh weight, bulb dry weight, fresh and dry yield t ha^{-1}. Mortality number was calculated subtracting the producing number of bulb from the number of the planting seedlings. All these data were statistically analyzed to asses the levels of significance of the treatments. Finally, the means were compared by Duncan Multiple Range Test (DMRT) at 1% and 5% levels of probability.

3.2.8 Experiment # 7: Effect of lower storied crops on the performance of MPTs

3.2.8.1 Objectives

1. To know the effect of lower storey crops on the growth performance of associate trees
2. To search the effect of intercultural operation of lower storey crops on the bearing performance of associate fruit trees

3.2.8.2 Experimental technique

Data of growth parameter i.e. plant height, base girth, diameter of breast height, canopy diameter, bole volume were taken before planting/ sowing of each crop. Mean annual increment and current annual increment was calculated and presented in the figure for comparison between agroforestry systems and sole production.

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3.2.9 Experiment # 8: Effect of Different Agroforestry Practices on the Properties of Soil.

3.2.9.1 Objectives

1. To know the change occurs in soil P^H.
2. To determine the changing pattern of the soil organic matter content.
3. To find out the variation of elemental status of the soil due to intensive cultivation.

3.2.9.2 Design: Single factor Experiment in RCBD with four replications

3.2.9.3 Treatment

T_1 = Potato – onion + banana + ipil ipil
T_2 = Potato – onion + banana + goraneem
T_3 = Potato – onion + ipil ipil
T_4 = Potato - onion + goraneem
T_5 = Banana + ipil ipil
T_6 = Banana + goraneem
T_7 = Potato - onion +banana
T_8 = Potato – onion
T_9 = Banana
T_{10} = Ipil ipil
T_{11} = Goraneem
T_{12} = Black siris+ wheat - mungbean - *T. aman*
T_{13} = Guava + wheat - mungbean - *T. aman*
T_{14} = Mango+ wheat – mungbean - *T. aman*
T_{15} = Wheat - mungbean- *T. aman*
T_{16} = Black siris
T_{17} = Guava
T_{18} = Mango

3.2.9.4 Sampling procedure

For this experiment, representing soil samples were collected from the field of each treatment (different agroforestry practices) every year and analyzed its physical and chemical properties in the laboratory of SRDI, Dinajpur.

3.3 Light measurement

The measurement of light intensity is very important in any Agroforestry research. Light intensity was measured once in a week by the Lux meter. It was recoded thrice a day (9.30 AM, 12.30 PM and 3.30 PM). Daily mean intensity of light was used for monthly mean calculation. Therefore, month wise light measurement was recorded from different treatments and various strata of the multistorey, which are presented in

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the Appendix I-VI. The light incident at different strata of different trees was computed as follows:

$$\% \text{ light incident} = \frac{li}{lo} \times 100$$

where, li = lux incident on the lower story crop

lo = lux incident in sole plot/open field

Plate 3.8. Measuring light intensity above the banana tree (middle storey plant)

3.4 Evaluation of the Agroforestry Systems

Any evaluation should be based on a specific set of criteria that, in turn, may be applied to the attributes under consideration. The basic attributes of all Agroforestry systems are productivity, sustainability and adoptability. The evaluation of the studied agroforestry systems ware done based on these attributes.

3.4.1 Productivity evaluation

The obvious approach for evaluation of this attribute would be to express the productivity of different outputs in measurable, quantitative as well as meaningful terms. A calculation of the economic value of different products is another easily understood basis of evaluation. Many of the products of Agroforestry are consumed at the point of production and they do not enter even in the local markets; these quantities

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are difficult to ascertain. Finally, the fact is that many of the products of indigenous Agroforestry Systems are of a non monetary (i.e. service) nature, which further complicates the issue. Land equivalent ratio (LER) and harvest index (HI) are the two measurements of productivities which are normally used by Agronomists but LER is commonly used in agroforestry. So the productivity evaluations of the experimental systems are done by HI and LER.

Harvest index: Harvest index denoted ratio of economic yield to biological yield and was calculated with the following formula (Gardner *et al.,* 1985):

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

For proper evaluation of agroforestry systems HI has some limitations. First in harvest index calculations, only above-ground dry matter in considered. Below ground dry matter production is very important too, because of its role in maintenance of soil organic matter. Secondly, the mass of dry matter is no indication of economic value of the product. Finally HI evaluation does not reflect the sustainability factor, an important consideration in agroforestry. To overcome these limitation LER, BCR and sustainability evaluation were also done of the studied agroforestry systems.

Land Equivalent Ratio (LER)

Originally proposed to help judging the relative performance of a component of a crop combination compared to sole stands of that species. The term land equivalent ratio (LER) is derived from its indication of relative land requirements for intercrops versus monocultures. LER helps to judge the relative performance of a component of a crop combination compared to sole stands of that species. LER is the sum or relative yields of the component species; i.e.

$$LER = \sum_{i=1}^{n} \frac{yi}{yii}$$

Where, yi is the yield of the "i" th component from a unit area of the intercrop; yii is the yield of the same component grown as a sole crop over the same area; and

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In simple Agroforestry situations, LER can be expressed as:

LER = Ci/Cs + Ti/Ts, Where:

Ci = crop yield under Agroforestry

Cs = crop yield under sole cropping

Ti = tree yield under Agroforestry, and

Ts = tree yield under sole cropping.

3.4.2 Sustainability Evaluation

Nowadays, sustainability is one of the most widely debated topics in all land use-related discussions. It is a rallying theme for both environmentalists and production scientists. It is a concept that incorporates the long term concerns of the society with the basic short-term needs of the worlds poor.

The sustainability attributes of agroforestry are based mainly on soil productivity and other such biophysical advantages. The latter includes beneficial effects such as erosion control, addition of organic matter, and improvement of physical properties, N_2 fixation, improved nutrient cycling, and synchrony in nutrient use and reclamation of degraded lands, of course, possible adverse aspects, such as competition for nutrients and moisture, increase soil acidity must also be considered in sustainability evaluations. At present there is no quantitative measure of sustainability. Several approaches are currently being discussed. One of them is to calculate the total factor productivity (TFP) of the system over a defined period of time (which could be the summation of total factor productivities of individual components); there could be separate indices for biological and socioeconomic characteristics. Initially TFP has been calculated using the following equation:

$$Y_{tot} = E_c Y_c + E_t Y_t + E_L \Delta_L$$

Where,

Y_{tot} = Total yield (Tk. ha^{-1})

E_c = Price per unit crop yield (Tk. $kg^{-1)}$

Y_c = Crop yield (kg. ha^{-1})

E_t = Price per unit yield of tree products (Tk. kg^{-1})

Y_t = Yields of tree products (kg. ha^{-1})

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3.4.3 Adoptability evaluation

As in the case of productivity and sustainability evaluations of agroforestry systems, there is no widely accredited criteria for adoptability evaluations also. Of course, it can be argued that indigenous Agroforestry systems have stood the test of time, and need no adoptability evaluation. In such situations, it will be useful to learn why farmers continue to practice such indigenous systems. That information could then be used as the basis for developing criteria for new technologies. Nonetheless, specific criteria or measures with wide applicability for assessing adoptability and the relative importance of each have still not been fully established.

Adoptability evaluations have been attempted in some agroforestry technology dissemination projects. For example, undertook a review of Agroforestry technology monitoring and evaluation in 165 projects worldwide and suggested a planning approach to the design of effective and adoptable project interventions. That approach had three steps: farmers evaluation, field evaluation and field testing.

Hence, Amrapali based wheat-mungbean-t.aman and banana based multistoried model are under evaluation and testing at the field of Agroforestry research farm, HSTU, Dinajpur. These technologies have already been started practicing by the farmers of Dinajpur region but they need technical observation and supports.

3.5 Economic analysis of the studied agroforestry Systems

Total man hours required for different operations were recorded along with cost of different variable inputs to find out the total variable cost of production of the crop combinations produced by the treatments. Total cost of production, gross return and benefit-cost ratio were also calculated on the basis of prevailing market price of different crops (grain and straw) and tree products at harvest.

3.5.1 Total cost of production

The cost of individual crop production (wheat, rice, mungbean, potato, onion, banana and tree species) included the cost items like human labour and animal power costs, material cost (cost of seeds, manures and fertilizers, bamboo, plastic rope etc.), land use cost and interest on operating capital. The total cost of production was calculated by the sum of all costs of individual crop production which were produced in a year in the same piece of land.

3.5.2 Gross return

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Gross return is the monetary value of total products and by-products. Per hectare gross returns from all produced crops were calculated by multiplying the total amount of production by their respective market prices.

3.5.3 Net return

Net return usually means the profit of the enterprises. Net return was calculated by deducting the total cost of productions from the gross return.

Net return = Gross return (Tk. ha^{-1} $year^{-1}$) - Total cost of Production (Tk. ha^{-1} $year^{-1}$)

3.5.4 Benefit-cost ratio (BCR)

Benefit-cost ratio is the ratio of gross returns with total cost of productions. It was calculated by the following formula -

$$\text{Benefit-cost ratio} = \frac{\text{Gross return (Tk. ha}^{-1}\text{ year}^{-1})}{\text{Total cost of Production (Tk. ha}^{-1}\text{ year}^{-1})}$$

3.6 Statistical analysis

Data obtained from the experiments for each parameter were analyzed following the ANOVA technique as designed by the computerized MSTAT program. The mean differences among the treatments were adjusted with Duncan's Multiple Range Test (Gomez and Gomez, 1984).

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CHAPTER 4
RESULTS AND DISCUSSION

Eight experiments were conducted during December 2005 to June 2008 to achieve the objectives of the study. The results of the study are presented in this chapter under different critical sections comprising of growth, yield and yield contributing characteristics of the selected crops (wheat, mungbean and *transplanted aman*), vegetable (potato) and spice (onion), their productivity and cost-effective analysis. The results are critically discussed here experiment-wise citing accessible literature.

Experiment # 1. Performance of Transplanted aman in Agroforestry Systems

Performance of Transplanted aman (*T. aman*) rice in agroforestry systems was evaluated in terms of Plant height (cm), Number of tillerss hill^{-1}, Fresh weight of straw plant^{-1} (g), Dry weight of straw plant^{-1} (g), Length of panicle (cm), Number of grains panicle^{-1}, Number of sterile spikelets panicle^{-1}, 1000 grain weight (g), Grain yield (t ha^{-1}), Harvest index (HI), Land equivalent ratio (LER) and Benefit cost ratio (BCR).

4.1.1 Plant height

Effect of tree species

Plant height of transplanted aman (*T. aman*) was not significantly influenced by the presence of different tree species in first year experimentation (2006), irrespective of transplanting dates (Figure 4.1.1). Although there was no significant variation in plant height of *T. aman* grown under different tree species, but numerically the highest plant height was recorded under guava tree species (T_3) in all sampling dates and the values were 68.46, 80.47, 93.71, 106.5 cm at 30, 45, 60 and 75 days after transplanting (DAT), respectively. The shortest plant height was recorded in the open field (T_1) at all sampling dates (60.81, 78.26, 89.5 and 102.0 cm at 30, 45, 60 and 75 DAT, respectively). In second year experimentation (2007), plant height of Transplanted aman was significantly influenced by the presence of different tree species (Figure 4.1.2). Significantly the tallest plant was observed in T4 treatment (*T. aman* grown under mango tree species) in all sampling dates (62.9, 80.3, 92.39, 104.6 cm at 30, 45, 60 and 75 DAT, respectively).

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At 30 DAT, T_2 treatment (*T. aman* grown under black siris) produced statistically similar plant height (60.4 cm) of T_4 but other sampling dates showed significantly lower plant height than T4 treatment. Significantly the shortest plant was recorded in T_3 treatment (*T. aman* grown under guava tree species) in all sampling dates and the values were 56.81, 76.66, 87.85 and 109 cm at 30, 45, 60 and 75 DAT, respectively. In this year (second year) open field produced intermediate plant height in all the sampling dates. The plant height of *transplanted aman* was not influenced significantly in the first year (2006) as because of the age of the tree was only two year and canopy diameter was not fully developed, but in the second year (2007), Black siris (T_2), Guava (T_3) and Mango (T_4) developed their canopy diameter to 3.2, 3.75 and 2.86 m, respectively and reduced light to 49.43, 53.5 and 44.3 % for lower storied *transplanted aman* crop. As a result, plant height was significantly influenced by the tree species. Amin (2007) observed higher plant height of *transplanted aman* in partial shaded condition of early aged multipurpose tree species. Minimum effect on plant height due to shading condition in alley cropping of upland rice was observed by Garrity *et al.* (1992).

Response of rice varieties

Plant height of rice varieties grown under different agroforestry systems responded significantly in both the experimental years irrespective of sampling dates. Among the five tested rice varieties BR 11 (V_2) produced highest plant height in all sampling dates except 30 DAT. At 30 DAT, BR 10 (V_1) possessed the tallest plant height, although V_1 and V_2 were statistically similar. BRRI dhan 33 (V_3) and BRRI dhan 39 (V_4) showed moderate plant height in both the cropping seasons. In the first year (2006), the plant height of V_3 and V_4 were statistically similar in all sampling dates, but in the second year (2007), plant height values were statistically different except 30 DAT (Figure 4.1.3. and Figure 4.1.4). On the other hand, significantly the shortest plant was recorded in sorna (V_5) in all sampling dates of both the cropping seasons. These variations might be due to genetic make-up of T. aman varieties. Almost similar variation of plant height in aromatic rice varieties was found by Hossain (2007).

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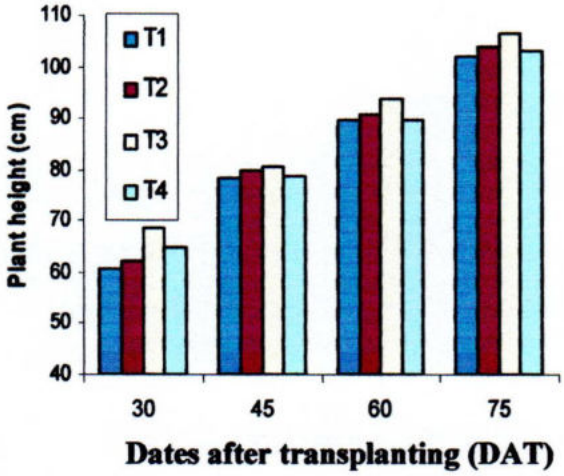


Fig 4.1.1. Effect of tree species on plant height at different dates after transplanting in 2006

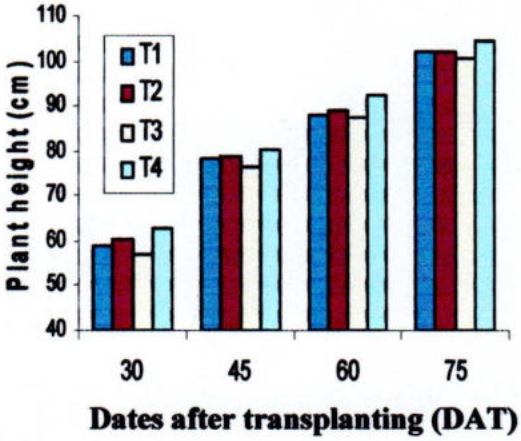


Fig 4.1.2. Effect of tree species on plant height at different dates after transplanting in 2007

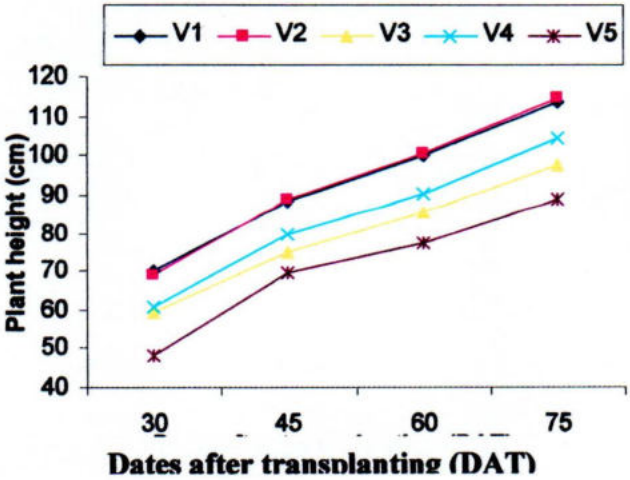
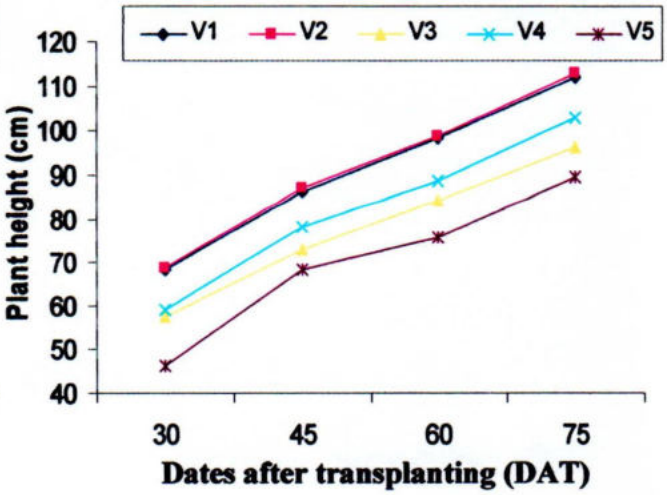


Fig 4.1.3. Effect of varieties on plant height at different dates after transplanting in 2006



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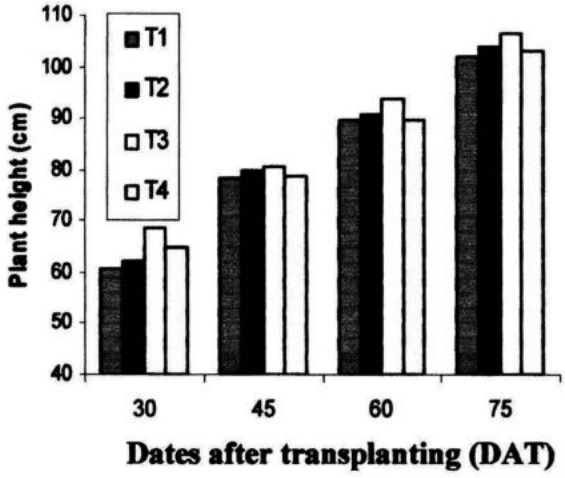

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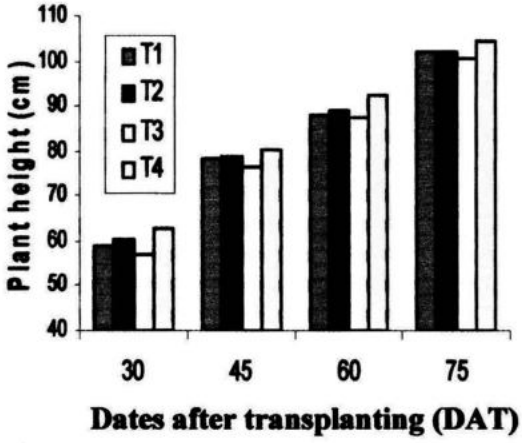

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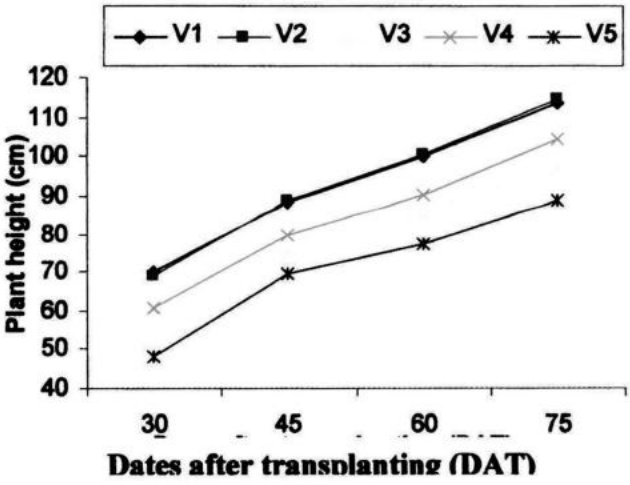

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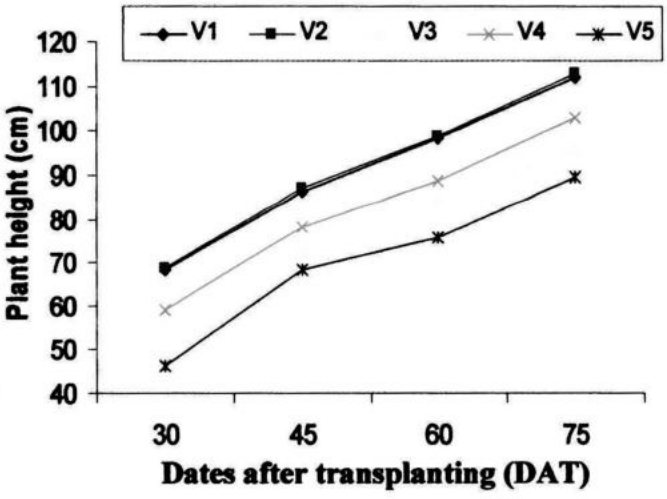

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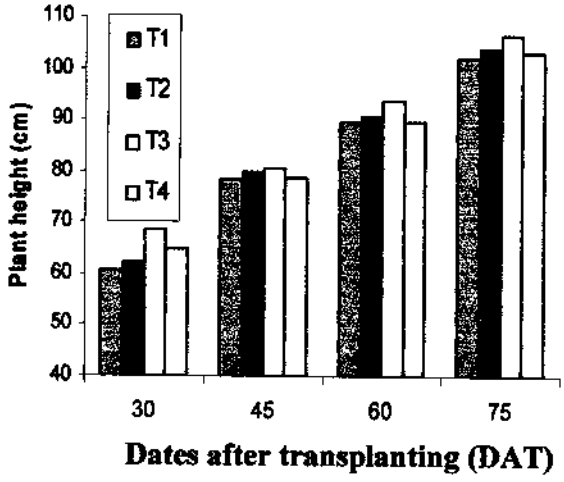

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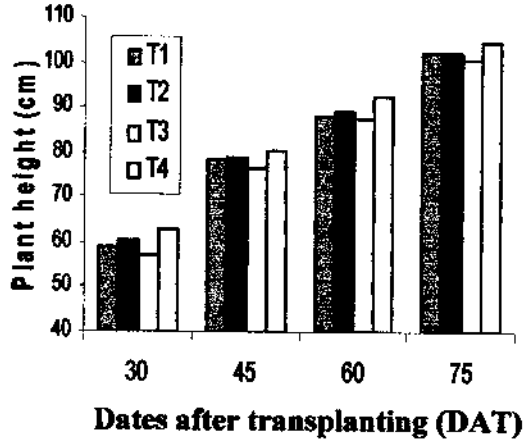

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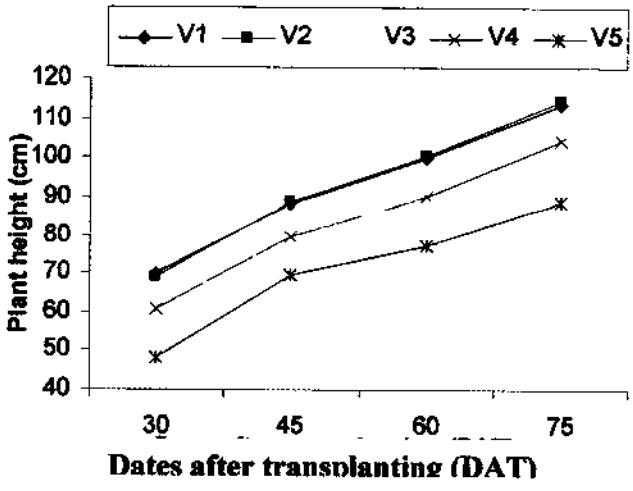

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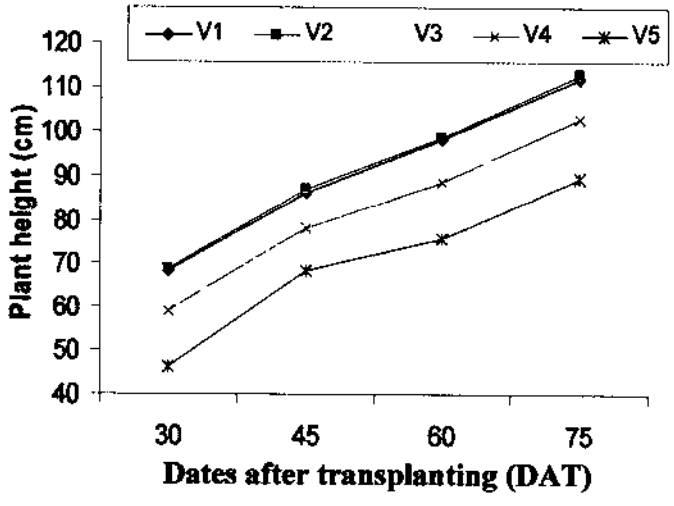

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Interaction Effect of tree species and rice variety

The interaction effect of tree species and rice varieties on the plant height of T. aman clearly stated that all the treatment combinations significantly influenced the plant height irrespective of sampling dates and cropping seasons (Table 4.1.1).

In 2006 experimentation, T_3V_2 combination (BR 11 under guava species) produced significantly the tallest plant in all sampling dates (73.57, 90.53, 97.67 and 118.4 cm at 30, 45, 60 and 75 DAT, respectively) which was followed by T_2V_2 combination (BR 11 under black siris species) while significantly the shortest plant was recorded in T_2V_5 combination (sorna under black siris species) at 30 DAT (47.80 cm) and 60 DAT (75.93 cm); but at 45 and 75 DAT, significantly the lowest plant height was found in T_4V_5 (sorna under mango) and T_1V_5 (sorna in open field) combinations and the values were 67.97 and 87.03 cm, respectively.

In second year experimentation (2007), significantly the highest plant height was recorded in T_4V_1 (BR 10 under mango tree species) which was statistically similar to that of T_2V_1 (BR 10 under black siris tree species), T_2V_2 (BR 11 under black siris tree species), T_1V_2 (BR 11 in open field), T_4V_2 (BR 11 under mango tree species) combinations irrespective of sampling dates, and significantly the shortest plant in all sampling dates were recorded in T_1V_5 (Sorna in open field) combination (Table 4.1.1). The Interaction effects revealed that BR 11 variety (V_2) showed superior vegetative growth in first year experiment at all treatment combinations but in second year experimentation BR 10 showed maximum growth performance in all treatment combinations at 75 DAT which was followed by the combinations comprising BR 11 variety (V_2). Plant heights of these two varieties (V_2 and V_1) were found intermediate under guava species (T_3).

Almost similar interaction effect of tree species and rice variety was found by Amin (2007). BR 10 is found highly sensitive than BR 11 in dense shade of MPTs (second year experiment) might be due to its genetical character.

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Table 4.1.1. Interaction Effect of tree species and rice variety on plant height during 2006 and 2007

Treatment combination	Plant height (cm) 2006				Plant height (cm) 2007			
	30 DAT	45DAT	60DAT	75DAT	30 DAT	45DAT	60DAT	75DAT
T_1V_1	67.60 abc	85.50abc	98.40a	111.2abcd	65.78bcd	84.17bc	96.43abc	109.7abcd
T_1V_2	69.93 ab	85.53abc	100.4a	114.2abcd	68.53ab	83.77c	99.10ab	113.2abcd
T_1V_3	57.63 ef	73.10abc	82.87bc	94.67efgh	55.80gh	71.35fgh	81.17ghi	93.13ijk
T_1V_4	60.40 cdef	79.00abc	87.73b	102.8bcdefg	59.07fg	77.32d	86.32def	101.1fgh
T_1V_5	48.50 g	68.17bc	78.07cd	87.03h	46.00i	65.67i	73.97k	86.00k
T_2V_1	72.97 a	87.03ab	102.4a	115.1abc	71.27a	88.85ab	99.67ab	113.4abcd
T_2V_2	73.50 a	91.67a	103.6a	117.6 ab	71.70a	89.32a	99.22ab	115.8ab
T_2V_3	57.80 ef	73.37abc	83.70bc	94.50 efgh	55.90gh	72.07efg	81.90ijk	92.93ijk
T_2V_4	58.57 def	78.30abc	87.90b	103.4bcdef	56.70gh	76.75de	86.18def	101.8efg
T_2V_5	47.80 g	68.47 bc	75.93d	88.40gh	46.42i	66.88hi	76.00ijk	86.65k
T_3V_1	73.57 a	86.03abc	97.93a	110.8abcd	64.65cde	84.07bc	96.05abc	109.3bcd
T_3V_2	70.37 ab	90.53a	97.67 a	118.4a	61.80ef	85.30abc	96.08abc	108cde
T_3V_3	57.80 ef	78.13abc	87.97b	100.2defgh	56.13gh	76.15def	86.00fgh	99.67ghi
T_3V_4	56.70 f	73.60abc	86.63b	103.2bcdef	55.05h	72.32efg	85.00fgh	101.7efg
T_3V_5	68.10 ab	74.30abc	77.70cd	92.10fgh	46.42i	73.75defg	86.10fgh	90.95jk
T_4V_1	66.03 abcd	91.03a	101.2a	109.6abcd	71.47a	89.18a	101.10a	116.4a
T_4V_2	63.23 bcdef	91.27a	100.9 a	116.5ab	68.30abc	90.03a	101.60a	114.4abc
T_4V_3	64.87 bcde	74.43abc	88.60b	100.8cdefgh	62.45def	71.07gh	89.07bcd	99.15ghi
T_4V_4	48.53 g	88.40a	99.87a	108.1abcde	66.10bcd	86.30abc	97.93abc	106.7def
T_4V_5	48.20g	67.90c	78.03cd	88.73fgh	46.17i	65.95i	76.05ijk	86.57k
CV%	1.18	2.10	0.66	1.30	3.99	3.90	5.18	4.19

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

T_1 = Sole (open field), T_2 = Black siris, T_3 = Guava, T_4 = mango tree, V_1 = BR10, V_2 = BR11, V_3 = BRRI Dhan 33, V_4 = BRRI Dhan 39, V_5 = Sorna (Local variety)

Table 4.1.1. Interaction Effect of tree species and rice variety on plant height during 2006 and 2007

Treatment combination	Plant height (cm) 2006				Plant height (cm) 2007			
	30 DAT	45DAT	60DAT	75DAT	30 DAT	45DAT	60DAT	75DAT
T_1V_1	67.60 abc	85.50abc	98.40a	111.2abcd	65.78bcd	84.17bc	96.43abc	109.7abcd
T_1V_2	69.93 ab	85.53abc	100.4a	114.2abcd	68.53ab	83.77c	99.10ab	113.2abcd
T_1V_3	57.63 ef	73.10abc	82.87bc	94.67efgh	55.80gh	71.35fgh	81.17ghi	93.13ijk
T_1V_4	60.40 cdef	79.00abc	87.73b	102.8bcdefg	59.07fg	77.32d	86.32def	101.1fgh
T_1V_5	48.50 g	68.17bc	78.07cd	87.03h	46.00i	65.67i	73.97k	86.00k
T_2V_1	72.97 a	87.03ab	102.4a	115.1abc	71.27a	88.85ab	99.67ab	113.4abcd
T_2V_2	73.50 a	91.67a	103.6a	117.6 ab	71.70a	89.32a	99.22ab	115.8ab
T_2V_3	57.80 ef	73.37abc	83.70bc	94.50 efgh	55.90gh	72.07efg	81.90ijk	92.93ijk
T_2V_4	58.57 def	78.30abc	87.90b	103.4bcdef	56.70gh	76.75de	86.18def	101.8efg
T_2V_5	47.80 g	68.47 bc	75.93d	88.40gh	46.42i	66.88hi	76.00ijk	86.65k
T_3V_1	73.57 a	86.03abc	97.93a	110.8abcd	64.65cde	84.07bc	96.05abc	109.3bcd
T_3V_2	70.37 ab	90.53a	97.67 a	118.4a	61.80ef	85.30abc	96.08abc	108cde
T_3V_3	57.80 ef	78.13abc	87.97b	100.2defgh	56.13gh	76.15def	86.00fgh	99.67ghi
T_3V_4	56.70 f	73.60abc	86.63b	103.2bcdef	55.05h	72.32efg	85.00fgh	101.7efg
T_3V_5	68.10 ab	74.30abc	77.70cd	92.10fgh	46.42i	73.75defg	86.10fgh	90.95jk
T_4V_1	66.03 abcd	91.03a	101.2a	109.6abcd	71.47a	89.18a	101.10a	116.4a
T_4V_2	63.23 bcdef	91.27a	100.9 a	116.5ab	68.30abc	90.03a	101.60a	114.4abc
T_4V_3	64.87 bcde	74.43abc	88.60b	100.8cdefgh	62.45def	71.07gh	89.07bcd	99.15ghi
T_4V_4	48.53 g	88.40a	99.87a	108.1abcde	66.10bcd	86.30abc	97.93abc	106.7def
T_4V_5	48.20g	67.90c	78.03cd	88.73fgh	46.17i	65.95i	76.05ijk	86.57k
CV%	1.18	2.10	0.66	1.30	3.99	3.90	5.18	4.19

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

T_1 = Sole (open field), T_2 = Black siris, T_3 = Guava, T_4 = mango tree, V_1 = BR10, V_2 = BR11, V_3 = BRRI Dhan 33, V_4 = BRRI Dhan 39, V_5 = Sorna (Local variety)

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Treatment combination	Plant height (cm) 2006				Plant height (cm) 2007			
	30 DAT	45DAT	60DAT	75DAT	30 DAT	45DAT	60DAT	75DAT
T_1V_1	67.60 abc	85.50abc	98.40a	111.2abcd	65.78bcd	84.17bc	96.43abc	109.7abcd
T_1V_2	69.93 ab	85.53abc	100.4a	114.2abcd	68.53ab	83.77c	99.10ab	113.2abcd
T_1V_3	57.63 ef	73.10abc	82.87bc	94.67efgh	55.80gh	71.35fgh	81.17ghi	93.13ijk
T_1V_4	60.40 cdef	79.00abc	87.73b	102.8bcdefg	59.07fg	77.32d	86.32def	101.1fgh
T_1V_5	48.50 g	68.17bc	78.07cd	87.03h	46.00i	65.67i	73.97k	86.00k
T_2V_1	72.97 a	87.03ab	102.4a	115.1abc	71.27a	88.85ab	99.67ab	113.4abcd
T_2V_2	73.50 a	91.67a	103.6a	117.6 ab	71.70a	89.32a	99.22ab	115.8ab
T_2V_3	57.80 ef	73.37abc	83.70bc	94.50 efgh	55.90gh	72.07efg	81.90ijk	92.93ijk
T_2V_4	58.57 def	78.30abc	87.90b	103.4bcdef	56.70gh	76.75de	86.18def	101.8efg
T_2V_5	47.80 g	68.47 bc	75.93d	88.40gh	46.42i	66.88hi	76.00ijk	86.65k
T_3V_1	73.57 a	86.03abc	97.93a	110.8abcd	64.65cde	84.07bc	96.05abc	109.3bcd
T_3V_2	70.37 ab	90.53a	97.67 a	118.4a	61.80ef	85.30abc	96.08abc	108cde
T_3V_3	57.80 ef	78.13abc	87.97b	100.2defgh	56.13gh	76.15def	86.00fgh	99.67ghi
T_3V_4	56.70 f	73.60abc	86.63b	103.2bcdef	55.05h	72.32efg	85.00fgh	101.7efg
T_3V_5	68.10 ab	74.30abc	77.70cd	92.10fgh	46.42i	73.75defg	86.10fgh	90.95jk
T_4V_1	66.03 abcd	91.03a	101.2a	109.6abcd	71.47a	89.18a	101.10a	116.4a
T_4V_2	63.23 bcdef	91.27a	100.9 a	116.5ab	68.30abc	90.03a	101.60a	114.4abc
T_4V_3	64.87 bcde	74.43abc	88.60b	100.8cdefgh	62.45def	71.07gh	89.07bcd	99.15ghi
T_4V_4	48.53 g	88.40a	99.87a	108.1abcde	66.10bcd	86.30abc	97.93abc	106.7def
T_4V_5	48.20g	67.90c	78.03cd	88.73fgh	46.17i	65.95i	76.05ijk	86.57k
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T_1 = Sole (open field), T_2 = Black siris, T_3 = Guava, T_4 = mango tree, V_1 = BR10, V_2 = BR11, V_3 = BRRI Dhan 33, V_4 = BRRI Dhan 39, V_5 = Sorna (Local variety)

4.1.2 Number of tillers

Effect of tree species

The effects of tree species on the number of tillers hill^{-1} of transplanted aman rice were insignificant in first year experimentation (2006) at all sampling dates (Figure 4.1.5). Numerically the highest number of tillers was recorded in T_1 treatment (open field) irrespective of sampling dates (6.88, 12.72 and 14.12 at 30, 45 and 60 days after transplanting respectively). The least number of tillers was found in T_3 treatment (guava) and the values were 6.52, 10.94 and 12.43 at 30, 45 and 60 days after transplanting (DAT), respectively.

In second year experimentation (2007), number of tillers hill^{-1} was not influenced significantly at 30 DAT by the presence of tree species, but at 45 and 60 DAT the number of tillers were greatly influenced and the influencing patterns were similar at both the sampling dates. Maximum number of tillers were recorded in T_1 treatment (12.35 and 13.73 at 45 and 60 DAT respectively) followed by T_2 treatment (black siris) and T_4 treatment (mango). Significantly the lowest number of tillers hill^{-1} (10.60 and 12.06 at 45 and 60 DAT respectively) was found in T_3 treatment (guava). These variations in number of tillers hill^{-1} might be due to shortage of light interception as well as below ground competition between tree and crop roots in agroforestry treatments. In 2007, tillering stage of transplanted aman received 47-60.5% available light under different tree canopies but in 2006 it was 70-80%, i.e. transplanted aman produced similar number of tillers at 20-30% shade of trees compared to the open field.

Response of rice varieties

Number of tillers hill^{-1} of transplanted aman rice was varied significantly due to variety (Figure 4.1.7-8). BR 11 (V_2) always significantly produced the highest number of tillers hill^{-1} over other varieties in both the cropping seasons irrespective of sampling dates followed by BRRI dhan 33 (V_1) and BRRI dhan 39 (V_4), which produced moderate number of tillers hill^{-1} at all the sampling dates in both the years. However, these two were statistically alike. Significantly the lowest number of tillers was recorded in sorna (V_5) at all sampling dates (Figure 4.1.7-8). These might be due to genetical disparities among the varieties.

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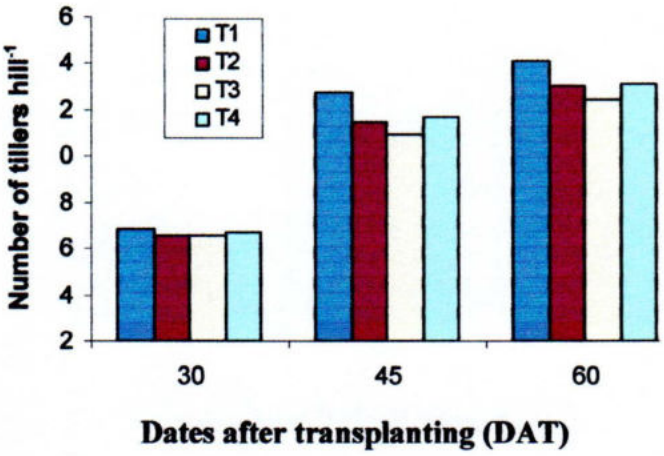

Fig 4.1.5. Effect of tree species on number of tillers hill^{-1} at different DAT in 2006

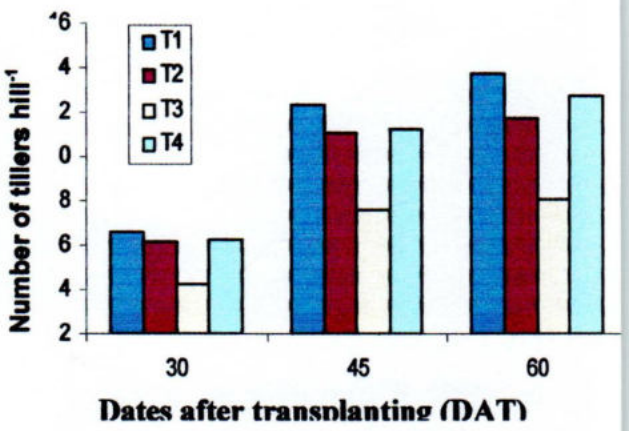

Fig 4.1.6. Effect of tree species on number of tillers hill^{-1} at different DAT in 2007

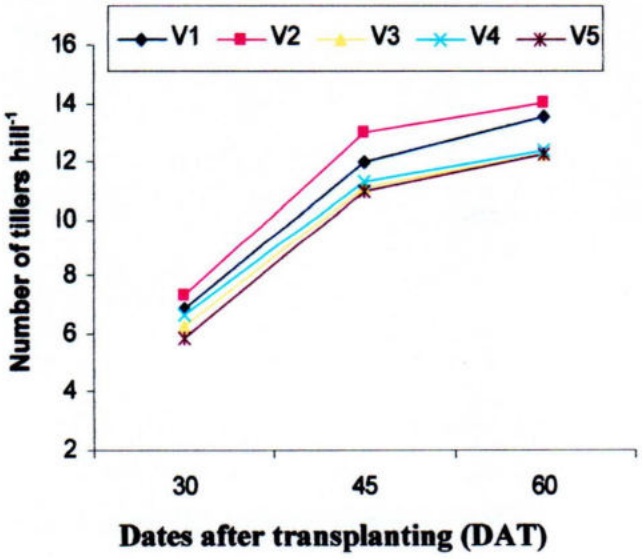

Fig 4.1.7. Effect of varieties on number of tillers hill^{-1} at different DAT in 2006

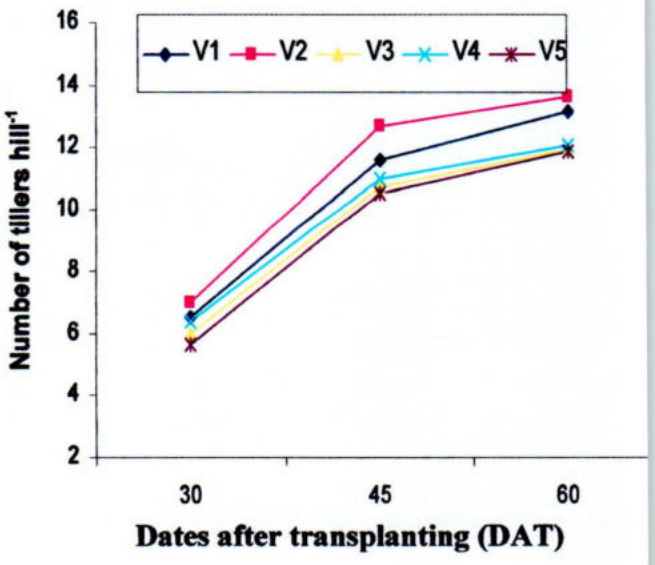

Fig 4.1.8. Effect of varieties on number of tillers hill^{-1} at different DAT in 2007

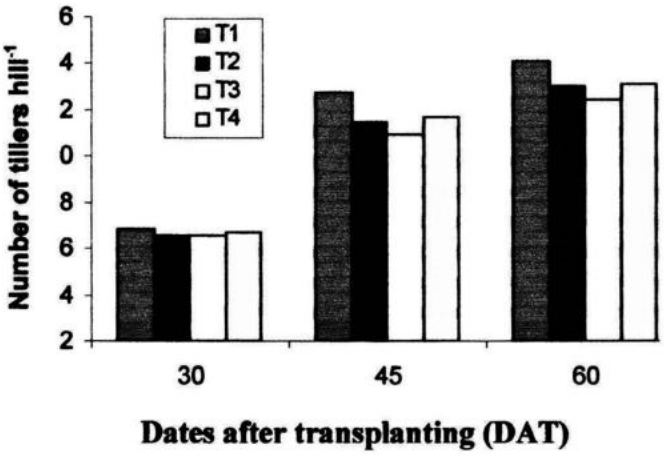

Fig 4.1.5. Effect of tree species on number of tillers hill^{-1} at different DAT in 2006

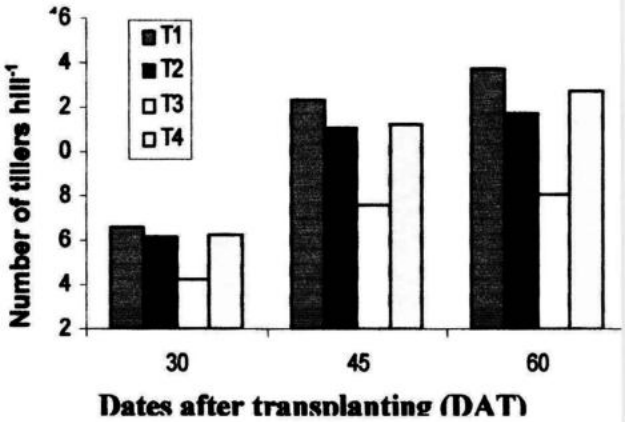

Fig 4.1.6. Effect of tree species on number of tillers hill^{-1} at different DAT in 2007

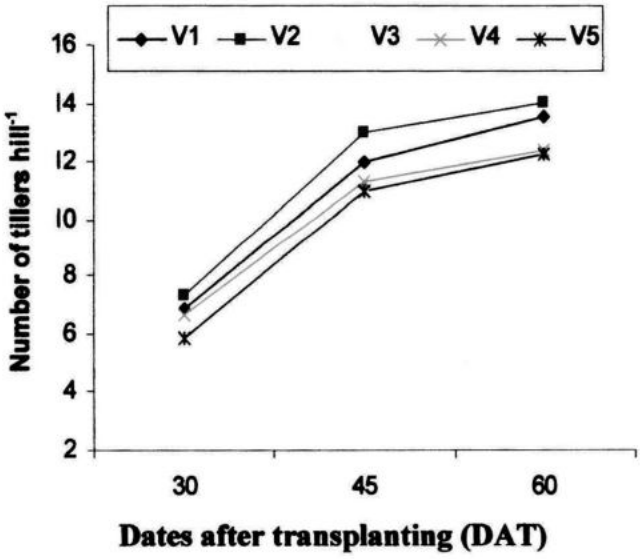

Fig 4.1.7. Effect of varieties on number of tillers hill^{-1} at different DAT in 2006

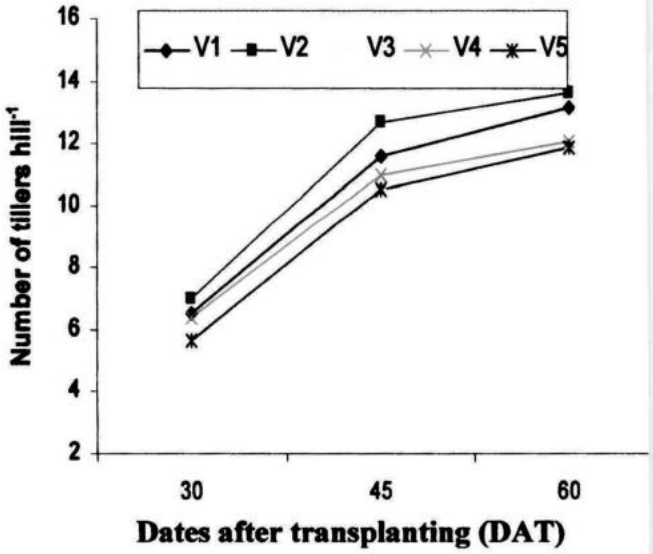

Fig 4.1.8. Effect of varieties on number of tillers hill^{-1} at different DAT in 2007

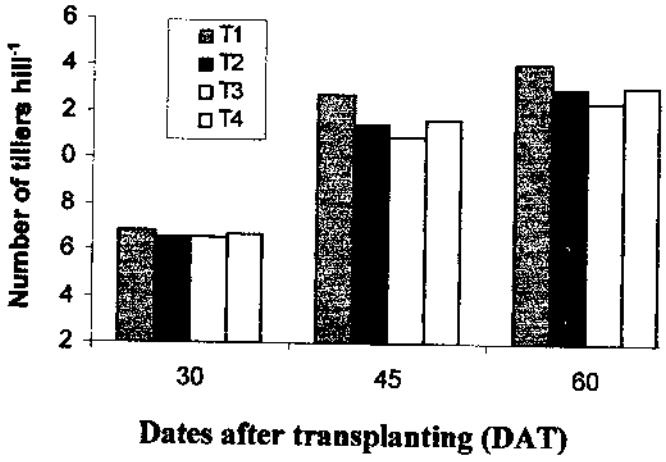

Fig 4.1.5. Effect of tree species on number of tillers hill^{-1} at different DAT in 2006

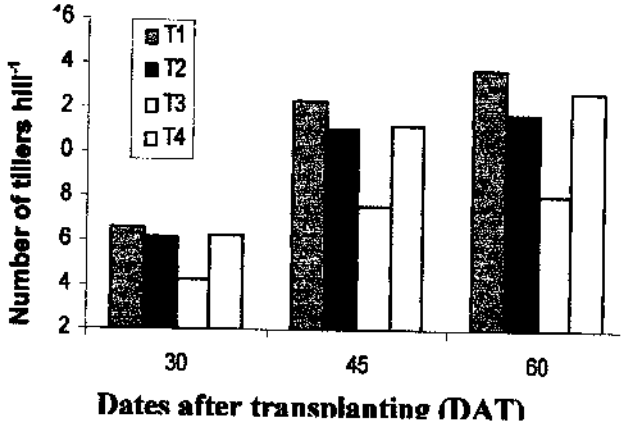

Fig 4.1.6. Effect of tree species on number of tillers hill^{-1} at different DAT in 2007

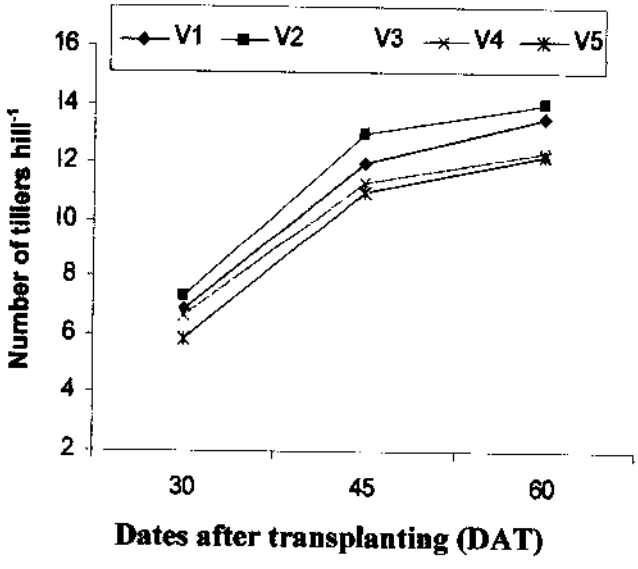

Fig 4.1.7. Effect of varieties on number of tillers hill^{-1} at different DAT in 2006

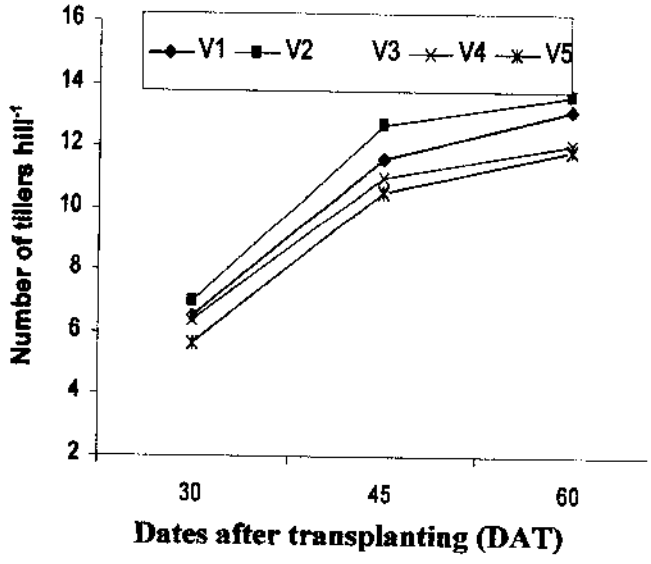

Fig 4.1.8. Effect of varieties on number of tillers hill^{-1} at different DAT in 2007

Interaction Effect of tree species and rice variety

In first year experimentation (2006), maximum number of tillers hill^{-1} was produced by BR 11 in open field condition (T_1V_2 combination) and the values were 7.2, 14.1 and 15.3 at 30, 45 and 60 DAT respectively. The combinations which were produced statistically similar number of tillers hill^{-1} at 30 and 45 DAT to that of T_1V_2 combination, were T_1V_1 (7.4 and 13.4 at 30 and 45 DAT respectively), T_2V_2 (7.4 and 13.3 at 30 and 45 DAT, respectively), and T_4V_2 (7.3 and 13.2 at 30 and 45 DAT, respectively).

In second year experimentation (2007), there was insignificant variation on number of tillers hill^{-1} at 30 DAT and the numerically higher number of tillers hill^{-1} was recorded in BR11 under guava species (T_3V_2 combination) followed by T_1V_4 combination (7.1) and then T_1V_1 (7.0). The lowest number of tiller hill^{-1} (5.5) at 30 DAT was produced by sorna in open field condition (T_1V_5). BR 11 in open field (T_1V_2) was the only combination which produced significantly highest number of tillers hill^{-1} at 45 and 60 DAT (13.7 and 14.9, respectively) followed T_2V_2 (12.95 and 13.68 at 45 and 60 DAT, respectively).

Significantly the lowest number of tillers hill^{-1} was recorded in T_4V_5 combination (sorna under guava) at all sampling dates in both the experimental years (Table 4.1.2).The results showed that BR 11 (V_2) was the best variety for producing maximum number of tillers per hill in association of all trees (i.e. black siris, guava and mango) in first year followed by BR 10 (V_1) that was also suitable for black siris and mango in second year.

Number of tillers hill^{-1} of transplanted aman was strongly influenced by the interaction effect of tree species and rice variety except at 30 DAT, of the year 2007 (Table 4.1.2). BR 11 in open field (T_1V_2) was found the best combination for producing maximum number of tiller hill^{-1} at all sampling dates in both the experimental years followed by BR 10 in open field (T_1V_1 combination).

Interaction Effect of tree species and rice variety

In first year experimentation (2006), maximum number of tillers hill^{-1} was produced by BR 11 in open field condition (T_1V_2 combination) and the values were 7.2, 14.1 and 15.3 at 30, 45 and 60 DAT respectively. The combinations which were produced statistically similar number of tillers hill^{-1} at 30 and 45 DAT to that of T_1V_2 combination, were T_1V_1 (7.4 and 13.4 at 30 and 45 DAT respectively), T_2V_2 (7.4 and 13.3 at 30 and 45 DAT, respectively), and T_4V_2 (7.3 and 13.2 at 30 and 45 DAT, respectively).

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Interaction Effect of tree species and rice variety

In first year experimentation (2006), maximum number of tillers hill^{-1} was produced by BR 11 in open field condition (T_1V_2 combination) and the values were 7.2, 14.1 and 15.3 at 30, 45 and 60 DAT respectively. The combinations which were produced statistically similar number of tillers hill^{-1} at 30 and 45 DAT to that of T_1V_2 combination, were T_1V_1 (7.4 and 13.4 at 30 and 45 DAT respectively), T_2V_2 (7.4 and 13.3 at 30 and 45 DAT, respectively), and T_4V_2 (7.3 and 13.2 at 30 and 45 DAT, respectively).

In second year experimentation (2007), there was insignificant variation on number of tillers hill^{-1} at 30 DAT and the numerically higher number of tillers hill^{-1} was recorded in BR11 under guava species (T_3V_2 combination) followed by T_1V_4 combination (7.1) and then T_1V_1 (7.0). The lowest number of tiller hill^{-1} (5.5) at 30 DAT was produced by sorna in open field condition (T_1V_5). BR 11 in open field (T_1V_2) was the only combination which produced significantly highest number of tillers hill^{-1} at 45 and 60 DAT (13.7 and 14.9, respectively) followed T_2V_2 (12.95 and 13.68 at 45 and 60 DAT, respectively).

Significantly the lowest number of tillers hill^{-1} was recorded in T_4V_5 combination (sorna under guava) at all sampling dates in both the experimental years (Table 4.1.2).The results showed that BR 11 (V_2) was the best variety for producing maximum number of tillers per hill in association of all trees (i.e. black siris, guava and mango) in first year followed by BR 10 (V_1) that was also suitable for black siris and mango in second year.

Number of tillers hill^{-1} of transplanted aman was strongly influenced by the interaction effect of tree species and rice variety except at 30 DAT, of the year 2007 (Table 4.1.2). BR 11 in open field (T_1V_2) was found the best combination for producing maximum number of tiller hill^{-1} at all sampling dates in both the experimental years followed by BR 10 in open field (T_1V_1 combination).

Table 4.1.2. Interaction Effect of tree species and rice variety on number of tillers hill^{-1} in 2006 and 2007

Treatment combination	Number of tillers/hill at 2006			Number of tillers/hill at 2007		
	30 DAT	45DAT	60DAT	30 DAT	45DAT	60DAT
T_1V_1	7.4a	13.4ab	15.2	7.0	13.0ab	14.8a
T_1V_2	7.2a	14.1a	15.3	6.9	13.7a	14.9a
T_1V_3	6.5ab	12.3bcd	13.3	6.2	11.9abcde	12.9c
T_1V_4	7.4a	12.4bc	13.3	7.1	12.1abcde	13.0bc
T_1V_5	5.7b	11.3cde	13.4	5.5	10.9defg	13.9b
T_2V_1	6.5ab	11.6cde	13.0	6.3	11.1bcdefg	12.7cd
T_2V_2	7.4a	13.3ab	14.1	7.0	12.9abc	13.6b
T_2V_3	6.6ab	11.4cde	12.6	6.3	11.0cdefg	12.2cd
T_2V_4	6.0b	10.5e	13.0	5.8	10.1fg	12.9c
T_2V_5	6.0b	10.5e	12.3	5.8	10.1efg	11.9d
T_3V_1	6.7ab	11.4cde	13.3	6.3	11.0defg	12.9c
T_3V_2	7.4a	11.5cde	13.4	7.1	11.2bcdefg	13.0bc
T_3V_3	5.8b	10.1e	11.7	5.6	9.85g	11.3de
T_3V_4	6.8b	10.8de	11.6	6.3	10.5efg	11.2de
T_3V_5	5.8b	10.8de	12.0	5.6	10.4efg	11.0e
T_4V_1	6.7ab	11.6cde	12.6	6.3	11.1bcdefg	12.2cd
T_4V_2	7.3a	13.2ab	13.4	6.9	12.8abcd	13.1bc
T_4V_3	6.0b	10.6e	11.5	5.7	10.2efg	11.0de
T_4V_4	6.4ab	11.6cde	11.5	6.1	11.2bcdefg	11.2de
T_4V_5	5.8b	11.2cde	11.3	5.6	10.8efg	11.7d
CV%	1.59	1.25	2.26	7.74	10.16	10.87

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT

T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4=mango tree, V_1= BR10, V_2= BR11, V_3= BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety)

Table 4.1.2. Interaction Effect of tree species and rice variety on number of tillers hill^{-1} in 2006 and 2007

Treatment combination	Number of tillers/hill at 2006			Number of tillers/hill at 2007		
	30 DAT	45DAT	60DAT	30 DAT	45DAT	60DAT
T_1V_1	7.4a	13.4ab	15.2	7.0	13.0ab	14.8a
T_1V_2	7.2a	14.1a	15.3	6.9	13.7a	14.9a
T_1V_3	6.5ab	12.3bcd	13.3	6.2	11.9abcde	12.9c
T_1V_4	7.4a	12.4bc	13.3	7.1	12.1abcde	13.0bc
T_1V_5	5.7b	11.3cde	13.4	5.5	10.9defg	13.9b
T_2V_1	6.5ab	11.6cde	13.0	6.3	11.1bcdefg	12.7cd
T_2V_2	7.4a	13.3ab	14.1	7.0	12.9abc	13.6b
T_2V_3	6.6ab	11.4cde	12.6	6.3	11.0cdefg	12.2cd
T_2V_4	6.0b	10.5e	13.0	5.8	10.1fg	12.9c
T_2V_5	6.0b	10.5e	12.3	5.8	10.1efg	11.9d
T_3V_1	6.7ab	11.4cde	13.3	6.3	11.0defg	12.9c
T_3V_2	7.4a	11.5cde	13.4	7.1	11.2bcdefg	13.0bc
T_3V_3	5.8b	10.1e	11.7	5.6	9.85g	11.3de
T_3V_4	6.8b	10.8de	11.6	6.3	10.5efg	11.2de
T_3V_5	5.8b	10.8de	12.0	5.6	10.4efg	11.0e
T_4V_1	6.7ab	11.6cde	12.6	6.3	11.1bcdefg	12.2cd
T_4V_2	7.3a	13.2ab	13.4	6.9	12.8abcd	13.1bc
T_4V_3	6.0b	10.6e	11.5	5.7	10.2efg	11.0de
T_4V_4	6.4ab	11.6cde	11.5	6.1	11.2bcdefg	11.2de
T_4V_5	5.8b	11.2cde	11.3	5.6	10.8efg	11.7d
CV%	1.59	1.25	2.26	7.74	10.16	10.87

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT

T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4=mango tree, V_1= BR10, V_2= BR11, V_3= BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety)

Table 4.1.2. Interaction Effect of tree species and rice variety on number of tillers hill^{-1} in 2006 and 2007

Treatment combination	Number of tillers/hill at 2006			Number of tillers/hill at 2007		
	30 DAT	45DAT	60DAT	30 DAT	45DAT	60DAT
T_1V_1	7.4a	13.4ab	15.2	7.0	13.0ab	14.8a
T_1V_2	7.2a	14.1a	15.3	6.9	13.7a	14.9a
T_1V_3	6.5ab	12.3bcd	13.3	6.2	11.9abcde	12.9c
T_1V_4	7.4a	12.4bc	13.3	7.1	12.1abcde	13.0bc
T_1V_5	5.7b	11.3cde	13.4	5.5	10.9defg	13.9b
T_2V_1	6.5ab	11.6cde	13.0	6.3	11.1bcdefg	12.7cd
T_2V_2	7.4a	13.3ab	14.1	7.0	12.9abc	13.6b
T_2V_3	6.6ab	11.4cde	12.6	6.3	11.0cdefg	12.2cd
T_2V_4	6.0b	10.5e	13.0	5.8	10.1fg	12.9c
T_2V_5	6.0b	10.5e	12.3	5.8	10.1efg	11.9d
T_3V_1	6.7ab	11.4cde	13.3	6.3	11.0defg	12.9c
T_3V_2	7.4a	11.5cde	13.4	7.1	11.2bcdefg	13.0bc
T_3V_3	5.8b	10.1e	11.7	5.6	9.85g	11.3de
T_3V_4	6.8b	10.8de	11.6	6.3	10.5efg	11.2de
T_3V_5	5.8b	10.8de	12.0	5.6	10.4efg	11.0e
T_4V_1	6.7ab	11.6cde	12.6	6.3	11.1bcdefg	12.2cd
T_4V_2	7.3a	13.2ab	13.4	6.9	12.8abcd	13.1bc
T_4V_3	6.0b	10.6e	11.5	5.7	10.2efg	11.0de
T_4V_4	6.4ab	11.6cde	11.5	6.1	11.2bcdefg	11.2de
T_4V_5	5.8b	11.2cde	11.3	5.6	10.8efg	11.7d
CV%	1.59	1.25	2.26	7.74	10.16	10.87

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T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4=mango tree, V_1= BR10, V_2= BR11, V_3= BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety)

4.1.3 Straw fresh weight

Effect of tree species

Straw fresh weight was significantly affected due to the Effect of tree species (Figure 4.1.9-10). In 2006, significantly the highest straw fresh weight per hill (80.82 g) was recorded in T_1 (open field) followed by T_2 (70.52 g). T_3 (guava) produced significantly the lowest amount (53.12 g) of fresh straw of rice.

In 2007, influencing pattern of straw fresh weight per hill by the treatment was quite similar to that of 2005. The results showed that decreasing light incidence was causing decreasing the amount straw fresh weight. This might be due to minimum photosynthesis in decreased light conditions.

Response of rice varieties

Straw fresh weight of transplanted aman rice was significantly influenced by varietals effect (Figure 4.1.11-12). In 2005, the highest straw fresh weight (72.82 g) per hill was produced by V_1 (BR 10) followed by V_2 (BR 11). The lowest amount of straw fresh weight (62.5 g) was recorded in V_5 (sorna) that was identical to (63.47 gm) V_3 (BRRI dhan 33).

In 2006, the highest straw fresh weight (72.82 g) per hill was produced by V_1 (BR 10) which was identical to V_2 (68.28 g). In this year V_3 and V_4 produced statistically similar fresh weight (61.04 and 64.22 g respectively). V_5 also produced lowest amount of straw fresh weight (60.19 g).

Interaction Effect of tree species and rice variety

Straw fresh weight of transplanted aman rice was significantly affected by the interaction of tree and variety (Table 4.1.3). In both the cropping seasons (2006 & 2007) T_1V_2 (BR 11 in open field) produced the highest straw fresh weight (84.70 and 82.20 g in 2006 and 2007 respectively). In 2007, T_1V_2 was statistically similar to that of T_1V_5 (77.75 g), T_2V_1 (77.3 g), T_1V_3 (76.95 g) and T_1V_4 (76.75 g). But the lowest straw fresh weight producing combinations were T_3V_1 (54.70 g), T_3V_2 (48.90 g), T_3V_3 (48.90 g), T_3V_4 (47.9 g) and T_3V_5 (52.70 g) which were statistically similar also. On the other hand in 2005 interaction effect made the combination almost dissimilar from each other. Although T_1V_1 (BR 10 in open field) combination produced the 2nd highest (81.70 g) straw fresh weight followed by T_2V_1 (79.8 g). The lowest amount of straw fresh weight (50.40 g) was recorded in T_3V_4 (BRRI dhan 39 under guava) which was identical to T_3V_2 (51.40 g) and T_3V_3 (51.40 g).

4.1.3 Straw fresh weight

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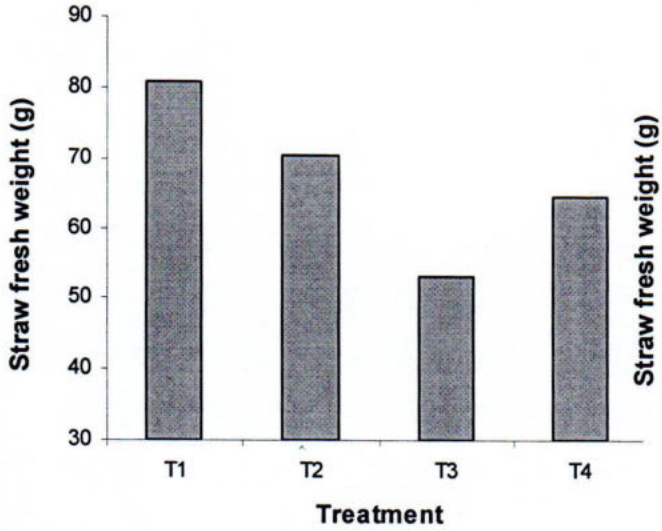

Fig 4.1.9. Effect of tree species on straw fresh weight in 2006

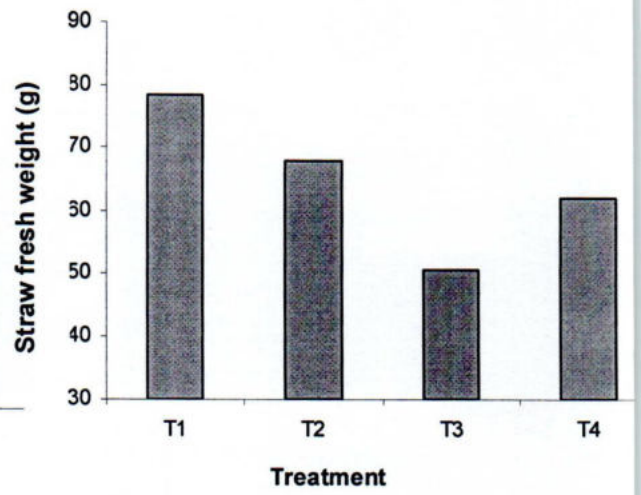

Fig 4.1.10. Effect of tree species on straw fresh weight in 2007

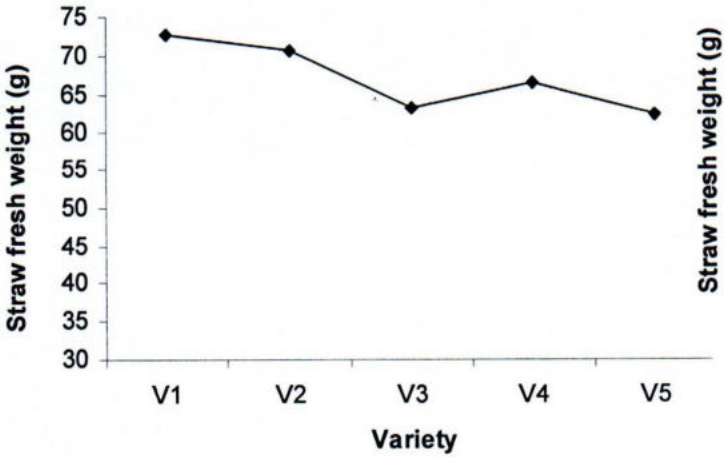

Fig 4.1.11. Effect of varieties on straw fresh weight in 2006

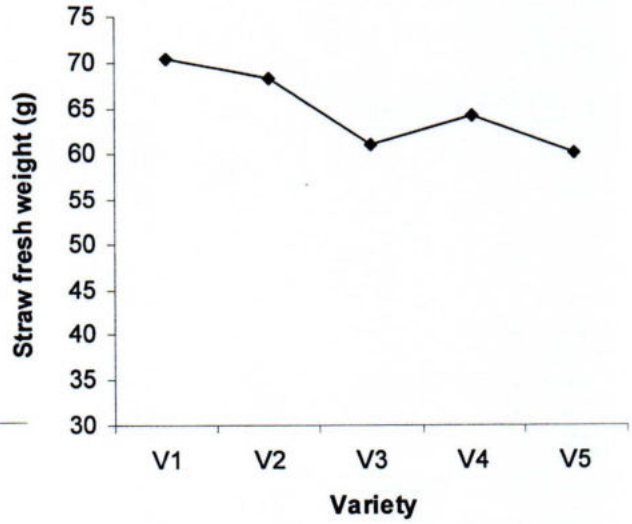

Fig 4.1.12. Effect of varieties on straw fresh weight in 2007

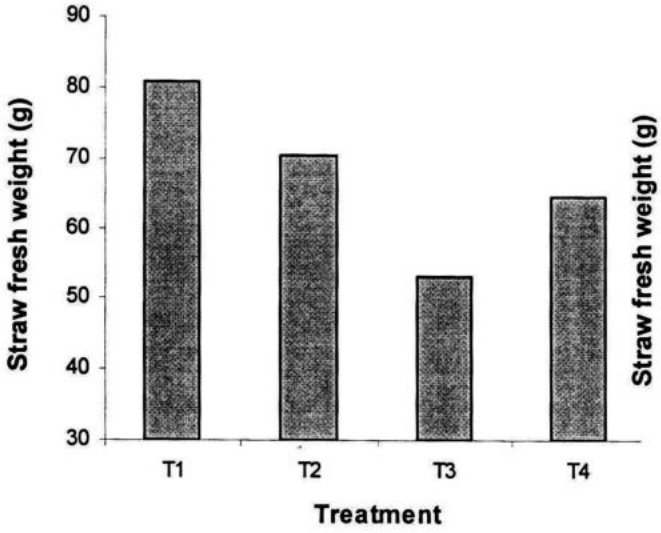

Fig 4.1.9. Effect of tree species on straw fresh weight in 2006

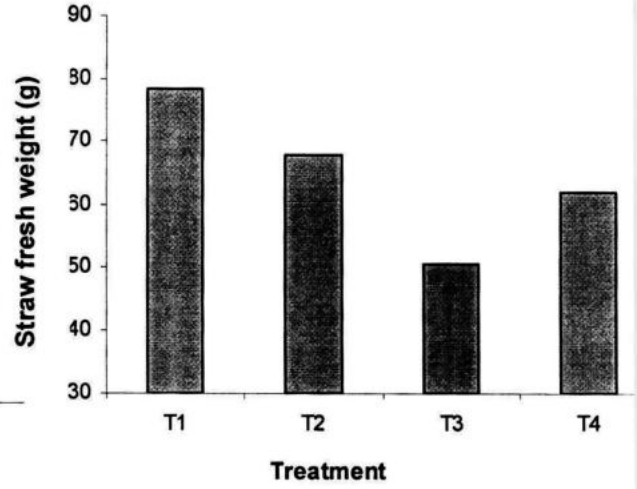

Fig 4.1.10. Effect of tree species on straw fresh weight in 2007

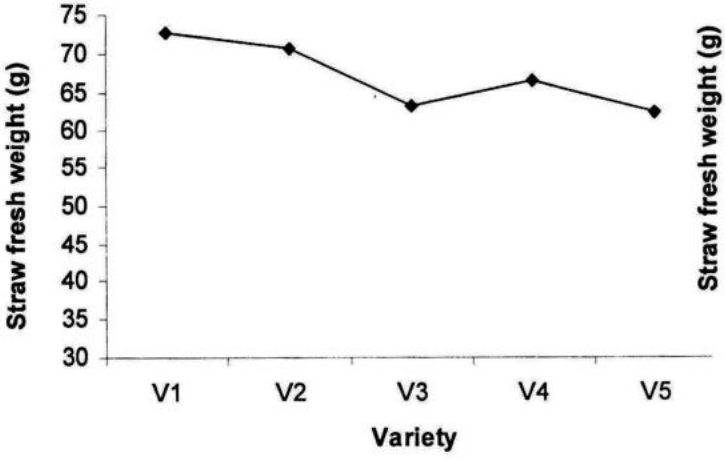

Fig 4.1.11. Effect of varieties on straw fresh weight in 2006

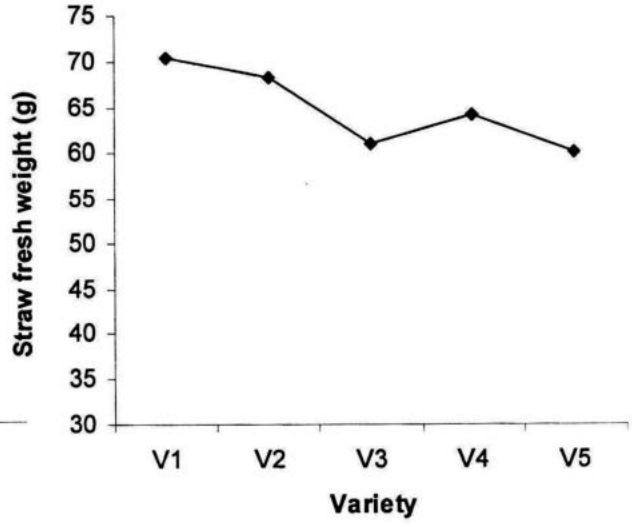

Fig 4.1.12. Effect of varieties on straw fresh weight in 2007

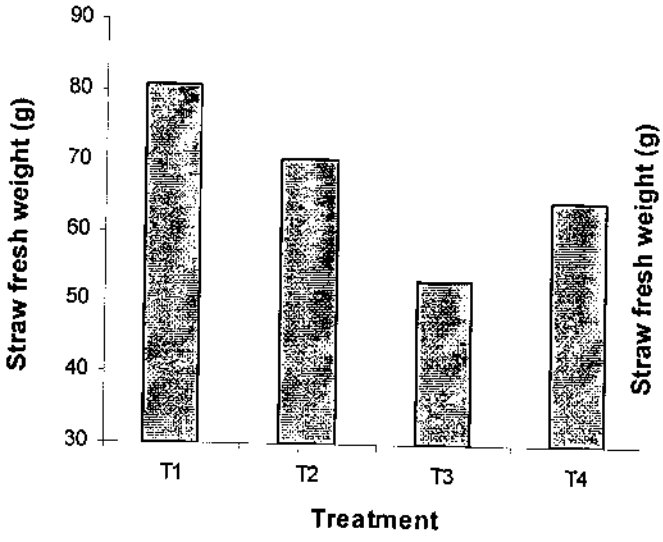

Fig 4.1.9. Effect of tree species on straw fresh weight in 2006

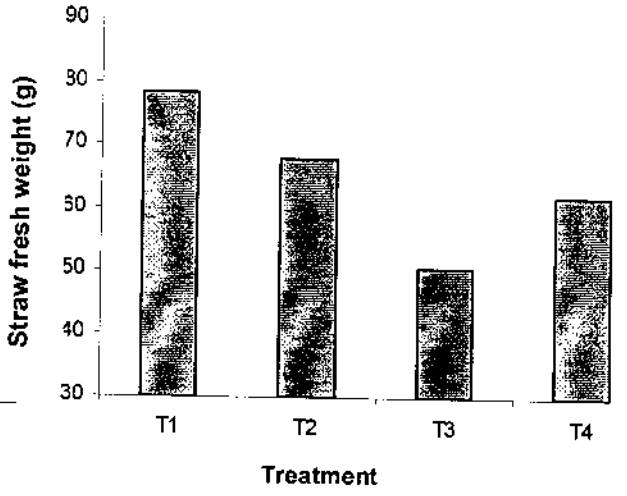

Fig 4.1.10. Effect of tree species on straw fresh weight in 2007

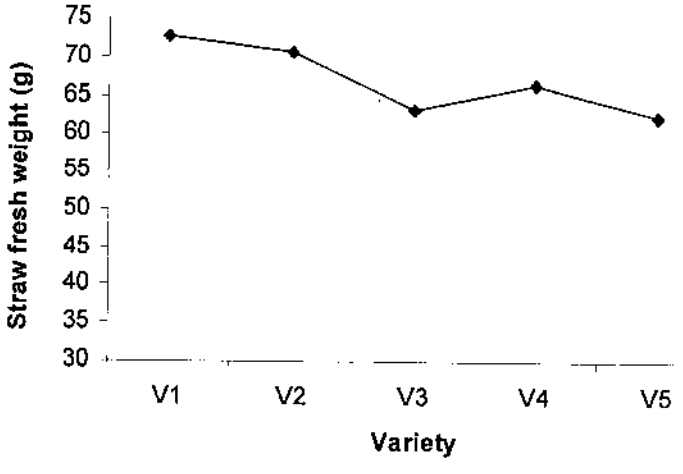

Fig 4.1.11. Effect of varieties on straw fresh weight in 2006

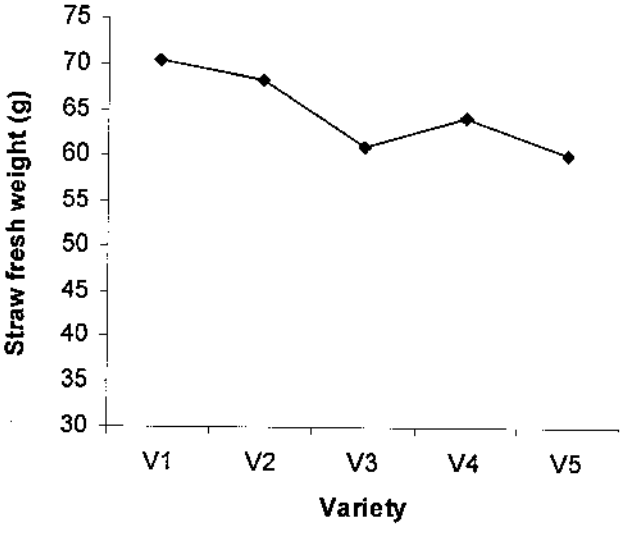

Fig 4.1.12. Effect of varieties on straw fresh weight in 2007

Table 4.1.3. Interaction Effect of tree species and variety on straw fresh weight and straw dry weight in 2006 and 2007

Treatment Combination	Straw fresh weight (g)		Straw dry weight (g)	
	2006	2007	2006	2007
T_1V_1	81.70 b	79.20 ab	28.50 abcd	28.13 d
T_1V_2	84.70 a	82.20 a	34.43 a	33.70 a
T_1V_3	79.20 c	76.95 abc	23.27 def	22.70 gh
T_1V_4	79.00 c	76.75 abc	27.03 bcde	26.65 e
T_1V_5	79.50 c	77.75 ab	32.70 ab	23.22 h
T_2V_1	79.80 c	77.3 ab	28.83 abcd	28.38 d
T_2V_2	75.40 d	72.9 bcd	24.67 cdef	24.33 f
T_2V_3	68.20 f	76.70 b	22.83 def	22.13 h
T_2V_4	69.20 f	66.70 de	18.23 f	17.95 j
T_2V_5	60.00 g	57.53 f	18.00 f	17.63 j
T_3V_1	57.20 h	54.70f g	24.80 cdef	24.38 f
T_3V_2	51.40 j	48.90 g	23.63 cdef	23.23 fgh
T_3V_3	51.40 j	48.90 g	23.50 cdef	23.15 fgh
T_3V_4	50.40 j	47.90 g	21.17 ef	20.88 i
T_3V_5	55.20 i	52.70f g	20.33 ef	20.13 i
T_4V_1	72.60 e	70.10 cde	29.00 abcd	28.50 d
T_4V_2	71.60 e	69.10 de	30.57 abc	30.2 c
T_4V_3	55.10 i	52.60 fg	24.87 cdef	25.92 e
T_4V_4	67.97 f	65.55 e	23.93 cdef	23.7 fg
T_4V_5	55.30 i	52.80 fg	20.53 ef	20.17 i
CV%	0.19	6.92	2.56	3.49

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

T_1 = Sole (open field), T_2 = Black siris, T_3 = Guava, T_4 =mango tree, V_1 = BR10, V_2 = BR11, V_3 = BRRI Dhan 33, V_4 = BRRI Dhan 39, V_5 = Sorna (Local variety)

Table 4.1.3. Interaction Effect of tree species and variety on straw fresh weight and straw dry weight in 2006 and 2007

Treatment Combination	Straw fresh weight (g)		Straw dry weight (g)	
	2006	2007	2006	2007
T_1V_1	81.70 b	79.20 ab	28.50 abcd	28.13 d
T_1V_2	84.70 a	82.20 a	34.43 a	33.70 a
T_1V_3	79.20 c	76.95 abc	23.27 def	22.70 gh
T_1V_4	79.00 c	76.75 abc	27.03 bcde	26.65 e
T_1V_5	79.50 c	77.75 ab	32.70 ab	23.22 h
T_2V_1	79.80 c	77.3 ab	28.83 abcd	28.38 d
T_2V_2	75.40 d	72.9 bcd	24.67 cdef	24.33 f
T_2V_3	68.20 f	76.70 b	22.83 def	22.13 h
T_2V_4	69.20 f	66.70 de	18.23 f	17.95 j
T_2V_5	60.00 g	57.53 f	18.00 f	17.63 j
T_3V_1	57.20 h	54.70f g	24.80 cdef	24.38 f
T_3V_2	51.40 j	48.90 g	23.63 cdef	23.23 fgh
T_3V_3	51.40 j	48.90 g	23.50 cdef	23.15 fgh
T_3V_4	50.40 j	47.90 g	21.17 ef	20.88 i
T_3V_5	55.20 i	52.70f g	20.33 ef	20.13 i
T_4V_1	72.60 e	70.10 cde	29.00 abcd	28.50 d
T_4V_2	71.60 e	69.10 de	30.57 abc	30.2 c
T_4V_3	55.10 i	52.60 fg	24.87 cdef	25.92 e
T_4V_4	67.97 f	65.55 e	23.93 cdef	23.7 fg
T_4V_5	55.30 i	52.80 fg	20.53 ef	20.17 i
CV%	0.19	6.92	2.56	3.49

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

T_1 = Sole (open field), T_2 = Black siris, T_3 = Guava, T_4 =mango tree, V_1 = BR10, V_2 = BR11, V_3 = BRRI Dhan 33, V_4 = BRRI Dhan 39, V_5 = Sorna (Local variety)

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	2006	2007	2006	2007
T_1V_1	81.70 b	79.20 ab	28.50 abcd	28.13 d
T_1V_2	84.70 a	82.20 a	34.43 a	33.70 a
T_1V_3	79.20 c	76.95 abc	23.27 def	22.70 gh
T_1V_4	79.00 c	76.75 abc	27.03 bcde	26.65 e
T_1V_5	79.50 c	77.75 ab	32.70 ab	23.22 h
T_2V_1	79.80 c	77.3 ab	28.83 abcd	28.38 d
T_2V_2	75.40 d	72.9 bcd	24.67 cdef	24.33 f
T_2V_3	68.20 f	76.70 b	22.83 def	22.13 h
T_2V_4	69.20 f	66.70 de	18.23 f	17.95 j
T_2V_5	60.00 g	57.53 f	18.00 f	17.63 j
T_3V_1	57.20 h	54.70f g	24.80 cdef	24.38 f
T_3V_2	51.40 j	48.90 g	23.63 cdef	23.23 fgh
T_3V_3	51.40 j	48.90 g	23.50 cdef	23.15 fgh
T_3V_4	50.40 j	47.90 g	21.17 ef	20.88 i
T_3V_5	55.20 i	52.70f g	20.33 ef	20.13 i
T_4V_1	72.60 e	70.10 cde	29.00 abcd	28.50 d
T_4V_2	71.60 e	69.10 de	30.57 abc	30.2 c
T_4V_3	55.10 i	52.60 fg	24.87 cdef	25.92 e
T_4V_4	67.97 f	65.55 e	23.93 cdef	23.7 fg
T_4V_5	55.30 i	52.80 fg	20.53 ef	20.17 i
CV%	0.19	6.92	2.56	3.49

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T_1 = Sole (open field), T_2 = Black siris, T_3 = Guava, T_4 =mango tree, V_1 = BR10, V_2 = BR11, V_3 = BRRI Dhan 33, V_4 = BRRI Dhan 39, V_5 = Sorna (Local variety)

4.1.4 Straw dry weight

Effect of tree species

Straw dry weight (g) was significantly influenced by the tree and influencing pattern was similar to that of straw fresh weight in both the cropping seasons. Significantly the highest straw weight was recorded in open field (29.19 and 28.68 g in 2006 and 2007, respectively) which was followed by T_4 and then T_3. In 2005, straw dry weight (25.78 g) produced by T_4 (mango) was statistically similar to that of (22.51 g) T_2 (black siris) but in 2007 they were statistically different. T_3 (guava) always produced significantly lowest straw dry weight (16.69 and 15.35 g in 2006 and 2007, respectively)

Response of rice varieties

There was significant effect of variety on straw dry weight. The maximum straw dry weight (28.33 and 27.86 g in 2006 and 2007, respectively) was produced by V_1 (BR 10) which was identical to V_2 (BR 11) in both the year (27.78 and 27.34 in 2006 and 2007, respectively). V_3, V_4 and V_5 produced statistically similar but lowest straw dry weight in 2006. In 2007, V_5 (22.29 g) and V_3 (22.54 g) produced the lowest but similar straw dry weight.

Interaction Effect of tree species and rice variety

Straw dry weight was significantly influenced by the interaction effect of tree species and variety in both experimental years (2006 and 2007). Significantly the highest straw dry weight obtained from T_1V_1 combination in both the years (34.43 and 33.7 gm in 2006 and 2007 respectively) which was followed by T_4V_1 (30.57 and 30.2 gm in 2006 and 2007 respectively) combination. Significantly the lowest amount of straw dry weight was recorded in T_3V_5 combination (18.0 and 17.63 g in 2006 and 2007, respectively)

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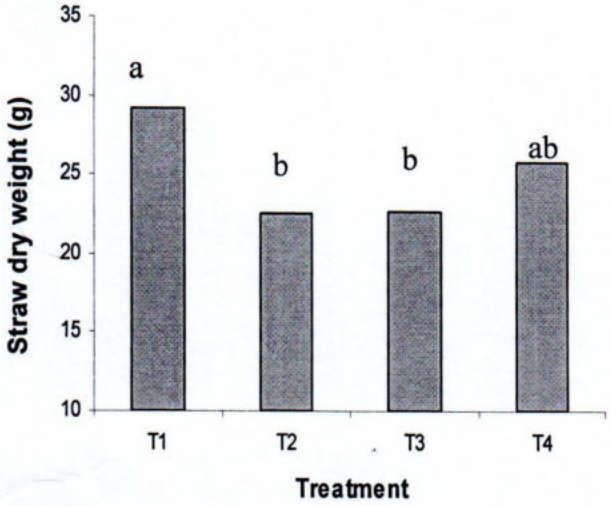

Fig 4.1.13. Effect of tree species on straw dry weight in 2006

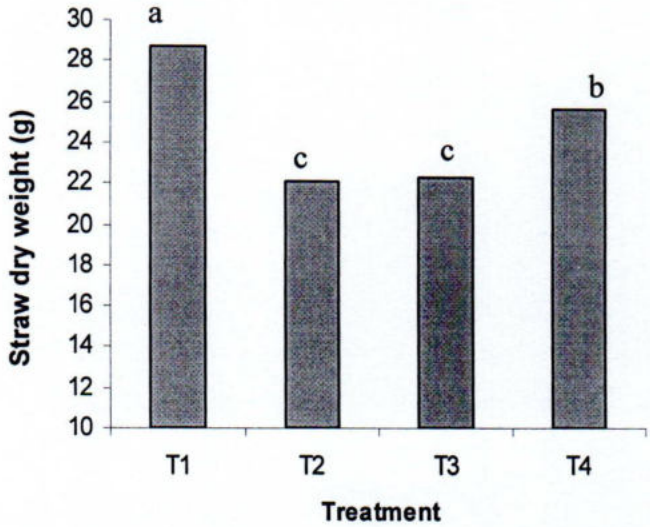

Fig 4.1.14. Effect of tree species on straw dry weight in 2007

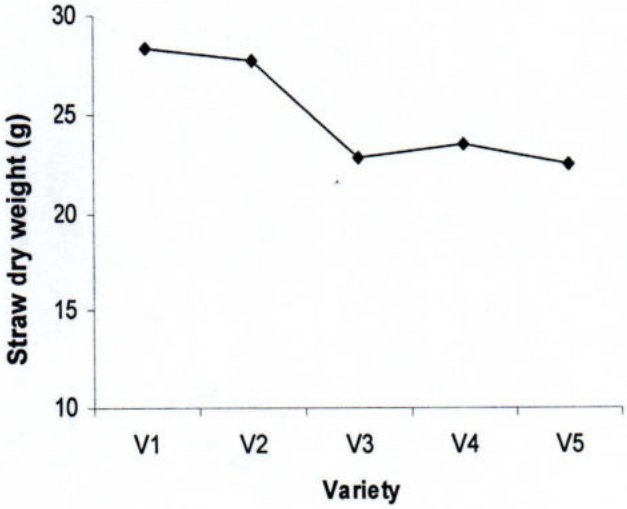

Fig 4.1.15. Effect of varieties on straw dry weight in 2006

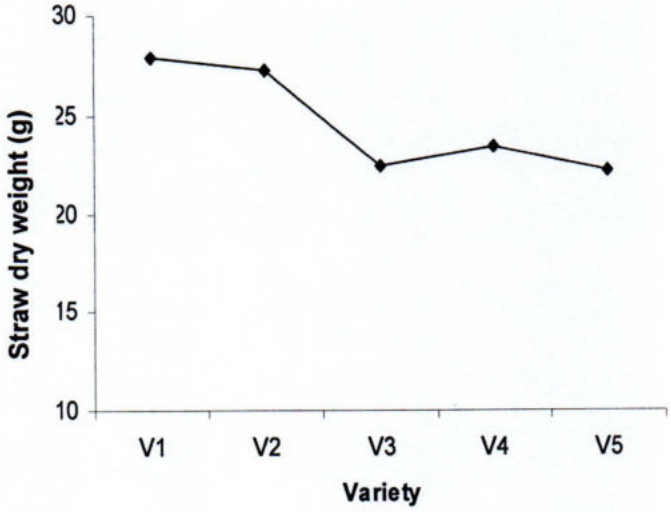

Fig 4.1.16. Effect of varieties on straw dry weight in 2007

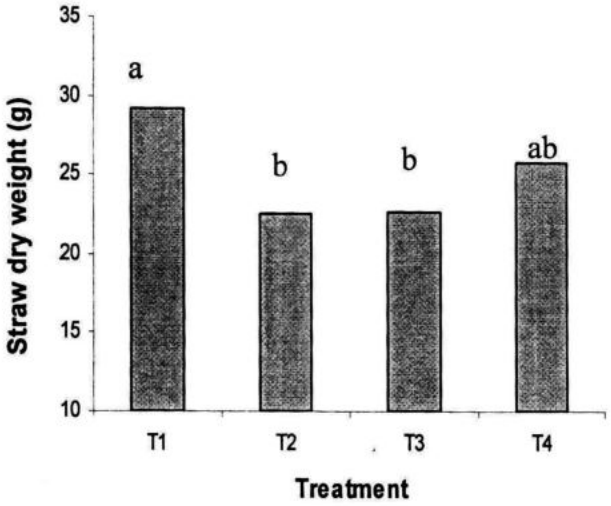

Fig 4.1.13. Effect of tree species on straw dry weight in 2006

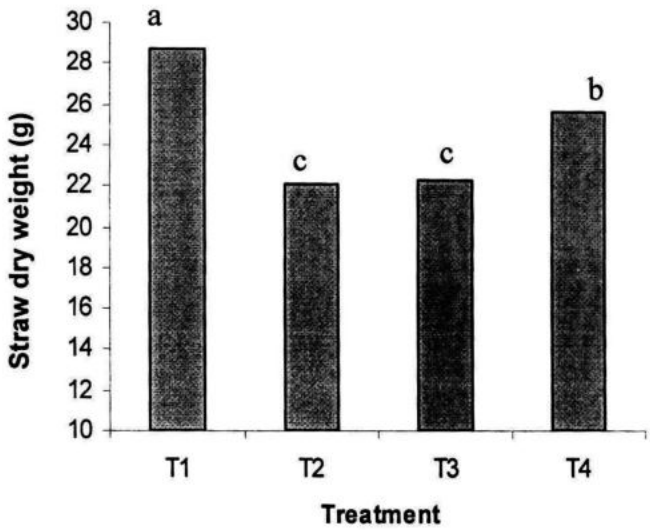

Fig 4.1.14. Effect of tree species on straw dry weight in 2007

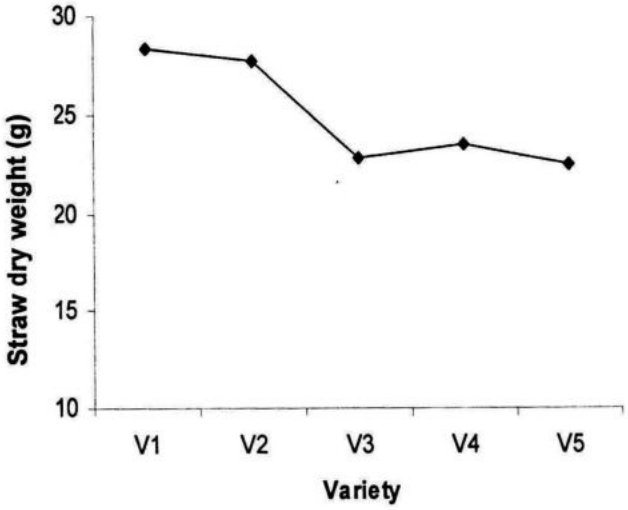

Fig 4.1.15. Effect of varieties on straw dry weight in 2006

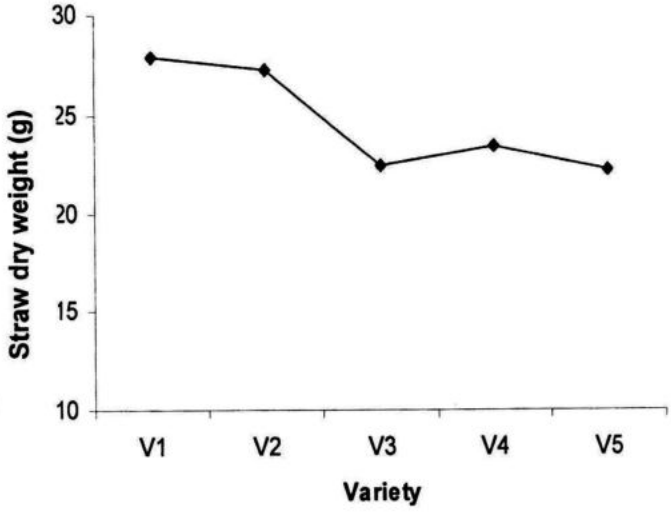

Fig 4.1.16. Effect of varieties on straw dry weight in 2007

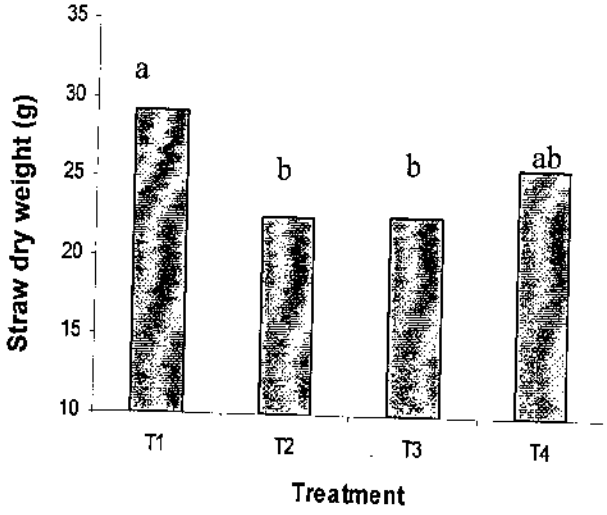

Fig 4.1.13. Effect of tree species on straw dry weight in 2006

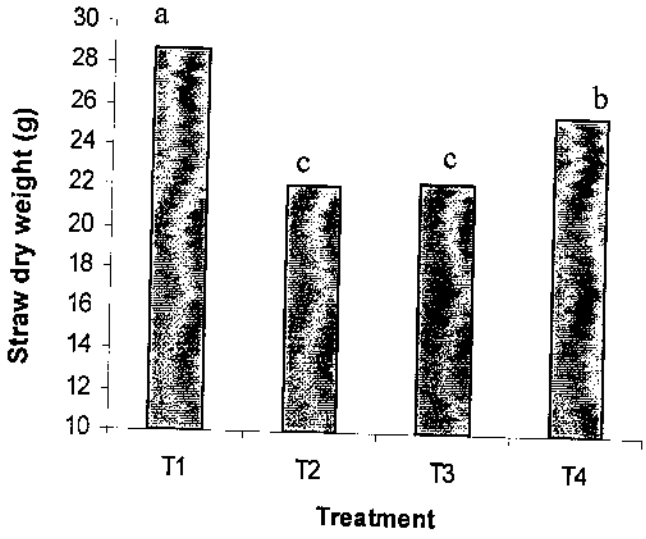

Fig 4.1.14. Effect of tree species on straw dry weight in 2007

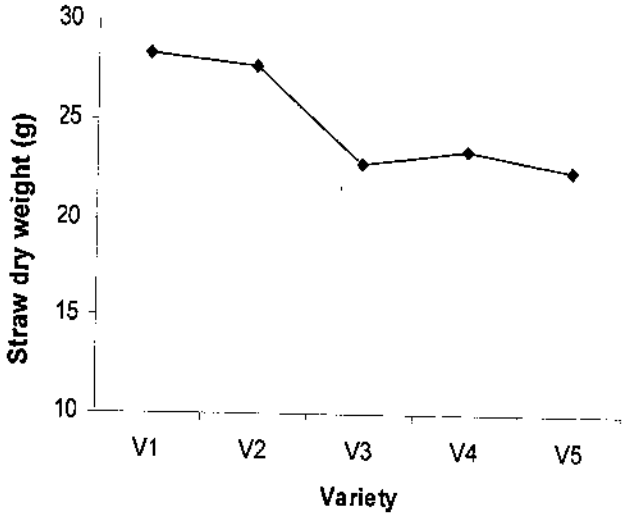

Fig 4.1.15. Effect of varieties on straw dry weight in 2006

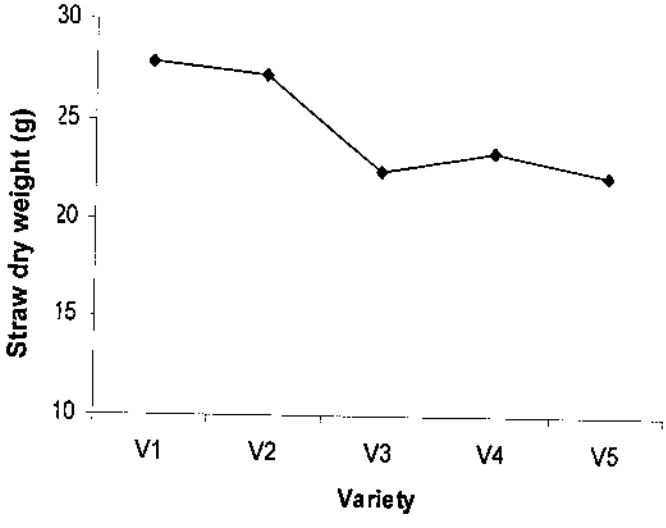

Fig 4.1.16. Effect of varieties on straw dry weight in 2007

4.1.5 Panicle length

Effect of tree species

The panicle length of transplanted aman was significantly influenced by the presence of different tree species in both year experiments. In 2006, significantly the highest panicle length (24.93 cm) was recorded in T_1 (open field) which was statistically identical to T_2 (24.25 cm). Significantly the lowest panicle length (23.04 cm) was recorded in T_4 (mango) which was statistically similar to T_3 (23.17cm).

In 2007, significantly the highest panicle length (24.62 cm) was recorded in T_1 (open field) which was statistically identical to T_2 (23.97 cm), panicle length (22.80 cm) produced by T_4 (mango) was similar to that of T_2. Significantly the lowest panicle length (20.35 cm) was recorded in T_3 (guava).

Response of rice varieties

Panicle length was significantly influenced by the effect of variety. In 2006, longest panicle length (25.66 cm) was produced by V_2 (BR 11) followed by V_1 (24.88 cm). V_1 was statistically similar to those of V_2 and V_3 (23.81 cm). The shortest panicle length (22.11 cm) was produced by V_5 which was quite identical to that of V_4 (22.77 cm) and similar to that of V_3. In 2007, panicle length was affected as it was in 2006. The highest length of panicle was recorded in V_2 (25.38 cm) followed by V_1 (24.57 cm), V_3 (23.58 cm), V_4 (22.77 cm) and V_5 (22.13 cm)

Interaction Effect of tree species and rice variety

Panicle length was significantly influenced by the interaction effect of tree species and variety (Table 4.1.4) in both the year. In 2006, the highest panicle length (26.50 cm) was recorded in T_1V_2 combination (BR 11 in open field) which was statistically similar to that of T_1V_1 (25.73 cm), T_1V_3 (24.90 cm), T_2V_1 (24.67 cm), T_2V_2 (25.63 cm), T_3V_2 (25.00 cm) and T_4V_2 (25.50 cm). Significantly the lowest length (19.77 cm) of panicle was obtained from T_4V_5 combination. In 2007, significantly the highest panicle length (26.17 cm) was recorded from BR 11 in open field (T_1V_2). Although no other combination was found similar to T_1V_2, but it was followed by T_1V_1 (25.38 cm), T_2V_2 (25.35 cm) and T_4V_2 (25.25 cm). Significantly the shortest panicle length (19.58 cm) was recorded in sorna under mango (T_4V_5 combination). The distinct variation of panicle length in 2006 among the treatment combination might be due to remarkable variation of light intensity permitted different tree canopies (the range was 46.5 - 100 %).

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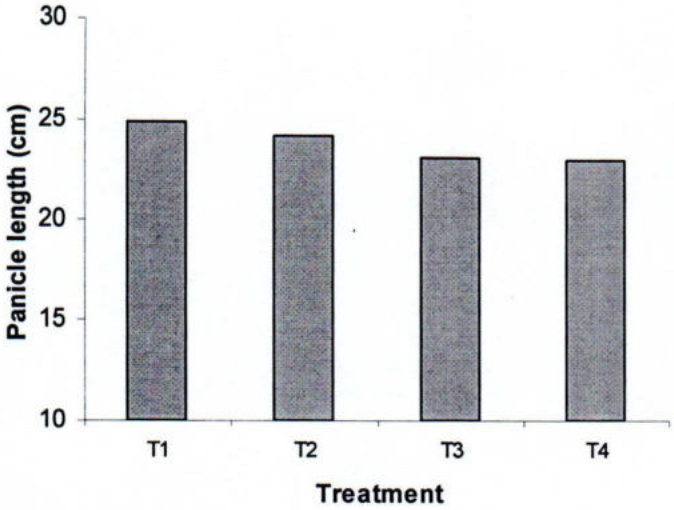

Fig 4.1.17. Effect of tree species on panicle length in 2006

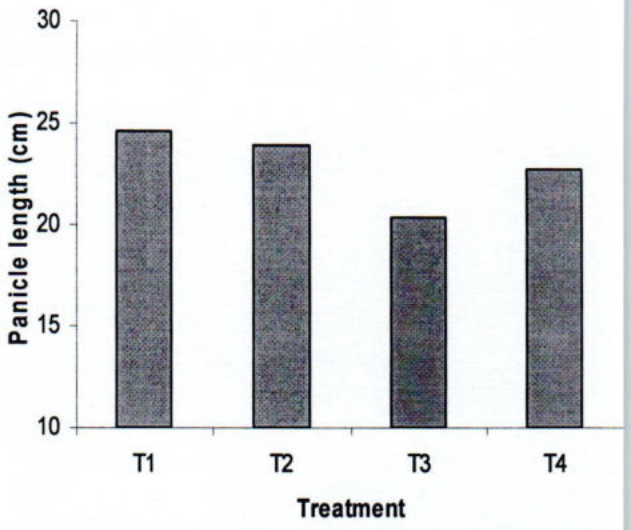

Fig 4.1.18. Effect of tree species on panicle length in 2007

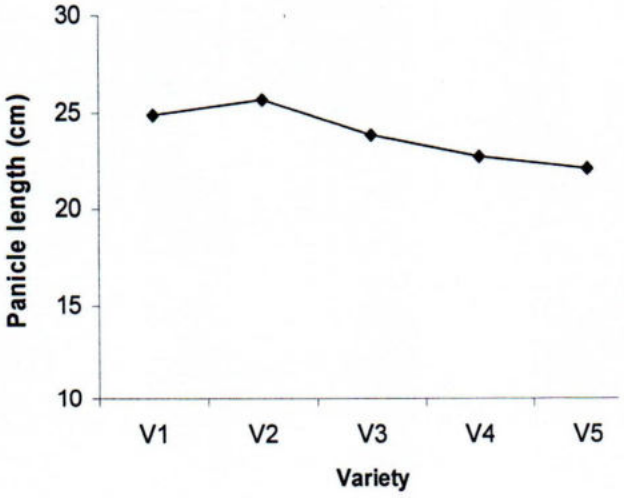

Fig 4.1.19. Effect of varieties on panicle length weight in 2006

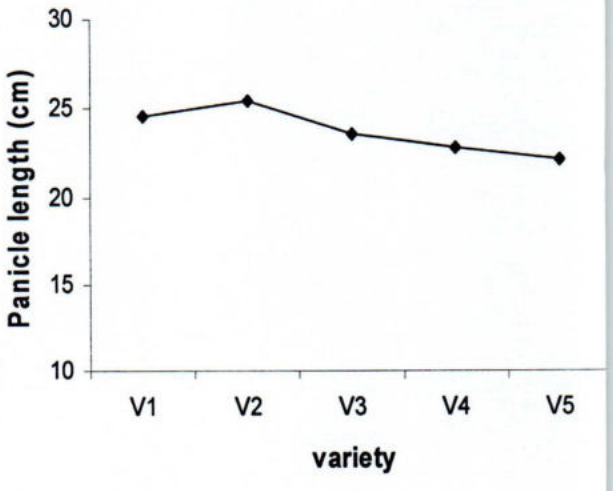

Fig 4.1.20. Effect of varieties on panicle length weight in 2007

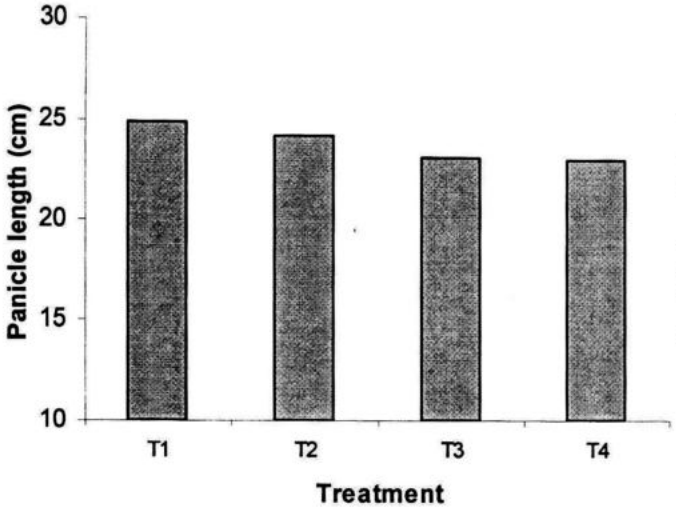

Fig 4.1.17. Effect of tree species on panicle length in 2006

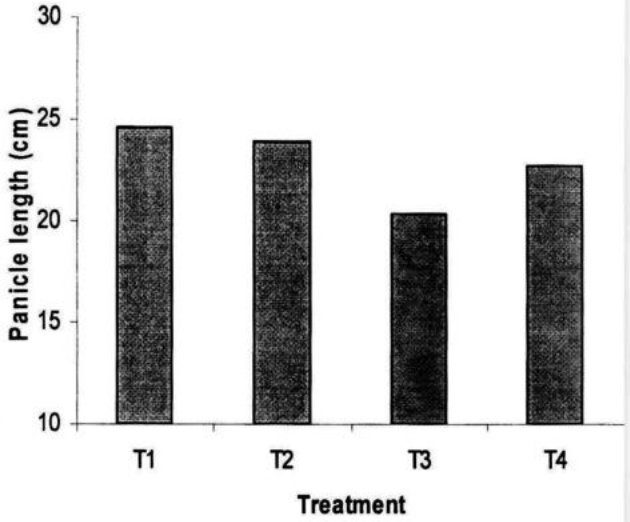

Fig 4.1.18. Effect of tree species on panicle length in 2007

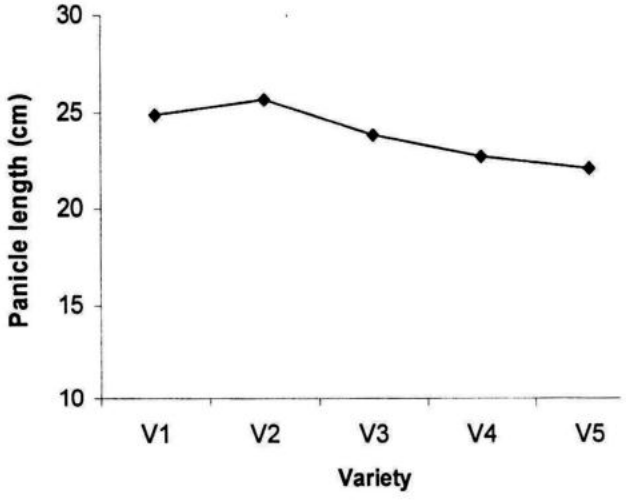

Fig 4.1.19. Effect of varieties on panicle length weight in 2006

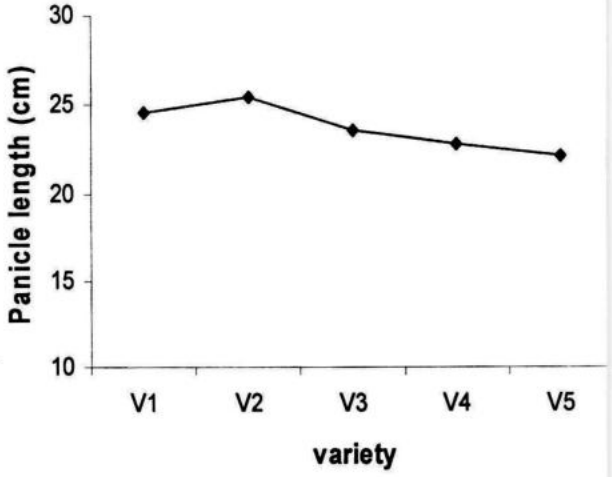

Fig 4.1.20. Effect of varieties on panicle length weight in 2007

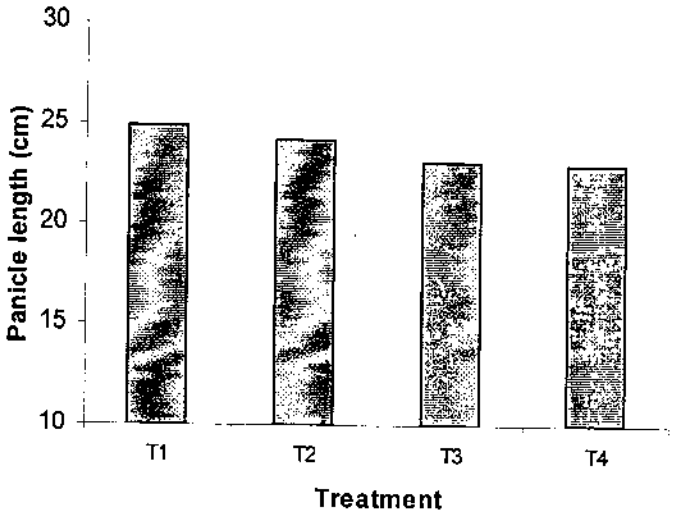

Fig 4.1.17. Effect of tree species on panicle length in 2006

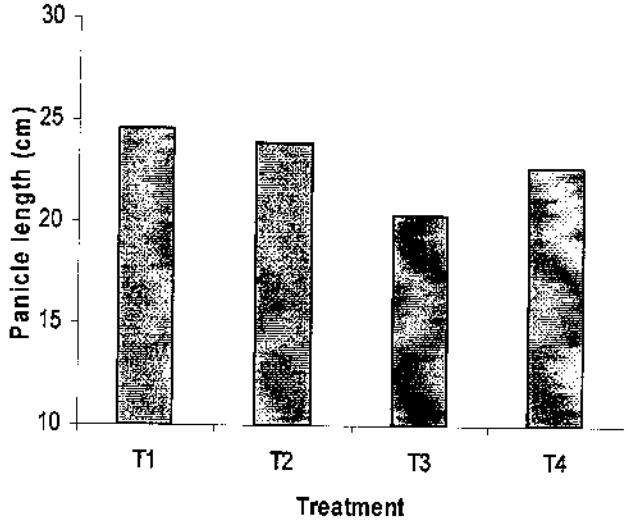

Fig 4.1.18. Effect of tree species on panicle length in 2007

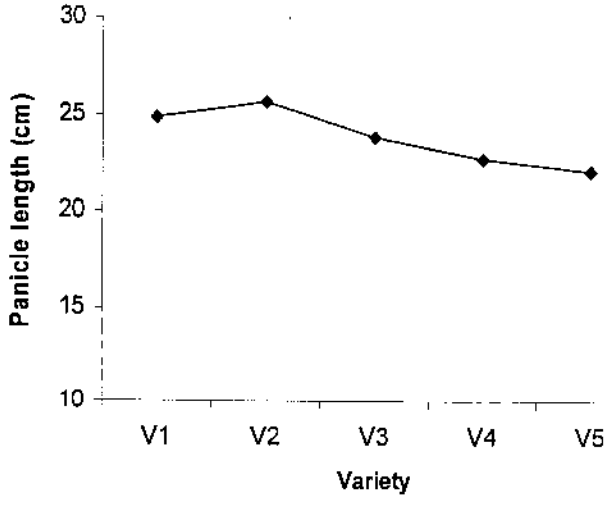

Fig 4.1.19. Effect of varieties on panicle length weight in 2006

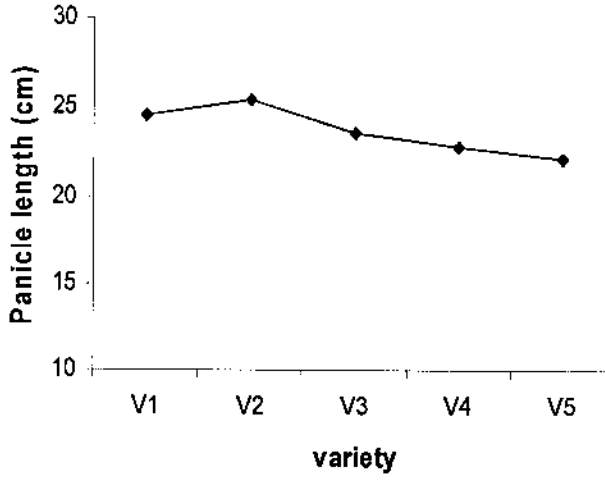

Fig 4.1.20. Effect of varieties on panicle length weight in 2007

4.1.6 Number of grains panicle^{-1}

Effect of tree species

The effect of tree species on number of grains panicle^{-1} of transplanted aman rice was not significant in 2006. In 2006, the highest number of grains panicle^{-1} (158.5) was recorded in T_1 (open field). The lowest number of grains panicle^{-1} (148.3) was recorded in T_3 (guava).

In 2007, significantly the highest number of grains panicle^{-1} (157.40) was recorded in T_1 (open field) followed by T_2 (150.90). Significantly the lowest number of grains panicle^{-1} (136.4) was recorded in T_3 (guava) followed by T_4 (147.50).

Response of rice varieties

Number of grains panicle^{-1} of transplanted aman rice was significantly varied among the varieties. In 2006, significantly the highest number of grains panicle^{-1} (165.1) was recorded in V_2 (BR 11) which was statistically identical to V_1 (154.9). Significantly the lowest number of grain/ panicle (143) was recorded in V_5 (sorna) which was statistically similar to V_4 (148.4) and V_3 (149.9)

In 2007, significantly the highest number of grains panicle^{-1}(162.6) was recorded in V_2 (BR 11) followed by V_1 (151.1) and V_3 (151.1). Significantly the lowest number of grains panicle^{-1} (141.6) was recorded in V_5 (sorna) which was statistically similar to V_4 (146.40).

Interaction Effect of tree species and rice variety

Number of grains panicle^{-1} was greatly affected by the interaction effects of tree and variety (Table 4.1.4) in both experimental years and the affecting pattern was almost similar to influencing pattern of panicle length.

In 2006, significantly the maximum no. of grains panicle^{-1} was recorded (175.0) in T_1V_2 (164.3) combination no. of grain produced by T_4V_2 (BR 11 under mango) combination was statistically similar to those of T_1V_2 and T_1V_1 (163.7) combinations. The moderate no. of grain was found in T_2V_2 (161.0), T_3V_2 (160.0), T_1V_3 (155.3) and T_2V_1 (154.3) combinations. The lowest no. of grain (137.7) was recorded in T_3V_5 combination which was statistically similar to that of T_4V_5 (140.0), T_4V_4 (146.0), T_4V_3 (146.7), T_3V_4 (146.7), T_3V_3 (146.7) and T_2V_5 (146.7) combinations. The Interaction effect showed that V_2 (BR 11) was more tolerant to shade than other varieties in all treatment combinations followed by V_1 (BR 10).

In 2007, highest no. of grains panicle^{-1} (172.5) was produced by T_1V_2 (BR 11 in open field) combination followed by T_4V_2 (166.0) and then T_1V_1 (154.0) combinations. These two combinations were also statistically similar to that of T_1V_2. Other combinations were varied like 2006. (Table 4.1.4)

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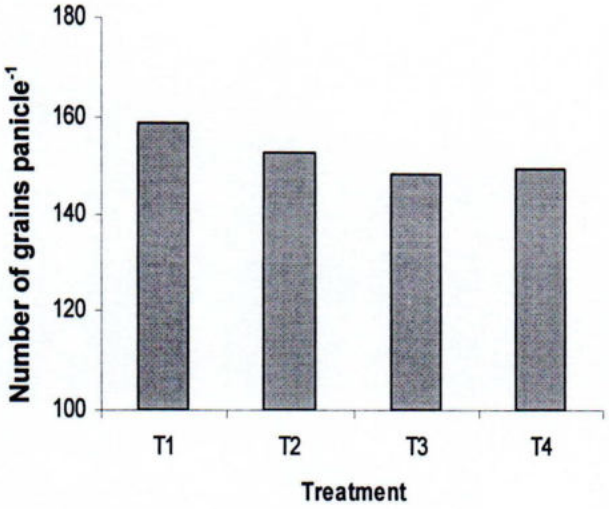


Fig 4.1.21. Effect of tree species on number of grains panicle^{-1}in 2006

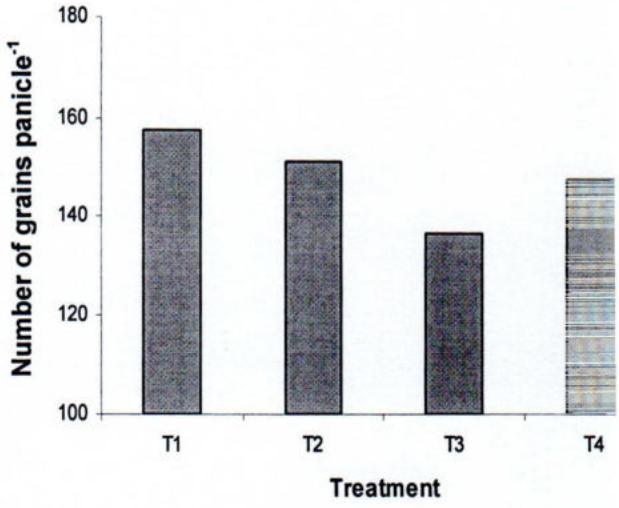


Fig 4.1.22. Effect of tree species on number o grains panicle^{-1}in 2007

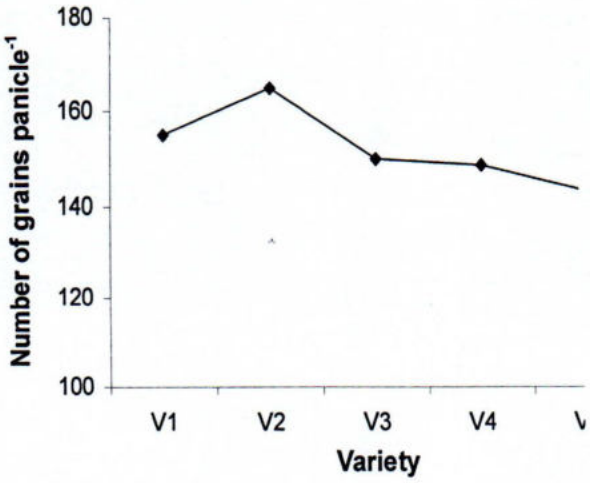
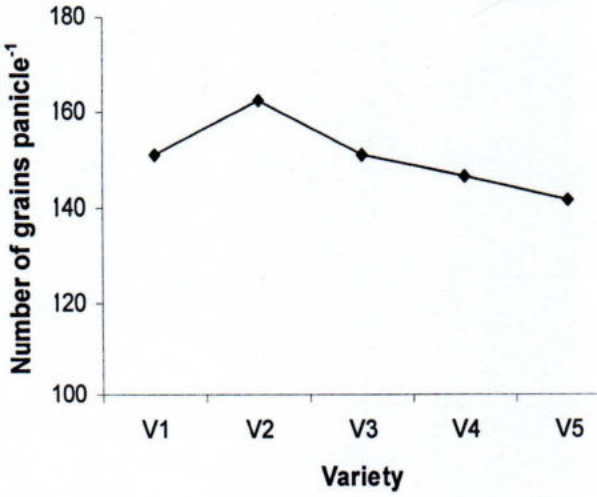


Fig 4.1.23. Effect of varieties on number of grains panicle^{-1}weight in 2006



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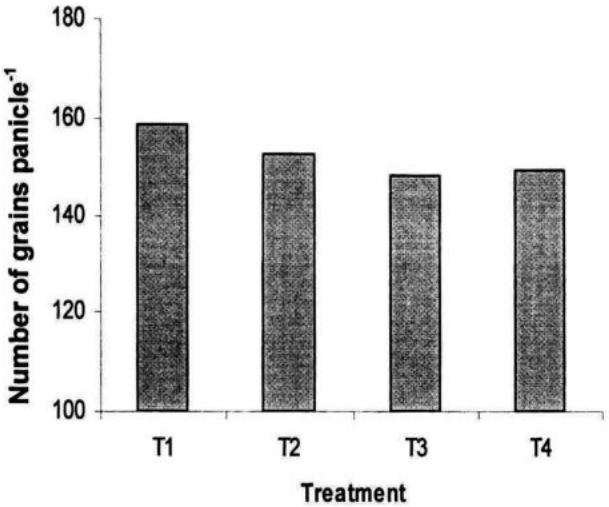

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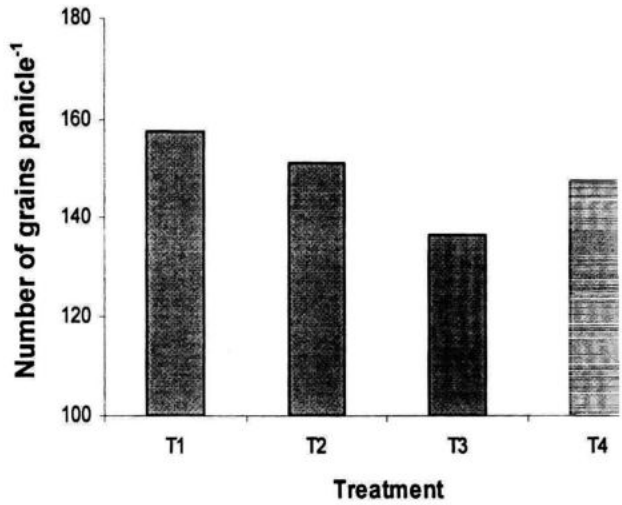

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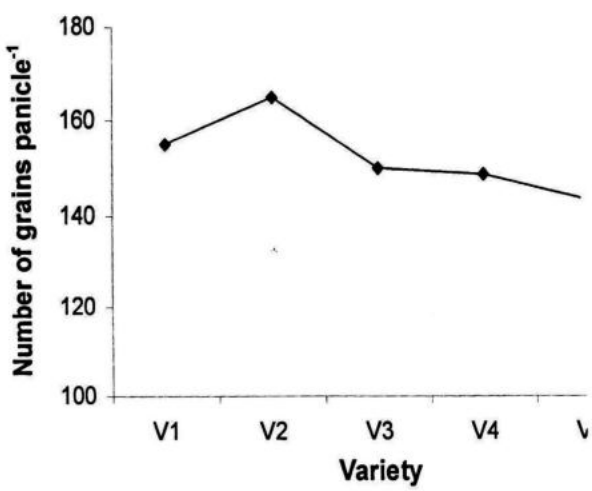

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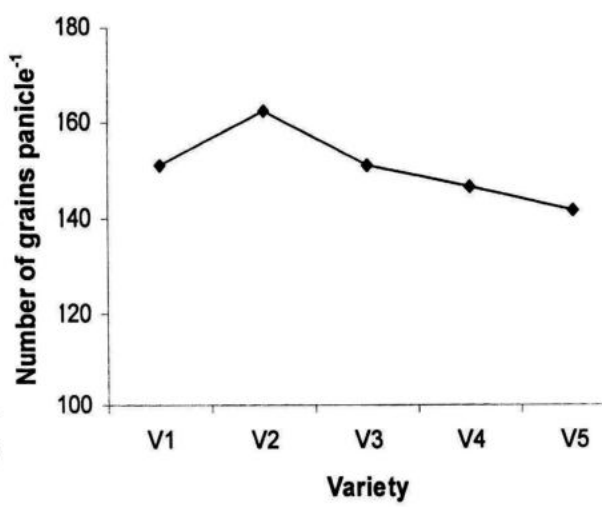

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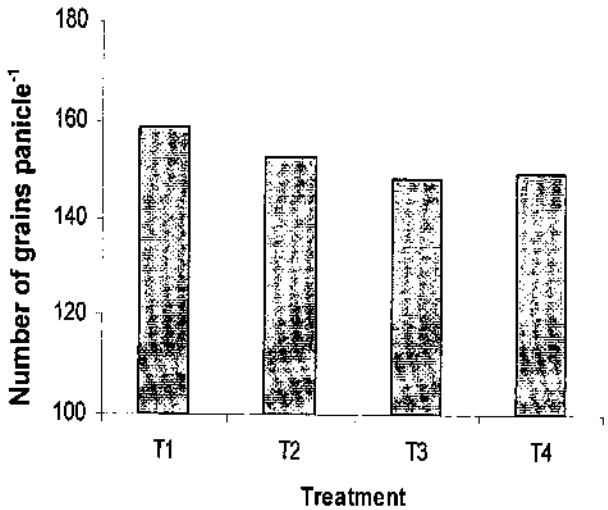

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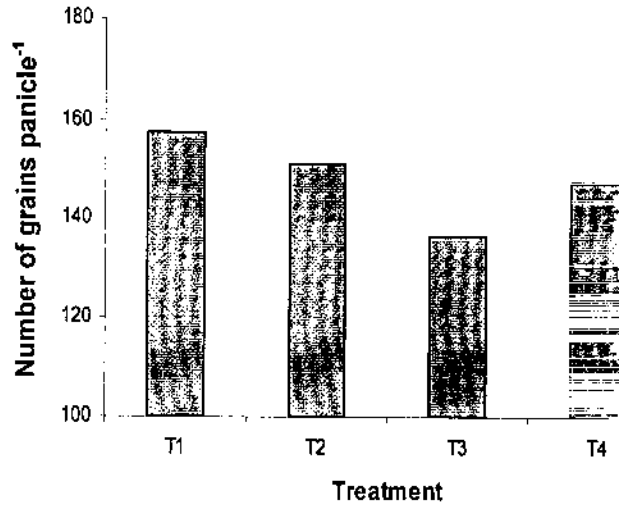

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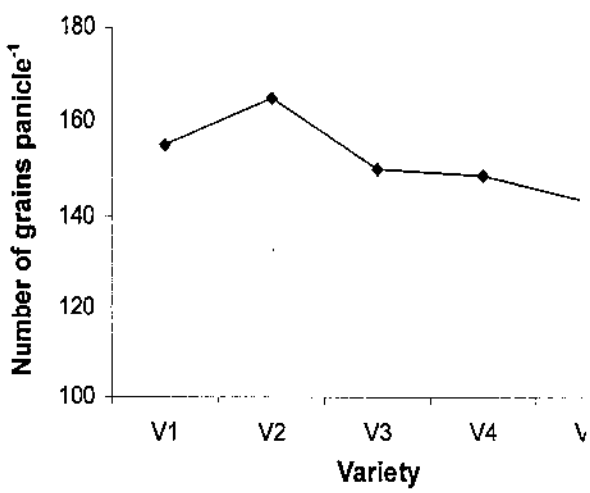

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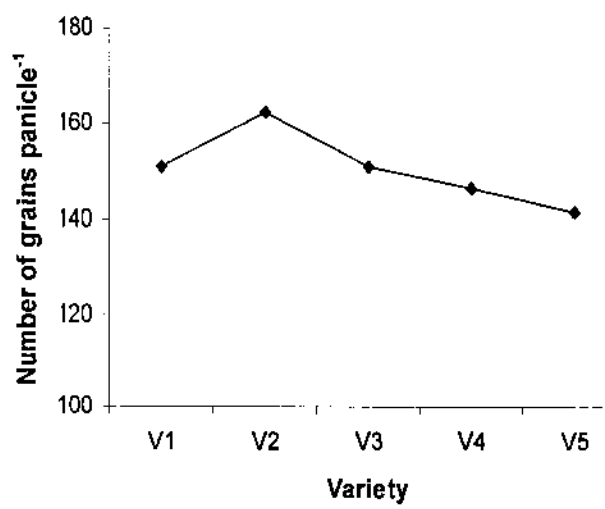

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4.1.7 Sterile Spikelets panicle^{-1}

Effect of tree species

Sterile spikelets panicle^{-1} was significantly affected due to the effect of tree species. In 2006, significantly the highest sterile spikelets panicle^{-1} (16.59) was recorded in T_3 (guava) which was statistically identical to T_2 (14.82). Significantly the lowest sterile spikelets panicle^{-1} (12.49) was recorded in T_1 (open field) which was statistically similar to T_4 (13.17cm).

In 2007, significantly the highest sterile spikelets panicle^{-1} (20.16) was recorded in T_3 (guava) followed by T_2 (14.42). Significantly the lowest sterile spikelets panicle^{-1} (12.10) was recorded in T_1 (open field) which was statistically similar to T_4 (12.79).

Response of rice varieties

Sterile spikelets panicle^{-1} of transplanted aman rice was significantly influenced by varietal effect. In 2006, significantly the highest sterile spikelets panicle^{-1} (18.45) was recorded in V_4 (BRRI dhan 39) which was statistically identical to V_3 (17.89). Significantly the lowest Sterile spikelets panicle^{-1} (10.51) was recorded in V_2 (BR 11) followed by V_1 (12.6).

In 2007, significantly the highest sterile Spikelets panicle^{-1} (17.47) was recorded in V_4 (BRRI dhan 39) which was statistically identical to V_3 (17.89). Significantly the lowest sterile spikelets panicle^{-1} (9.57) was recorded in V_2 (BR 11) followed by V_1 (11.36).

Interaction Effect of tree species and rice variety

Sterile spikelets panicle^{-1} was one of the most important parameter for yield reduction which was influenced greatly by the interaction Effect of tree species and variety (Table 4.1.4) and influencing pattern was almost similar in both the cropping seasons. In both the years (2006 and 2007) significantly the highest no. of sterile spikelets panicle^{-1} was recorded in T_3V_4 (BRRI dhan 39 under guava) combination (21.17 and 20.88 in 2006 and 2007, respectively) followed by T_2V_3 and T_3V_3 combinations in both the cropping seasons (Table 4.1.5). Significantly the lowest number of sterile spikelets was recorded in T_1V_2 combination both the years and the values were 7.5 and 7.1 in the year 2006 and 2007, respectively.

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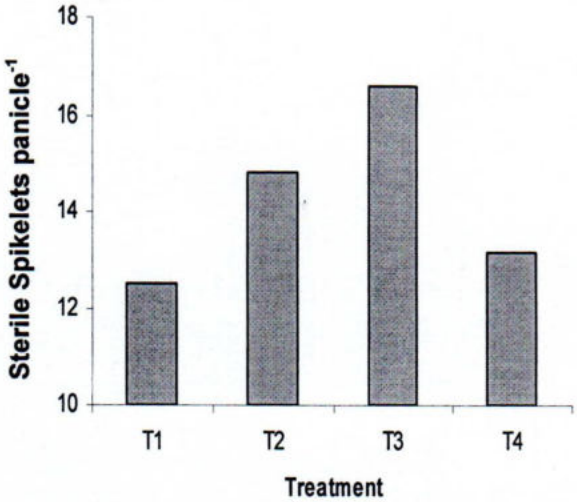


Fig 4.1.25. Effect of tree species on Sterile Spikelets panicle^{-1} in 2006

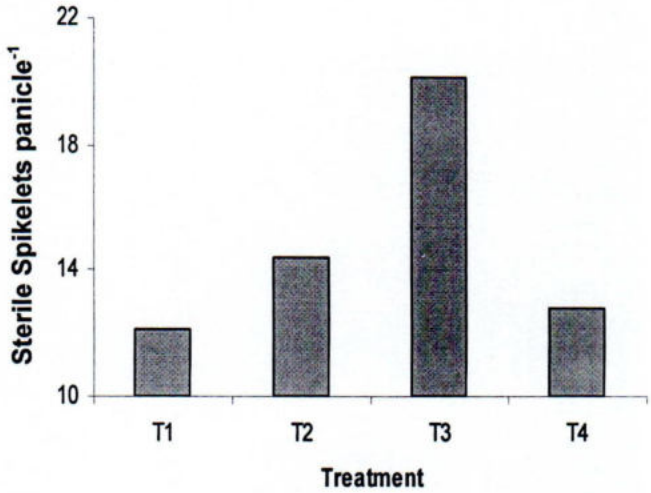
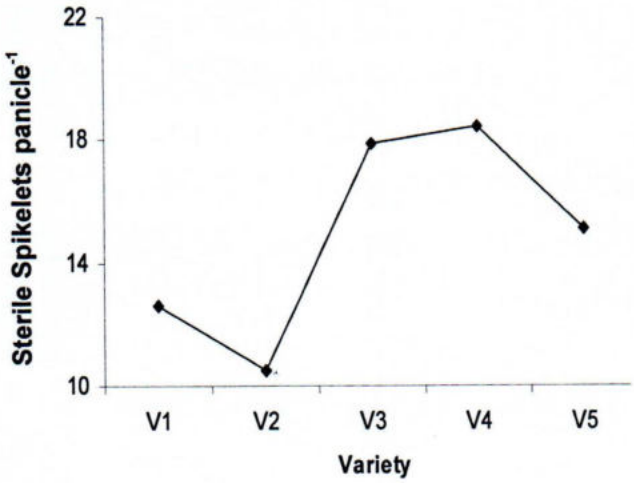


Fig 4.1.26. Effect of tree species on Sterile Spikelets panicle^{-1} in 2007



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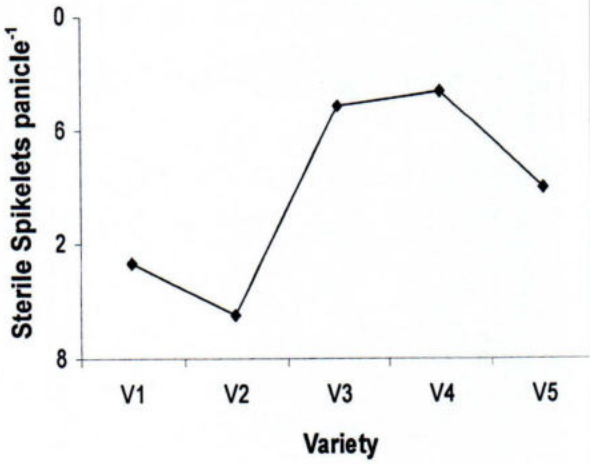
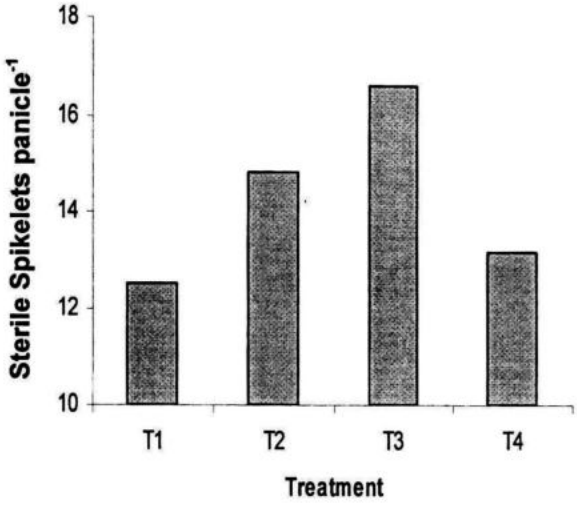


Fig 4.1.28. Effect of varieties on Sterile Spikelets panicle^{-1} in 2007



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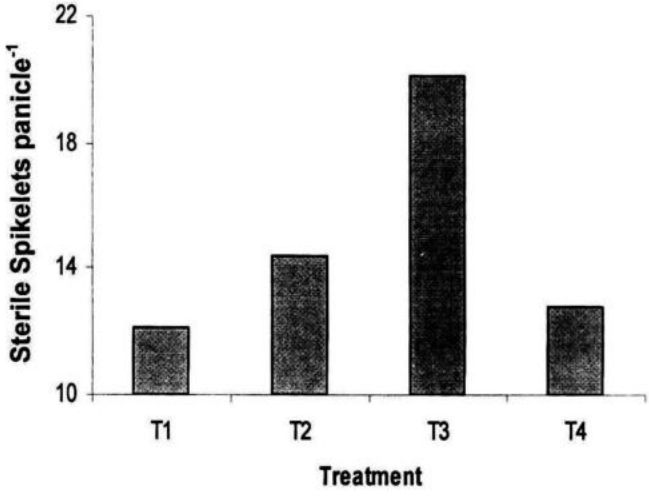

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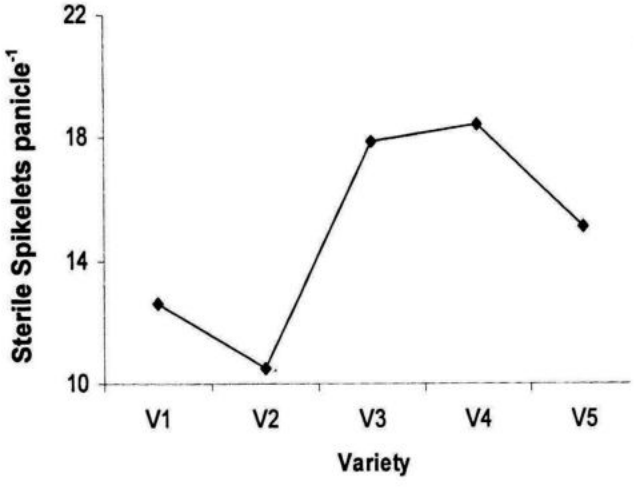

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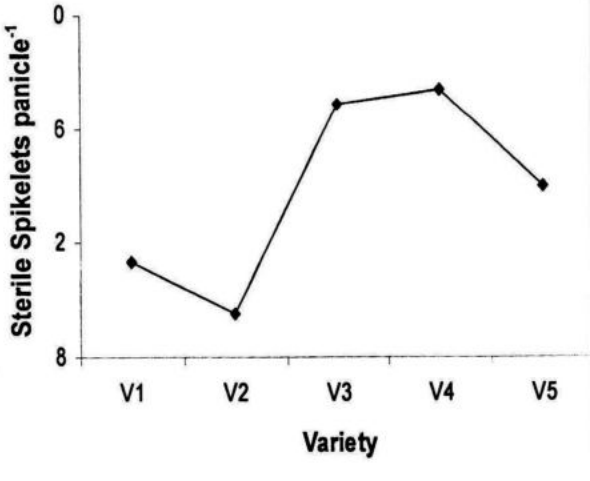


Fig 4.1.28. Effect of varieties on Sterile Spikelets panicle^{-1} in 2007

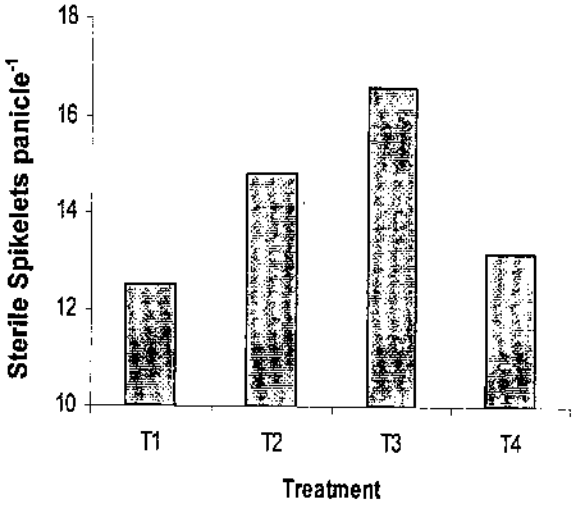


Fig 4.1.25. Effect of tree species on Sterile Spikelets panicle^{-1} in 2006

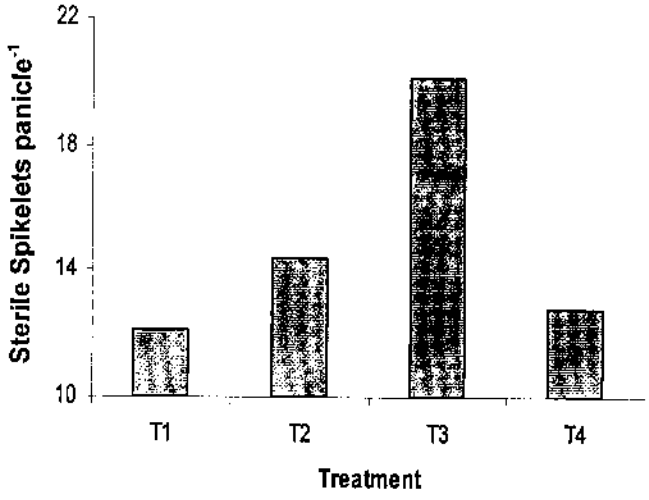


Fig 4.1.26. Effect of tree species on Sterile Spikelets panicle^{-1} in 2007

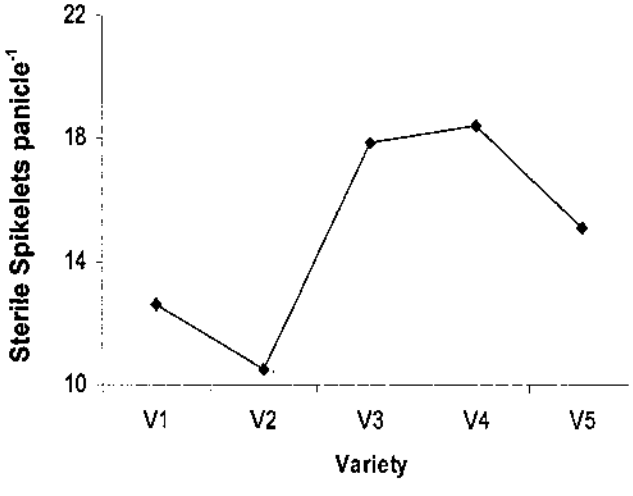
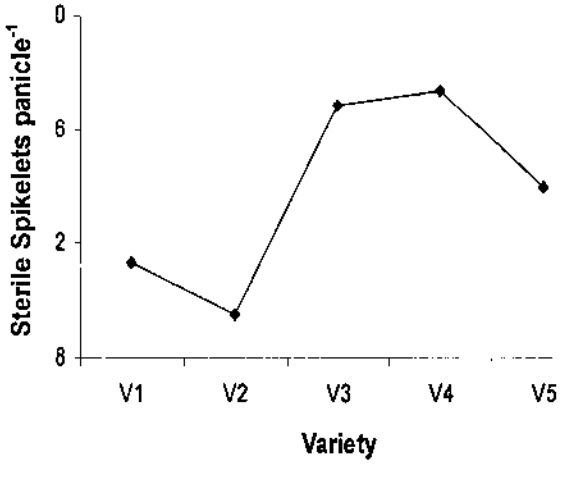


Fig 4.1.27. Effect of varieties on Sterile Spikelets panicle^{-1} in 2006



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4.1.8 1000 grain weight

Effect of tree species

The effect of tree species on 1000 grain weight of transplanted aman rice was not significant in 2006. In 2006, the highest 1000 grain weight (20.47 g) was recorded in T_1 (open field). The lowest 1000 grain weight (20.35 g) was recorded in T_3 (guava).

The effect of tree species on 1000 grain weight of transplanted aman rice was not also significant in 2007. In 2007, the highest 1000 grain weight (20.4g) was recorded in T_1 (open field). The lowest 1000 grain weight (20.12g) was recorded in T_3 (guava).

Response of rice varieties

The thousand grain weight of rice was significantly influenced by varieties. In 2006, significantly the highest 1000 grain weight (21.85 g) was recorded in V_2 (BRR 11) which was statistically identical to V_3 (21.72 g). Significantly the lowest 1000 grain weight (17.83 g) was recorded in V_5 (sorna) followed by V_4 (20.51 g).

In 2007, significantly the highest 1000 grain weight (21.63 g) was recorded in V_2 (BRR 11) which was statistically identical to V_3 (21.22 g). Significantly the lowest 1000 grain weight (17.43 g) was recorded in V_5 (sorna) followed by V_4 (20.31 g).

Interaction Effect of tree species and rice variety

The thousand grain weight was one of the vital yield contributing characters which varied between 1% and 5% level of significance in 2006 and 2007, respectively (Table 4.1.4) but their variation pattern was similar in both the years. The T_1V_2 combination produced the highest 1000 grain weight and the values were 21.97 and 21.73g in 2006 and 2007 respectively which was closely followed by T_2V_2 (21.93 and 21.7g in 2006 and 21.65g in 2006 and 2007 respectively) and then T_3V_2(21.67 and 21.42g in 2006 and 2007, respectively).

Significantly the lowest 1000 grain weight was recorded in T_3V_5 and T_4V_5 combinations and the values were 17.60 and 17.4 in 2005 and 2006, respectively which were statistically similar to that of T_1V_5 and T_2V_5.

From the Interaction Effect of tree species and variety on 1000 grain weight it was clear that V_2 (BR 11) performed the best in all treatment combinations. Although the numerical values of 1000 grain weight became higher where the light intensities were higher.

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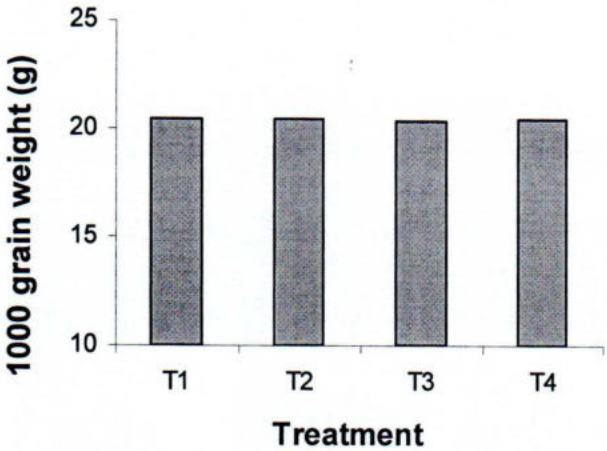


Fig 4.1.29. Effect of tree species on 1000 grain weight (g) in 2006

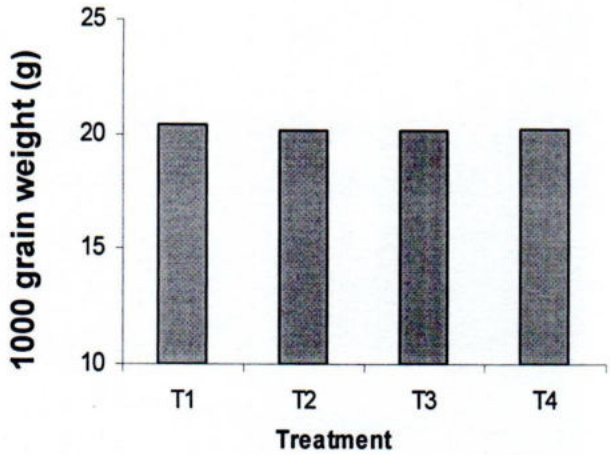


Fig 4.1.30. Effect of tree species on 1000 grain weight (g) in 2007

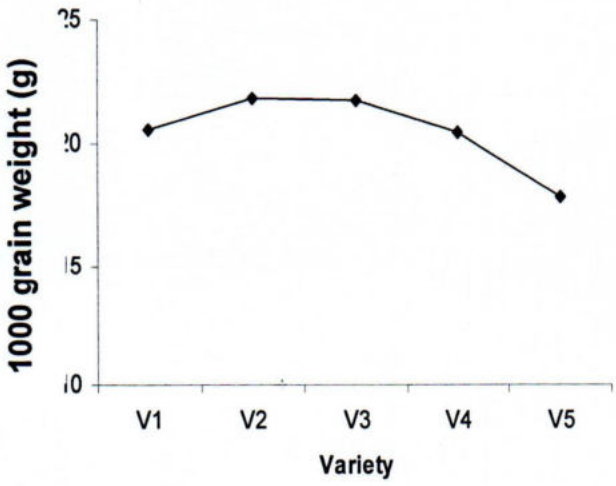


Fig 4.1.31. Effect of varieties on 1000 grain weight (g) in 2006

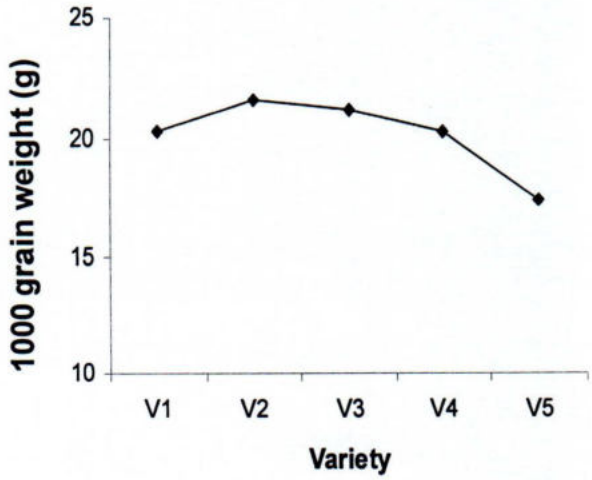
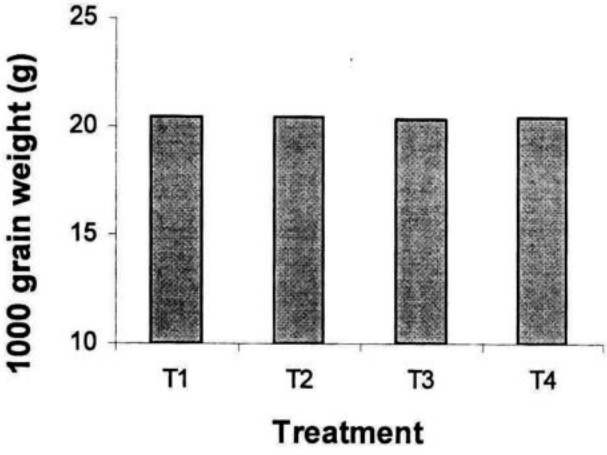


Fig 4.1.32. Effect of varieties on 1000 grain weight (g) in 2007



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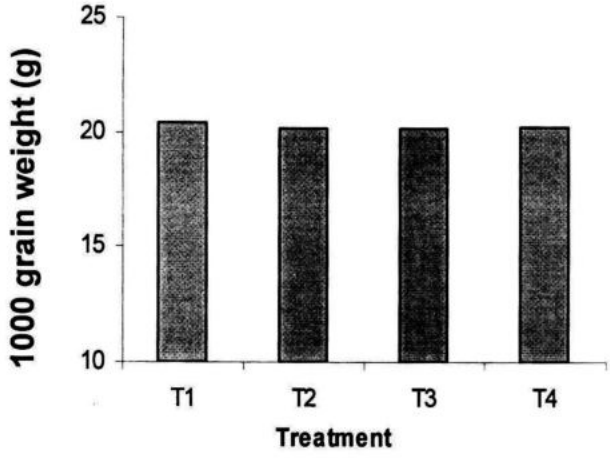

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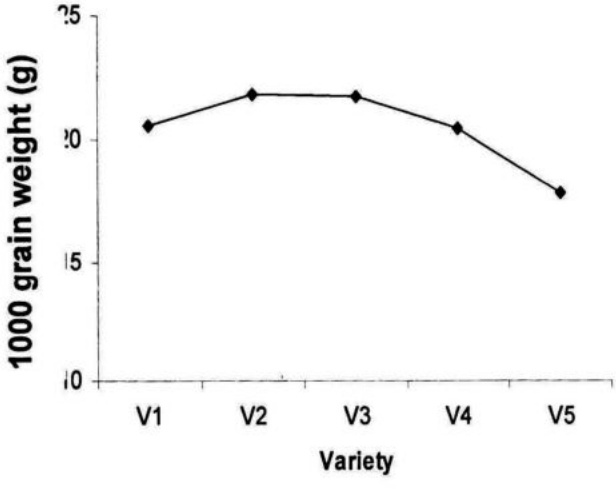

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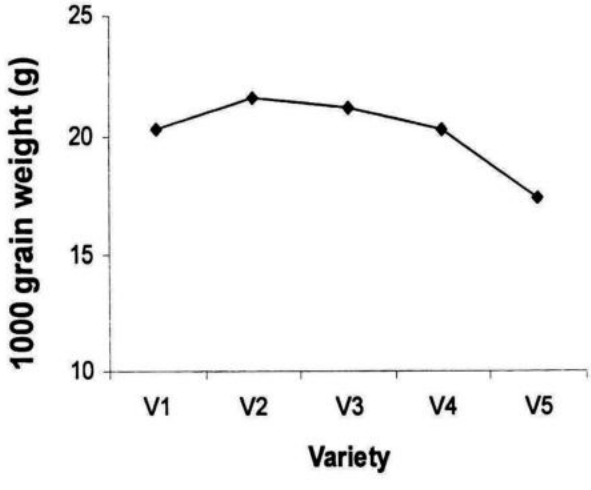

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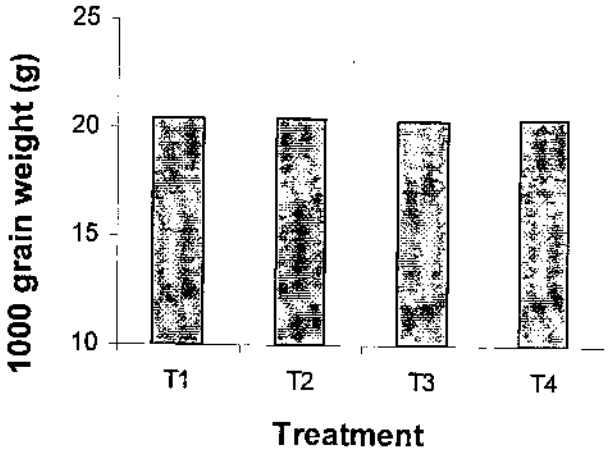

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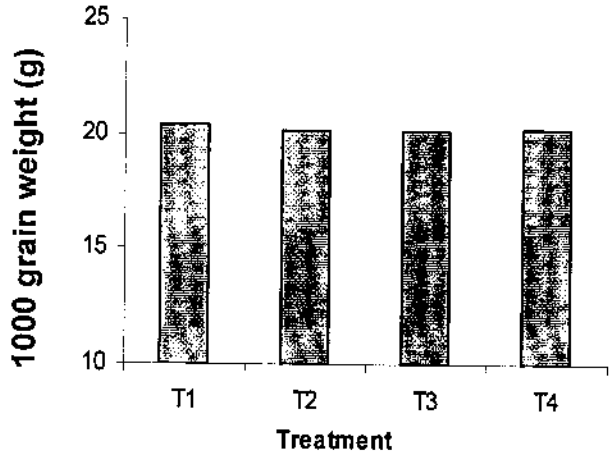

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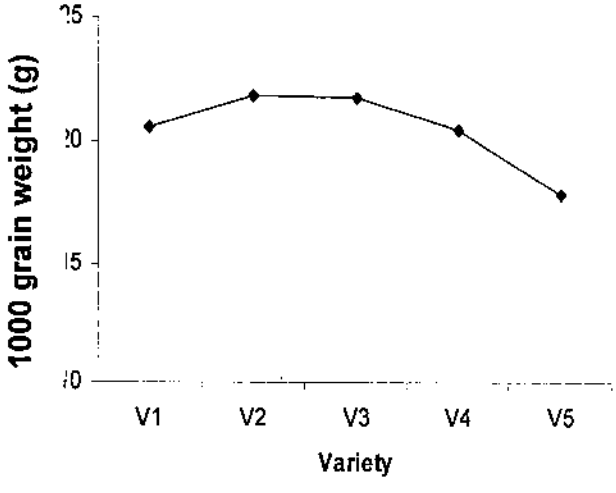

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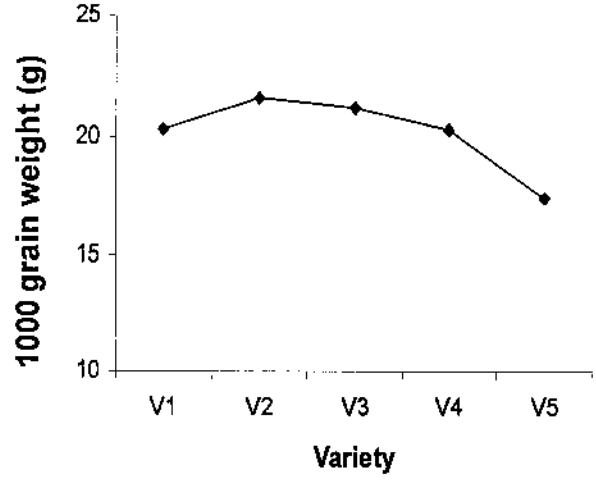

Fig 4.1.32. Effect of varieties on 1000 grain weight (g) in 2007

4.1.9 Grain yield

Effect of tree species

Grain yield (t ha^{-1}) of T. man rice was not varied significantly in 2006 (first year) by the effect of tree species. Numerically highest grain yield (3.93 t ha^{-1}) was obtained from T_1 (open field i.e. 100% light level) that was followed by T_2 (3.84 t ha^{-1}). The lowest grain yield (3.61 t ha^{-1}) was recorded under guava (T_3) as there was minimum light intensities (65.25 %) under guava tree.

The average light intensities under mango and black siris were 74.8 and 63.25%, respectively. The result showed that transplanted aman could be grown under two years aged black siris, guava and mango trees without significant yield loss. But in 2007, trees became larger and canopy spread was more and the effect of tree species was found significant. Significantly the highest grain yield (3.86 t ha^{-1}) was recorded in open field (100% light). T_2 (black siris) and T_4 (mango) produced moderate and statistically identical grain yield (3.27 and 3.26 t ha^{-1}, respectively), where as T_3 (guava) produced significantly lowest grain yield (2.5 t ha^{-1}), this was due to heaviest shade or minimum light intensities (average 46.5%) beneath the guava tree.

Response of rice varieties

Grain yield of transplanted aman was significantly influenced by the effect of variety in both the cropping seasons and influencing pattern was almost similar in both the years. (Appendix 4.1.10). The highest grain yield (4.82 and 4.74 t ha^{-1} in 2006 and 2007, respectively) was produced by V_2 (BR 11) which was statistically identical to V_1 (4.58 and 4.51 t/ha in 2006 and 2007, respectively). The moderate grain yield was produced by V_3 (BRRI dhan 33) that was statistically similar to that of V_4 (BRRI dhan 39) in both the year (Appendix 4.1.10). Sorna (V_5) produced always lowest yield (2.88 and 2.83 t ha^{-1} in 2006 and 2007, respectively). These variations might be due to their genetic variabilities.

Interaction Effect of tree species and variety

Grain yield was significantly influenced by the interaction effect of tree species and variety (Table 4.1.4). In 2006, the highest grain yield (5.1 t ha^{-1}) was found in V_2 (BR 11) with sole rice (T_1V_2 combination) which was statistically similar to that produced from T_1V_1, T_2V_2, T_2V_1, T_4V_1, T_4V_2 and T_3V_2 combinations and the values were 4.83, 4.8, 4.6, 4.53, 4.63 and 4.43 t/ha respectively. Significantly the lowest grain yield was produced by T_3V_5 and`T_4V_5 combination and yield was 2.7 t ha^{-1}in both the cases. The moderate grain yield was produced by T_1V_3 (BRRI dhan 33 in open field), T_2V_3 under black siris and T_4V_3 (BRRI dhan 33 under mango) combination.

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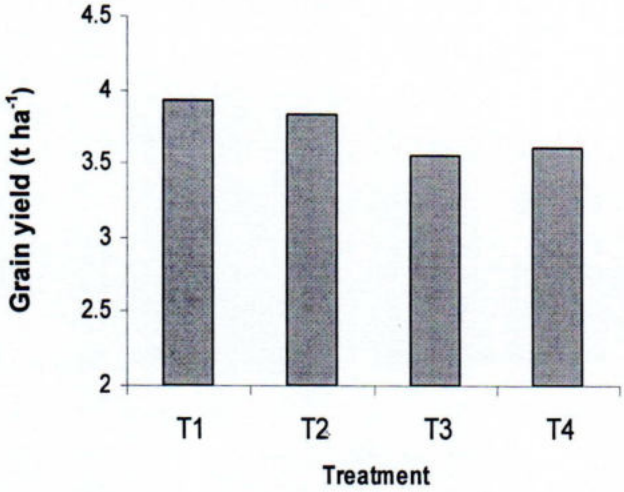


Fig 4.1.33. Effect of tree species on grain yield (t ha^{-1}) in 2006

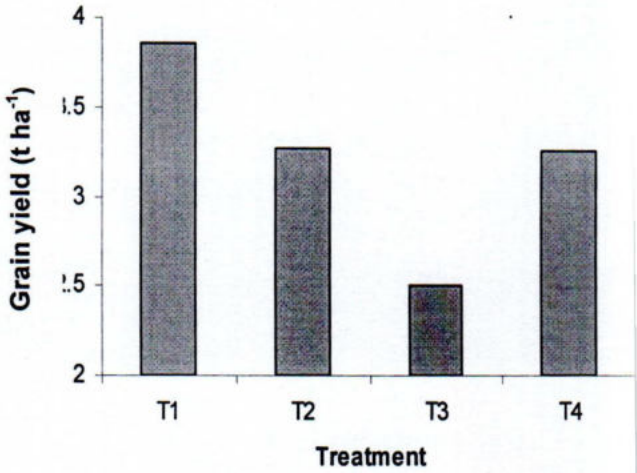


Fig 4.1.34. Effect of tree species on grain yield (t ha^{-1}) in 2007

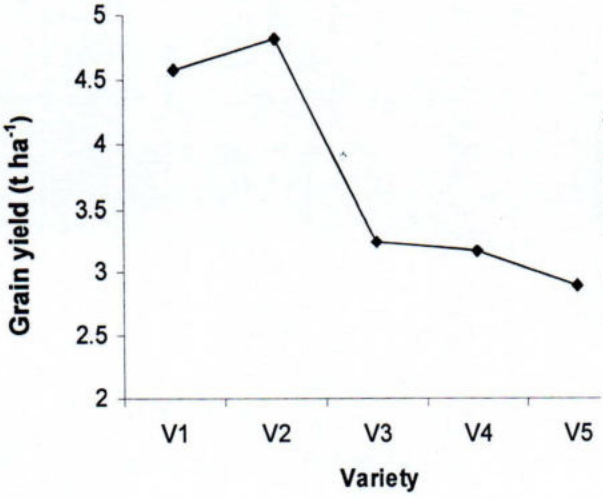


Fig 4.1.35. Effect of varieties on grain yield (t ha^{-1}) in 2006

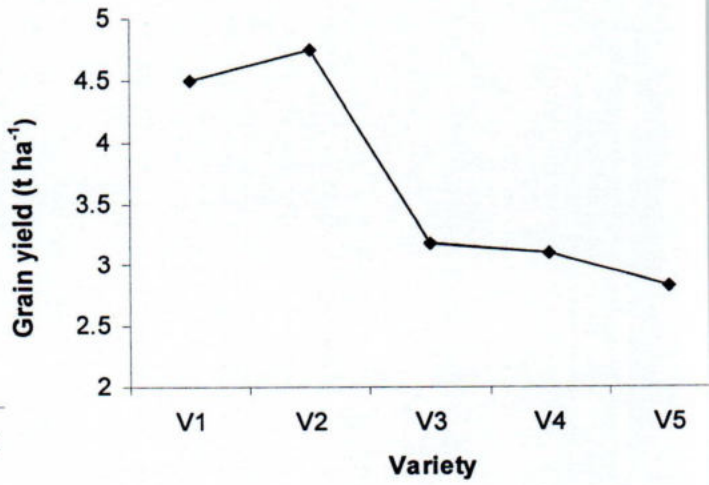
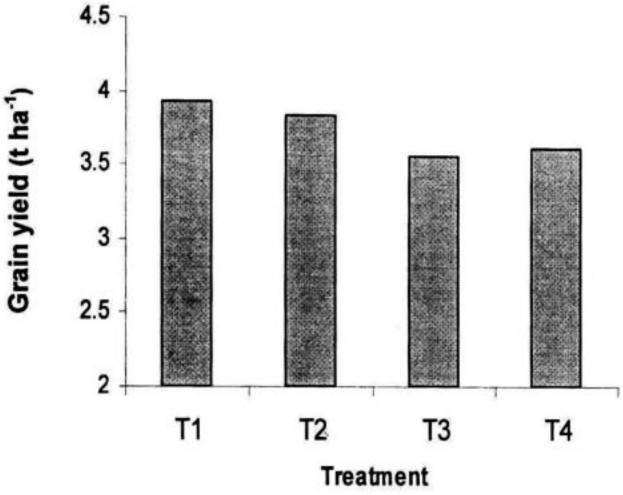


Fig 4.1.36. Effect of varieties on grain yield (t ha^{-1}) in 2007



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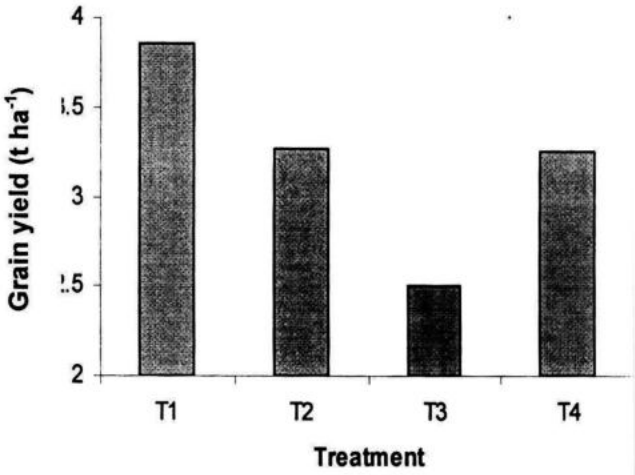

Fig 4.1.34. Effect of tree species on grain yield (t ha^{-1}) in 2007

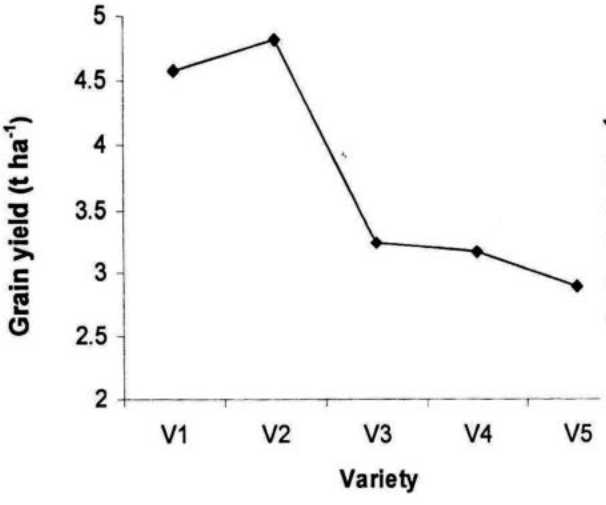

Fig 4.1.35. Effect of varieties on grain yield (t ha^{-1}) in 2006

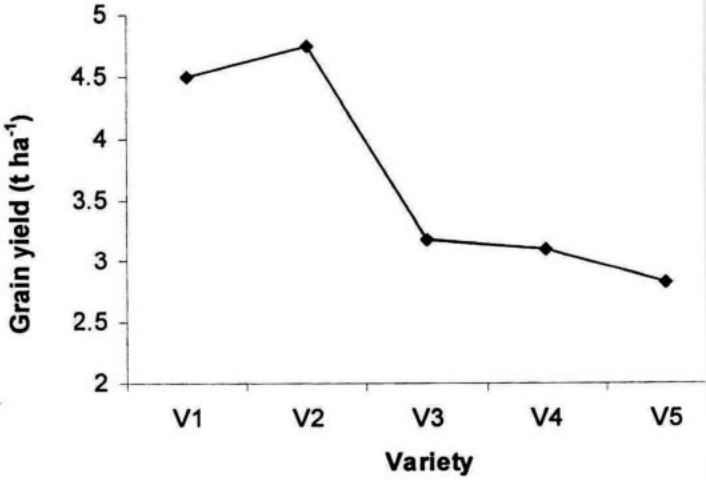

Fig 4.1.36. Effect of varieties on grain yield (t ha^{-1}) in 2007

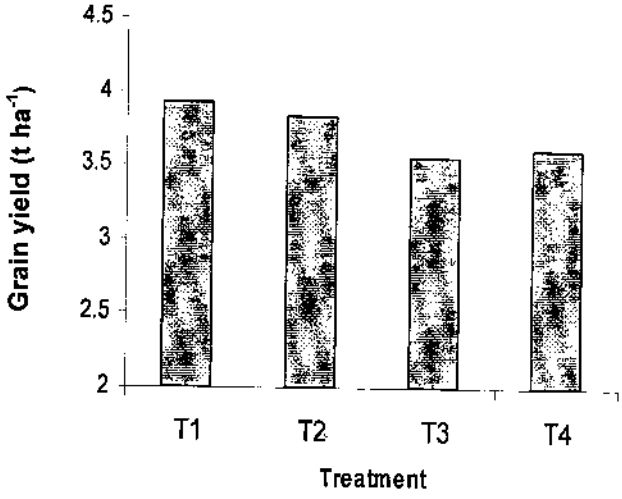

Fig 4.1.33. Effect of tree species on grain yield (t ha^{-1}) in 2006

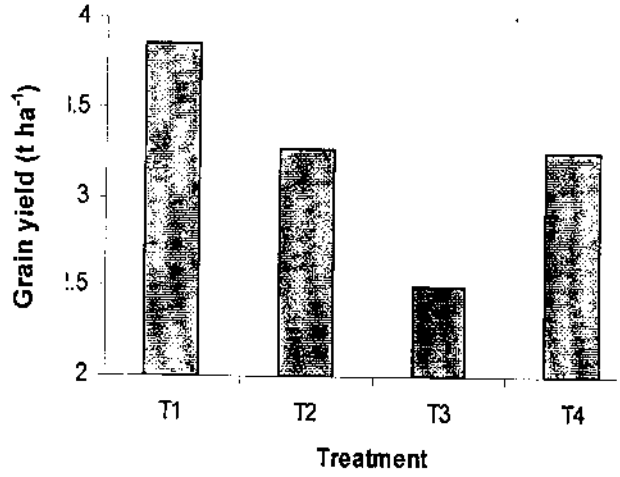

Fig 4.1.34. Effect of tree species on grain yield (t ha^{-1}) in 2007

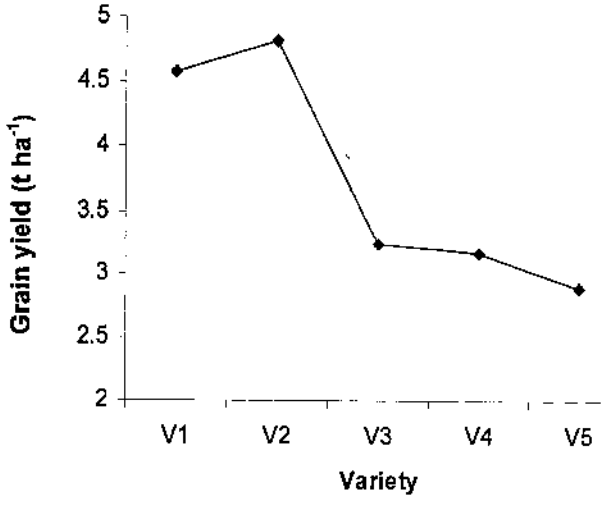

Fig 4.1.35. Effect of varieties on grain yield (t ha^{-1}) in 2006

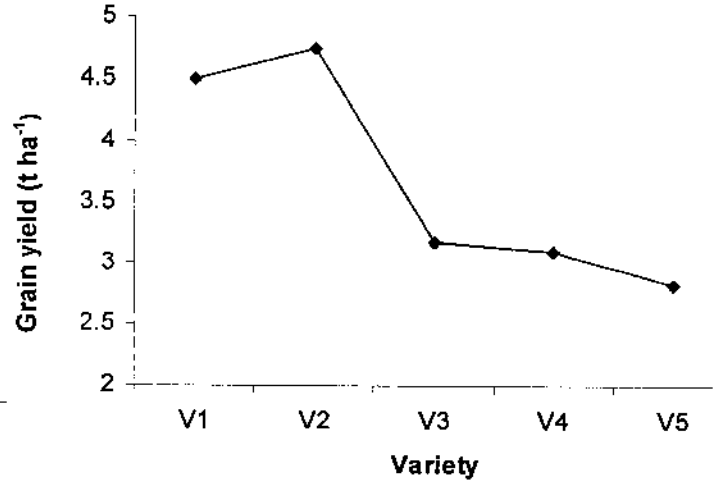

Fig 4.1.36. Effect of varieties on grain yield (t ha^{-1}) in 2007

Table 4.1.4. Interaction effect of tree species and rice variety on yield and yield contributing characters of T. aman rice in 2006 and 2007

Treatment Combination	Panicle length (cm)		No of grain Panicles^{-1}		Sterile Spikelets Panicle^{-1}		1000 grain weight (g)		Yield (t ha-^{1})	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1V_1	25.73 ab	25.38 bc	163.7 abc	154.00 abc	9.133 g	8.85h	20.67 bc	20.38 bc	4.833 ab	4.25b
T_1V_2	26.50 a	26.17 a	175.0 a	172.50 a	7.500 g	7.18i	21.97 a	21.73 a	5.100 a	4.50a
T_1V_3	24.90 abcde	24.63 c	155.3 bcdef	166.00 abc	17.17 bc	16.63c	21.53 abc	21.27 abc	3.433 c	2.87e
T_1V_4	24.03 bcdef	23.77 cd	151.0 defg	148.80 cde	17.23 bc	16.80c	20.53 bc	20.27bc	3.233 cd	2.57f
T_1V_5	23.47 efg	23.15 c	147.7 efgh	146.00cde	11.40 f	11.05fg	17.67 d	17.38 d	3.033 cd	2.47fg
T_2V_1	24.67 abcdef	24.30 c	154.3 bcdef	152.50 bcd	14.23 de	13.93e	20.57 bc	20.30 bc	4.600 ab	4.02bc
T_2V_2	25.63 abc	25.35 bc	161.0 bcd	158.30 de	11.50 f	11.13g	21.93 a	21.70 a	4.900 ab	4.32b
T_2V_3	23.83 bcdef	23.63 d	151.0 cdefg	148.80cde	19.07 b	18.58b	21.43 abc	21.08 abc	3.300 cd	2.75e
T_2V_4	23.63 def	23.35 d	150.0 defgh	148.30 cde	16.10 cd	15.70c	20.57 bc	20.33 bc	3.300 cd	2.75e
T_2V_5	23.47 efg	23.23 d	146.7 fgh	146.50 de	13.20 ef	12.77ef	17.80 d	17.50 d	3.100 cd	2.55f
T_3V_1	24.60 bcdef	24.33 c	150.7 defgh	145.00 de	14.10 de	13.57e	20.40 c	20.17 c	4.333 b	3.77c
T_3V_2	25.00 abcde	24.75 c	160.0 bcde	147.50 de	11.40 f	11.05fg	21.67 ab	21.42 ab	4.633 ab	4.07bc
T_3V_3	22.77 fg	22.58 de	146.7 fgh	140.00 ef	19.03 b	18.55b	21.50 abc	21.27 abc	3.100 cd	2.55f
T_3V_4	21.73 g	22.55 de	146.7 fgh	140.00ef	21.17 a	20.88a	20.53 bc	20.27 bc	3.000 cd	2.45fg
T_3V_5	21.73 g	22.55 de	137.7 h	135.80 efg	17.27 bc	16.75c	17.67 d	17.45 d	2.700 d	2.15h
T_4V_1	24.53 bcdef	24.27 c	151.0 cdefg	149.00 bc	9.400 g	9.10h	20.67 bc	20.40 bc	4.533 ab	3.97c
T_4V_2	25.50 abcd	25.25 bc	164.3 ab	162.00 bc	9.233 g	8.93h	21.87 a	21.65	4.633 ab	4.07bc
T_4V_3	23.73 cdef	23.48 d	146.7 fgh	144.50 de	14.13 de	13.85de	21.47 abc	21.25	3.100 cd	2.55f
T_4V_4	21.67 g	21.40 e	146.0 fgh	143.80 de	17.00 bc	16.50c	20.63 bc	20.38	3.100 cd	2.55f
T_4V_5	19.77 h	19.58 f	140.0 gh	138.30 efg	16.07 cd	15.58cd	17.60 d	17.40	2.700 d	2.15h
CV%	0.73	9.72	0.78	6.27	1.38	8.33	5.33	11.29	1.57	8.85

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT

T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4=mango tree, V_1= BR10, V_2= BR11, V_3= BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety

Table 4.1.4. Interaction effect of tree species and rice variety on yield and yield contributing characters of T. aman rice in 2006 and 2007

Treatment Combination	Panicle length (cm)		No of grain Panicles^{-1}		Sterile Spikelets Panicle^{-1}		1000 grain weight (g)		Yield (t ha-^{1})	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1V_1	25.73 ab	25.38 bc	163.7 abc	154.00 abc	9.133 g	8.85h	20.67 bc	20.38 bc	4.833 ab	4.25b
T_1V_2	26.50 a	26.17 a	175.0 a	172.50 a	7.500 g	7.18i	21.97 a	21.73 a	5.100 a	4.50a
T_1V_3	24.90 abcde	24.63 c	155.3 bcdef	166.00 abc	17.17 bc	16.63c	21.53 abc	21.27 abc	3.433 c	2.87e
T_1V_4	24.03 bcdef	23.77 cd	151.0 defg	148.80 cde	17.23 bc	16.80c	20.53 bc	20.27bc	3.233 cd	2.57f
T_1V_5	23.47 efg	23.15 c	147.7 efgh	146.00cde	11.40 f	11.05fg	17.67 d	17.38 d	3.033 cd	2.47fg
T_2V_1	24.67 abcdef	24.30 c	154.3 bcdef	152.50 bcd	14.23 de	13.93e	20.57 bc	20.30 bc	4.600 ab	4.02bc
T_2V_2	25.63 abc	25.35 bc	161.0 bcd	158.30 de	11.50 f	11.13g	21.93 a	21.70 a	4.900 ab	4.32b
T_2V_3	23.83 bcdef	23.63 d	151.0 cdefg	148.80cde	19.07 b	18.58b	21.43 abc	21.08 abc	3.300 cd	2.75e
T_2V_4	23.63 def	23.35 d	150.0 defgh	148.30 cde	16.10 cd	15.70c	20.57 bc	20.33 bc	3.300 cd	2.75e
T_2V_5	23.47 efg	23.23 d	146.7 fgh	146.50 de	13.20 ef	12.77ef	17.80 d	17.50 d	3.100 cd	2.55f
T_3V_1	24.60 bcdef	24.33 c	150.7 defgh	145.00 de	14.10 de	13.57e	20.40 c	20.17 c	4.333 b	3.77c
T_3V_2	25.00 abcde	24.75 c	160.0 bcde	147.50 de	11.40 f	11.05fg	21.67 ab	21.42 ab	4.633 ab	4.07bc
T_3V_3	22.77 fg	22.58 de	146.7 fgh	140.00 ef	19.03 b	18.55b	21.50 abc	21.27 abc	3.100 cd	2.55f
T_3V_4	21.73 g	22.55 de	146.7 fgh	140.00ef	21.17 a	20.88a	20.53 bc	20.27 bc	3.000 cd	2.45fg
T_3V_5	21.73 g	22.55 de	137.7 h	135.80 efg	17.27 bc	16.75c	17.67 d	17.45 d	2.700 d	2.15h
T_4V_1	24.53 bcdef	24.27 c	151.0 cdefg	149.00 bc	9.400 g	9.10h	20.67 bc	20.40 bc	4.533 ab	3.97c
T_4V_2	25.50 abcd	25.25 bc	164.3 ab	162.00 bc	9.233 g	8.93h	21.87 a	21.65	4.633 ab	4.07bc
T_4V_3	23.73 cdef	23.48 d	146.7 fgh	144.50 de	14.13 de	13.85de	21.47 abc	21.25	3.100 cd	2.55f
T_4V_4	21.67 g	21.40 e	146.0 fgh	143.80 de	17.00 bc	16.50c	20.63 bc	20.38	3.100 cd	2.55f
T_4V_5	19.77 h	19.58 f	140.0 gh	138.30 efg	16.07 cd	15.58cd	17.60 d	17.40	2.700 d	2.15h
CV%	0.73	9.72	0.78	6.27	1.38	8.33	5.33	11.29	1.57	8.85

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT

T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4=mango tree, V_1= BR10, V_2= BR11, V_3= BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety

Table 4.1.4. Interaction effect of tree species and rice variety on yield and yield contributing characters of T. aman rice in 2006 and 2007

Treatment Combination	Panicle length (cm)		No of grain Panicles^{-1}		Sterile Spikelets Panicle^{-1}		1000 grain weight (g)		Yield (t ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1V_1	25.73 ab	25.38 bc	163.7 abc	154.00 abc	9.133 g	8.85h	20.67 bc	20.38 bc	4.833 ab	4.25b
T_1V_2	26.50 a	26.17 a	175.0 a	172.50 a	7.500 g	7.18i	21.97 a	21.73 a	5.100 a	4.50a
T_1V_3	24.90 abcde	24.63 c	155.3 bcdef	166.00 abc	17.17 bc	16.63c	21.53 abc	21.27 abc	3.433 c	2.87e
T_1V_4	24.03 bcdef	23.77 cd	151.0 defg	148.80 cde	17.23 bc	16.80c	20.53 bc	20.27bc	3.233 cd	2.57f
T_1V_5	23.47 efg	23.15 c	147.7 efgh	146.00cde	11.40 f	11.05fg	17.67 d	17.38 d	3.033 cd	2.47fg
T_2V_1	24.67 abcdef	24.30 c	154.3 bcdef	152.50 bcd	14.23 de	13.93e	20.57 bc	20.30 bc	4.600 ab	4.02bc
T_2V_2	25.63 abc	25.35 bc	161.0 bcd	158.30 de	11.50 f	11.13g	21.93 a	21.70 a	4.900 ab	4.32b
T_2V_3	23.83 bcdef	23.63 d	151.0 cdefg	148.80cde	19.07 b	18.58b	21.43 abc	21.08 abc	3.300 cd	2.75e
T_2V_4	23.63 def	23.35 d	150.0 defgh	148.30 cde	16.10 cd	15.70c	20.57 bc	20.33 bc	3.300 cd	2.75e
T_2V_5	23.47 efg	23.23 d	146.7 fgh	146.50 de	13.20 ef	12.77ef	17.80 d	17.50 d	3.100 cd	2.55f
T_3V_1	24.60 bcdef	24.33 c	150.7 defgh	145.00 de	14.10 de	13.57e	20.40 c	20.17 c	4.333 b	3.77c
T_3V_2	25.00 abcde	24.75 c	160.0 bcde	147.50 de	11.40 f	11.05fg	21.67 ab	21.42 ab	4.633 ab	4.07bc
T_3V_3	22.77 fg	22.58 de	146.7 fgh	140.00 ef	19.03 b	18.55b	21.50 abc	21.27 abc	3.100 cd	2.55f
T_3V_4	21.73 g	22.55 de	146.7 fgh	140.00ef	21.17 a	20.88a	20.53 bc	20.27 bc	3.000 cd	2.45fg
T_3V_5	21.73 g	22.55 de	137.7 h	135.80 efg	17.27 bc	16.75c	17.67 d	17.45 d	2.700 d	2.15h
T_4V_1	24.53 bcdef	24.27 c	151.0 cdefg	149.00 bc	9.400 g	9.10h	20.67 bc	20.40 bc	4.533 ab	3.97c
T_4V_2	25.50 abcd	25.25 bc	164.3 ab	162.00 bc	9.233 g	8.93h	21.87 a	21.65	4.633 ab	4.07bc
T_4V_3	23.73 cdef	23.48 d	146.7 fgh	144.50 de	14.13 de	13.85de	21.47 abc	21.25	3.100 cd	2.55f
T_4V_4	21.67 g	21.40 e	146.0 fgh	143.80 de	17.00 bc	16.50c	20.63 bc	20.38	3.100 cd	2.55f
T_4V_5	19.77 h	19.58 f	140.0 gh	138.30 efg	16.07 cd	15.58cd	17.60 d	17.40	2.700 d	2.15h
CV%	0.73	9.72	0.78	6.27	1.38	8.33	5.33	11.29	1.57	8.85

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Table 4.1.5. Productivity evaluation through harvest index and land equivalent ratio of Transplanted aman rice in agroforestry practice at 2006 and 2007

Treatment Combination	Grain yield (tha^{-1})		Straw yield (tha^{-1})		Biological yield (tha^{-1})		Harvest index (%)		Ci/Cs		Ti/Ts		LER	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1V_1	4.83	4.25	7.05	6.85	11.88	11.1	40.67	38.29	-	-	-	-	-	-
T_1V_2	5.10	4.50	6.81	6.59	11.91	11.09	42.82	40.58	-	-	-	-	-	-
T_1V_3	3.43	3.87	6.59	6.41	10.02	10.28	34.25	37.65	-	-	-	-	-	-
T_1V_4	3.30	3.57	6.58	6.40	9.88	9.97	33.40	35.81	-	-	-	-	-	-
T_1V_5	3.10	3.47	6.60	6.48	9.70	9.95	31.96	34.87	-	-	-	-	-	-
T_2V_1	4.60	4.02	5.99	5.84	10.59	9.86	43.44	40.77	0.95	0.95	1.06	1.16	2.01	2.11
T_2V_2	4.80	4.32	5.95	5.82	10.75	10.14	44.65	42.60	0.94	0.96	1.06	1.16	2.00	2.12
T_2V_3	3.30	2.75	4.58	4.38	7.88	7.13	41.88	38.57	0.96	0.71	1.06	1.16	2.02	1.87
T_2V_4	3.23	2.75	5.58	5.46	8.81	8.21	36.68	33.50	0.98	0.77	1.06	1.16	2.04	1.93
T_2V_5	3.03	2.55	4.59	4.39	7.62	6.94	39.79	36.74	0.98	0.73	1.06	1.16	2.04	1.89
T_3V_1	4.33	2.77	4.75	4.55	9.08	7.32	47.70	37.84	0.90	0.65	1.00	1.06	1.90	1.71
T_3V_2	4.43	3.07	4.25	4.17	8.68	7.24	51.05	42.40	0.87	0.68	1.00	1.06	1.87	1.74
T_3V_3	3.10	2.55	4.25	4.07	7.35	6.62	42.18	38.52	0.91	0.65	1.00	1.06	1.91	1.71
T_3V_4	3.00	2.45	4.24	4.00	7.24	6.45	41.44	37.98	0.91	0.69	1.00	1.06	1.91	1.75
T_3V_5	2.70	2.15	4.54	4.39	7.24	6.54	37.29	32.87	0.87	0.61	1.00	1.06	1.87	1.67
T_4V_1	4.53	3.97	6.65	6.44	11.18	10.41	40.53	38.14	0.94	0.93	1.05	1.14	1.99	2.07
T_4V_2	4.63	4.07	6.28	6.07	10.91	10.14	42.45	40.14	0.91	0.91	1.05	1.14	1.96	2.05
T_4V_3	3.10	2.55	5.67	6.40	8.77	8.95	35.35	28.49	0.90	0.65	1.05	1.14	1.95	1.79
T_4V_4	3.10	2.55	5.69	5.50	8.79	8.05	35.27	31.68	0.94	0.71	1.05	1.14	1.99	1.85
T_4V_5	2.70	2.15	4.99	4.79	7.69	6.94	35.11	30.98	0.87	0.62	1.05	1.14	1.92	1.76

T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4=mango tree, V_1= BR10, V_2= BR11, V_3= BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety)

Table 4.1.5. Productivity evaluation through harvest index and land equivalent ratio of Transplanted aman rice in agroforestry practice at 2006 and 2007

Treatment Combination	Grain yield (tha^{-1})		Straw yield (tha^{-1})		Biological yield (tha^{-1})		Harvest index (%)		Ci/Cs		Ti/Ts		LER	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1V_1	4.83	4.25	7.05	6.85	11.88	11.1	40.67	38.29	-	-	-	-	-	-
T_1V_2	5.10	4.50	6.81	6.59	11.91	11.09	42.82	40.58	-	-	-	-	-	-
T_1V_3	3.43	3.87	6.59	6.41	10.02	10.28	34.25	37.65	-	-	-	-	-	-
T_1V_4	3.30	3.57	6.58	6.40	9.88	9.97	33.40	35.81	-	-	-	-	-	-
T_1V_5	3.10	3.47	6.60	6.48	9.70	9.95	31.96	34.87	-	-	-	-	-	-
T_2V_1	4.60	4.02	5.99	5.84	10.59	9.86	43.44	40.77	0.95	0.95	1.06	1.16	2.01	2.11
T_2V_2	4.80	4.32	5.95	5.82	10.75	10.14	44.65	42.60	0.94	0.96	1.06	1.16	2.00	2.12
T_2V_3	3.30	2.75	4.58	4.38	7.88	7.13	41.88	38.57	0.96	0.71	1.06	1.16	2.02	1.87
T_2V_4	3.23	2.75	5.58	5.46	8.81	8.21	36.68	33.50	0.98	0.77	1.06	1.16	2.04	1.93
T_2V_5	3.03	2.55	4.59	4.39	7.62	6.94	39.79	36.74	0.98	0.73	1.06	1.16	2.04	1.89
T_3V_1	4.33	2.77	4.75	4.55	9.08	7.32	47.70	37.84	0.90	0.65	1.00	1.06	1.90	1.71
T_3V_2	4.43	3.07	4.25	4.17	8.68	7.24	51.05	42.40	0.87	0.68	1.00	1.06	1.87	1.74
T_3V_3	3.10	2.55	4.25	4.07	7.35	6.62	42.18	38.52	0.91	0.65	1.00	1.06	1.91	1.71
T_3V_4	3.00	2.45	4.24	4.00	7.24	6.45	41.44	37.98	0.91	0.69	1.00	1.06	1.91	1.75
T_3V_5	2.70	2.15	4.54	4.39	7.24	6.54	37.29	32.87	0.87	0.61	1.00	1.06	1.87	1.67
T_4V_1	4.53	3.97	6.65	6.44	11.18	10.41	40.53	38.14	0.94	0.93	1.05	1.14	1.99	2.07
T_4V_2	4.63	4.07	6.28	6.07	10.91	10.14	42.45	40.14	0.91	0.91	1.05	1.14	1.96	2.05
T_4V_3	3.10	2.55	5.67	6.40	8.77	8.95	35.35	28.49	0.90	0.65	1.05	1.14	1.95	1.79
T_4V_4	3.10	2.55	5.69	5.50	8.79	8.05	35.27	31.68	0.94	0.71	1.05	1.14	1.99	1.85
T_4V_5	2.70	2.15	4.99	4.79	7.69	6.94	35.11	30.98	0.87	0.62	1.05	1.14	1.92	1.76

T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4=mango tree, V_1= BR10, V_2= BR11, V_3= BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety)

Table 4.1.5. Productivity evaluation through harvest index and land equivalent ratio of Transplanted aman rice in agroforestry practice at 2006 and 2007

Treatment Combination	Grain yield (tha^{-1})		Straw yield (tha^{-1})		Biological yield (tha^{-1})		Harvest index (%)		Ci/Cs		Ti/Ts		LER	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1V_1	4.83	4.25	7.05	6.85	11.88	11.1	40.67	38.29	-	-	-	-	-	-
T_1V_2	5.10	4.50	6.81	6.59	11.91	11.09	42.82	40.58	-	-	-	-	-	-
T_1V_3	3.43	3.87	6.59	6.41	10.02	10.28	34.25	37.65	-	-	-	-	-	-
T_1V_4	3.30	3.57	6.58	6.40	9.88	9.97	33.40	35.81	-	-	-	-	-	-
T_1V_5	3.10	3.47	6.60	6.48	9.70	9.95	31.96	34.87	-	-	-	-	-	-
T_2V_1	4.60	4.02	5.99	5.84	10.59	9.86	43.44	40.77	0.95	0.95	1.06	1.16	2.01	2.11
T_2V_2	4.80	4.32	5.95	5.82	10.75	10.14	44.65	42.60	0.94	0.96	1.06	1.16	2.00	2.12
T_2V_3	3.30	2.75	4.58	4.38	7.88	7.13	41.88	38.57	0.96	0.71	1.06	1.16	2.02	1.87
T_2V_4	3.23	2.75	5.58	5.46	8.81	8.21	36.68	33.50	0.98	0.77	1.06	1.16	2.04	1.93
T_2V_5	3.03	2.55	4.59	4.39	7.62	6.94	39.79	36.74	0.98	0.73	1.06	1.16	2.04	1.89
T_3V_1	4.33	2.77	4.75	4.55	9.08	7.32	47.70	37.84	0.90	0.65	1.00	1.06	1.90	1.71
T_3V_2	4.43	3.07	4.25	4.17	8.68	7.24	51.05	42.40	0.87	0.68	1.00	1.06	1.87	1.74
T_3V_3	3.10	2.55	4.25	4.07	7.35	6.62	42.18	38.52	0.91	0.65	1.00	1.06	1.91	1.71
T_3V_4	3.00	2.45	4.24	4.00	7.24	6.45	41.44	37.98	0.91	0.69	1.00	1.06	1.91	1.75
T_3V_5	2.70	2.15	4.54	4.39	7.24	6.54	37.29	32.87	0.87	0.61	1.00	1.06	1.87	1.67
T_4V_1	4.53	3.97	6.65	6.44	11.18	10.41	40.53	38.14	0.94	0.93	1.05	1.14	1.99	2.07
T_4V_2	4.63	4.07	6.28	6.07	10.91	10.14	42.45	40.14	0.91	0.91	1.05	1.14	1.96	2.05
T_4V_3	3.10	2.55	5.67	6.40	8.77	8.95	35.35	28.49	0.90	0.65	1.05	1.14	1.95	1.79
T_4V_4	3.10	2.55	5.69	5.50	8.79	8.05	35.27	31.68	0.94	0.71	1.05	1.14	1.99	1.85
T_4V_5	2.70	2.15	4.99	4.79	7.69	6.94	35.11	30.98	0.87	0.62	1.05	1.14	1.92	1.76

T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4=mango tree, V_1= BR10, V_2= BR11, V_3= BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety)

4.1.10 Productivity evaluation of T.aman in agroforestry practice

There are two major indices for evaluation of productivity i.e. harvest index (HI) and land equivalent ratio (LER). For intercrop productivity evaluation in agronomy HI is used commonly but in Agroforestry LER is important. These two land use indices are described bellow on the basis of obtained results.

Harvest Index

Harvest index is of the important productivity evaluation technique. It indicates the economic yield performance in respect of biological yield.

In 2006, among the twenty treatment combinations the highest HI was (51.05 %) calculated for V_2 (BR 11) under guava, 2nd highest HI was (47.7 %) calculated for V_1 (43.44%) under black siris. The lowest percent of HI was recorded in open field irrespective of varieties. Although V_2 produced higher HI over other varieties in each treatment combination followed by V_1.

In 2007, the highest HI (42.6%) was calculated V_2 under black siris. The 2nd highest HI (42.4% was found under guava for V_2 followed by V_1 (40.77%) under black siris. The results revealed that partial shade (65.6% light intensities) might be helped more translocation of photosynthates to reproductive organ as a result higher HI (%) were found under tree canopy irrespective of variety (Table 4.1.6). Among the variety V_2 (BR 11) always showed highest HI over other varieties under all treatment condition followed by V_1 (BR 10).

Land equivalent ratio (LER)

All the varieties of Transplanted aman showed highest LER under black siris (2.0-2.04) followed by mango (range 1.92-1.99 in 2006 and 1.76-2.07 in 2007). The lowest LER was recorded under guava in all varieties. In 2006, maximum LER (2.12) was found in T_2V_2 combination (BR 11 under black siris) followed T_2V_1 (2.11). The third and 4th highest LER from V_1 and V_2 variety (2.07 and 2.05 from T_4V_1 and T_4V_2 combination respectively). The lowest LER was recorded under guava for all rice varieties and the range was 1.67-1.75. From the value of LER BR 11 and BR 10 were found suitable varieties for association of black siris and mango.

4.11.11 Economic evaluation

The economic analysis (Table 4.1.8) showed that highest BCR in 2006 (1.77) was obtained from T_1V_2 combination followed by T_1V_1 (1.69). The third highest BCR (1.65) recorded in T_2V_2, which was followed by T_4V_2 (1.62). The lowest BCR (0.96) was found in T_3V_5 combination. In 2007, the highest BCR (1.61) was obtained from T_2V_2 combination which was followed by T_1V_1 (1.54), T_2V_2 (1.53) and then T_4V_2 (1.46). The lowest BCR (0.81) was calculated in T_3V_5 combination (Table 4.11.8). The BCR value

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indicated that V_2 (BR 11) was highly profitable over other varieties in all treatment combination, which was followed by V_1 (BR 10). Under guava (T_3) tree all varieties produced their lowest yield as well as income. In this case only T_3V_2 and T_3V_1 showed positive net return but other three varieties showed negative net return (Table 4.1.8). These three varieties (V_3, V_4 and V_5) showed poor performance under mango and black siris also in 2006. The result proved that V_2 (BR 11) was the best T. .aman variety for agroforestry practice specially for highest economic gain followed by V_1 (BR 10).

Table 4.1.6. Economic evaluation through BCR of Transplanted aman rice in agroforestry practice in 2006 and 2007

Treatment Combination	Total cost of production (Tk ha^{-1})		Gross return (Tk ha^{-1})		Net return (Tk ha^{-1})		BCR	
	2006	2007	2006	2007	2006	2007	2006	2007
T_1V_1	28929	28569	55350	49350	26421	20781	1.913	1.727
T_1V_2	28929	28569	57810	51590	28881	23021	1.998	1.806
T_1V_3	28929	28569	40890	45110	11961	16541	1.413	1.579
T_1V_4	28929	28569	39580	42100	10651	13531	1.368	1.474
T_1V_5	28929	28569	37600	41180	8671	12611	1.300	1.441
T_2V_1	28929	28569	53215	129989.3	23061	101420.3	1.840	4.550
T_2V_2	28929	28569	55175	132969.3	25021	104400.3	1.907	4.654
T_2V_3	28929	28569	38805	115829.3	8651	87260.25	1.341	4.054
T_2V_4	28929	28569	39105	116909.3	8951	88340.25	1.352	4.092
T_2V_5	28929	28569	36115	113839.3	5961	85270.25	1.248	3.985
T_3V_1	28929	28569	49275	47256.25	19121	18687.25	1.703	1.654
T_3V_2	28929	28569	49775	49876.25	19621	21307.25	1.721	1.746
T_3V_3	28929	28569	36475	44576.25	6321	16007.25	1.261	1.560
T_3V_4	28929	28569	35465	43506.25	5311	14937.25	1.226	1.523
T_3V_5	28929	28569	32765	40896.25	2611	12327.25	1.133	1.431
T_4V_1	28929	28569	53175	62910.25	23021	34341.25	1.838	2.202
T_4V_2	28929	28569	53805	63540.25	23651	34971.25	1.860	2.224
T_4V_3	28929	28569	37895	48670.25	7741	20101.25	1.310	1.704
T_4V_4	28929	28569	37915	47770.25	7761	19201.25	1.311	1.672
T_4V_5	28929	28569	33215	43060.25	3061	14491.25	1.148	1.507

T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4= mango tree, V_1 = BR10, V_2 = BR11, V_3 = BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety)

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	2006	2007	2006	2007	2006	2007	2006	2007
T_1V_1	28929	28569	55350	49350	26421	20781	1.913	1.727
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T_1V_3	28929	28569	40890	45110	11961	16541	1.413	1.579
T_1V_4	28929	28569	39580	42100	10651	13531	1.368	1.474
T_1V_5	28929	28569	37600	41180	8671	12611	1.300	1.441
T_2V_1	28929	28569	53215	129989.3	23061	101420.3	1.840	4.550
T_2V_2	28929	28569	55175	132969.3	25021	104400.3	1.907	4.654
T_2V_3	28929	28569	38805	115829.3	8651	87260.25	1.341	4.054
T_2V_4	28929	28569	39105	116909.3	8951	88340.25	1.352	4.092
T_2V_5	28929	28569	36115	113839.3	5961	85270.25	1.248	3.985
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T_3V_4	28929	28569	35465	43506.25	5311	14937.25	1.226	1.523
T_3V_5	28929	28569	32765	40896.25	2611	12327.25	1.133	1.431
T_4V_1	28929	28569	53175	62910.25	23021	34341.25	1.838	2.202
T_4V_2	28929	28569	53805	63540.25	23651	34971.25	1.860	2.224
T_4V_3	28929	28569	37895	48670.25	7741	20101.25	1.310	1.704
T_4V_4	28929	28569	37915	47770.25	7761	19201.25	1.311	1.672
T_4V_5	28929	28569	33215	43060.25	3061	14491.25	1.148	1.507

T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4= mango tree, V_1 = BR10, V_2 = BR11, V_3 = BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety)

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Table 4.1.6. Economic evaluation through BCR of Transplanted aman rice in agroforestry practice in 2006 and 2007

Treatment Combination	Total cost of production (Tk ha^{-1})		Gross return (Tk ha^{-1})		Net return (Tk ha^{-1})		BCR	
	2006	2007	2006	2007	2006	2007	2006	2007
T_1V_1	28929	28569	55350	49350	26421	20781	1.913	1.727
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T_1V_5	28929	28569	37600	41180	8671	12611	1.300	1.441
T_2V_1	28929	28569	53215	129989.3	23061	101420.3	1.840	4.550
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T_3V_4	28929	28569	35465	43506.25	5311	14937.25	1.226	1.523
T_3V_5	28929	28569	32765	40896.25	2611	12327.25	1.133	1.431
T_4V_1	28929	28569	53175	62910.25	23021	34341.25	1.838	2.202
T_4V_2	28929	28569	53805	63540.25	23651	34971.25	1.860	2.224
T_4V_3	28929	28569	37895	48670.25	7741	20101.25	1.310	1.704
T_4V_4	28929	28569	37915	47770.25	7761	19201.25	1.311	1.672
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T_1= Sole (open field), T_2= Black siris, T_3= Guava, T_4= mango tree, V_1 = BR10, V_2 = BR11, V_3 = BRRI Dhan 33, V_4= BRRI Dhan 39, V_5= Sorna (Local variety)

T_1

T_2

T_3

T_4

Plate 4.1.1. Different transplanted aman rice varieties were shown in different treatment at early stage (T_1 = open field, T_2 = under Black siris, T_3 = under guava and T_4 = under mango trees).

T_1

T_2

T_3

T_4

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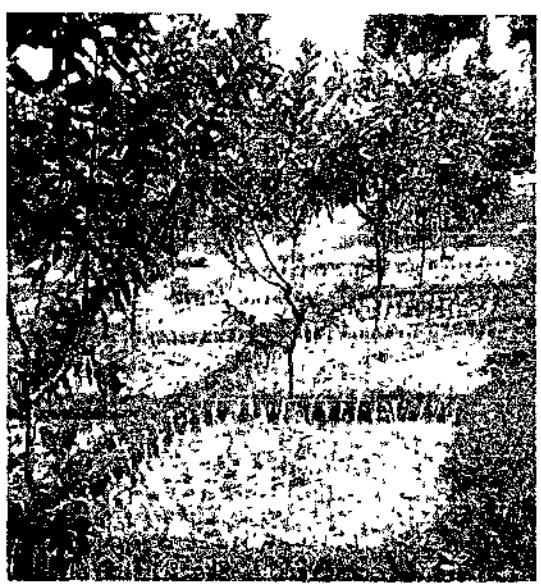
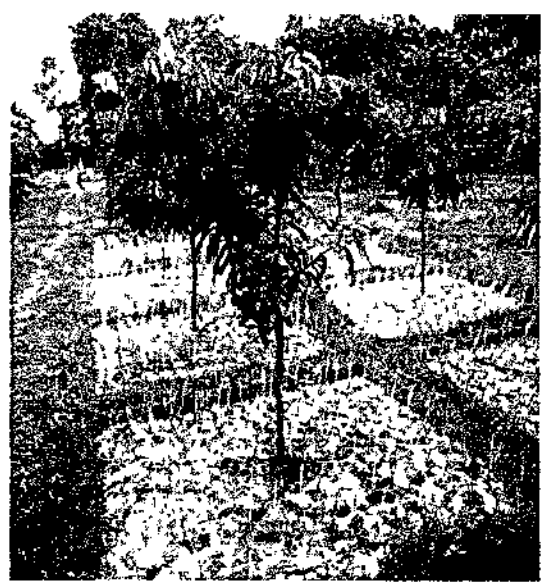
T_1

T_2

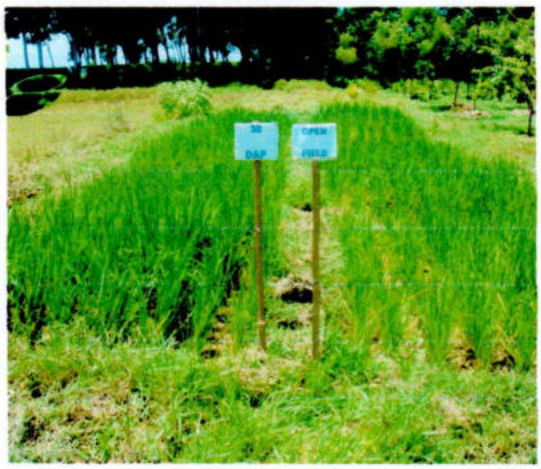


T_3



T_4

Plate 4.1.1. Different transplanted aman rice varieties were shown in different treatment at early stage (T_1 = open field, T_2 = under Black siris, T_3 = under guava and T_4 = under mango trees).



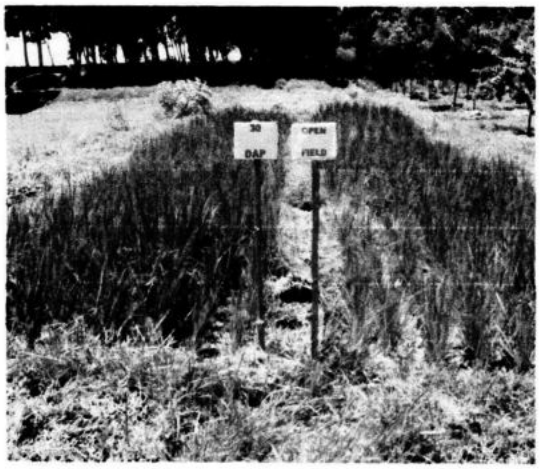
T_1

T_2

T_3

T_4

Plate 4.1.2. Different transplanted aman rice varieties were shown in different treatment at 30 DAT (T_1 = open field, T_2 = under Black siris, T_3 = under guava and T_4 = under mango trees).



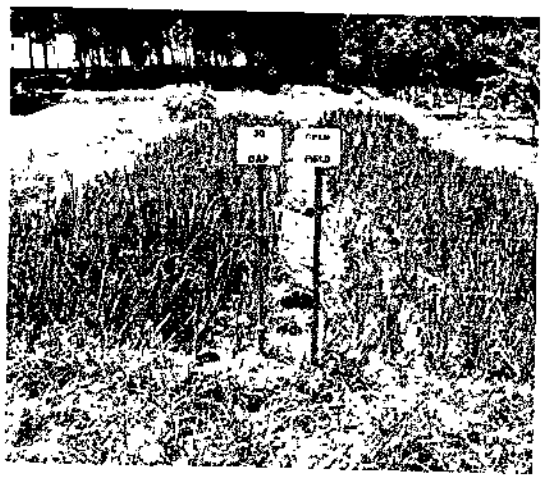
T_1

T_2

T_3

T_4

Plate 4.1.2. Different transplanted aman rice varieties were shown in different treatment at 30 DAT (T_1 = open field, T_2 = under Black siris, T_3 = under guava and T_4 = under mango trees).



T_1

T_2

T_3

T_4

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T_1

T_2

T_3

T_4

Plate 4.1.3. Different transplanted aman rice variety were shown in different treatment at harvesting stage (T_1= open field, T_2= under Black siris, T_3= under guava and T_4= under mango trees).

T_1

T_2

T_3

T_4

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T_1

T_2

T_3

T_4

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Experiment # 4.2. Performance of wheat in agroforestry systems

Performance of wheat varieties followed by transplanted aman rice was evaluated in different agroforestry systems with the following parameters-

4.2.1 Plant height

Plant height is an important growth characteristic of wheat, which is influenced at different growth stages by the shade of trees and below ground competition between tree and crops for nutrient. Effect of trees, varieties and their combined effects on plant height are described below-

Effect of tree species

Effect of trees on plant height of wheat was found significant irrespective of sowing dates and cropping seasons. In first year (2006-07) experiment, the highest plant height was recorded in T_4 (under mango) at all sampling dates (Figure 4.2.1). At 40 Days after sowing (DAS), T_4 (43.83 cm) and T_2 (43.39 cm) produced the similar plant height. At 80 and 120 DAS T_1, T_2 and T_4 produced the statistically similar plant height. Significantly the lowest plant height was recorded in T_3 (guava) in all sampling dates.

In 2nd year experiment (2007-08) plant height varied significantly by the treatments but influencing pattern was different to the previous year. Significantly the highest plant height were recorded in T_1 (open field) for all sampling dates (43.61, 88.89 and 95.17 cm in 40, 80 and 120 DAS respectively) which was statistically similar to that of T_2 except 40 DAS. Significantly the lowest plant heights were measured in T_3 (guava) irrespective of sampling dates (36.43, 77.93 and 84.53 cm at 40, 80 and 120 DAS respectively).

The response of plant height of wheat under different tree canopy revealed that up to 65 % light intensity (30-35 % shade) experienced by wheat up to their tillering stage might be caused higher plant height. In 2006-07, wheat grown under black siris, guava and mango experienced 74.5, 60.6 and 69.6% average light incidence respectively as a result plant height recorded under black siris and mango found taller than that of open field and under guava.

In 2007-08, average light incidence were 67.8, 45.0 and 49.1 % under black siris, guava and mango respectively in this year the tallest plant was found in open field as there were only 44-60 % light availability in different tree treatments (Appendix I and II). Shortage of light incidence might be caused of low photosynthesis and its corresponding effect was lower plant height.

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Many crops have this nature in responding to light i.e. in partial light intensities they elongated their height but further decrease of light intensity their height become dwarf. Although the critical range of partial light intensities varied crop to crop. Salina Hasan (2007) found that plant height of turmeric became longer up to 40-50 % intensity and further decreased of light may cause shorter plant height.

Response of wheat varieties

Plant height of wheat was varied due to the effect of varieties in the early stage of growth. At 40 DAS, the variation of plant height was found significant in both the experimental years but later on it was not significant. Although variation pattern was found similar at all sampling dates over the varieties. Significantly the highest plant height (47.95 and 43.43 cm in 2006-07 and 2007-08 respectively) were recorded for V_3 at 40 DAS in both the experimental years. In 2006-07, plant height at 40 DAS recorded from all others varieties were statistically similar (Figure 4.2.3) but in 2007, plant height produced by V_1 (43.23) and V_5 (43.13 cm) were statistically similar to that of V_3, V_2 and V_4. The plant height of wheat at other sampling dates (80 and 120 DAS) were not found significant but tallest plant was always recorded for V_3. Variation of plant height among the varieties might be due to their genetically characters.

Interaction effect of tree species and wheat variety

Interaction effect of tree species and wheat variety on plant height was found significant at 40 DAS in both the cropping seasons, although other sampling dates (80 and 120 DAS) showed non significant variation. There were also some dissimilar variation at the same sampling dates in two different experimental years. In first year (2006-07) significantly the highest plant height (49.27 cm) was recorded in T_4V_3 combination, followed by T_2V_3 (48.45 cm), T_3V_3 (47.10 cm) and then T_1V_3 (47.00 cm) at 40 DAS. These four combination produced statistically similar plant height (Table 4.2.1). Significantly the lowest plant height (40.19 cm) was obtained from T_3V_5 combination (protiva under guava). The variation of plant height recorded in 80 and 120 DAS were found not significant although V_3 (Shatabdi) under mango (T_4) produced numerically highest pant height in both sampling dates (49.27 and 90.34 cm in 80 and 120 DAS respectively).

In 2nd year experimentation (2007-08), V_3 (Shatabdi) also produced significantly the longest plant height (46.63 cm) in open field (T_1) at 40 DAS which was statistically identical to that of T_2V_3 combination (Shatabdi under black siris) and the value was 46.53 cm. Significantly the shortest plant height (41.03 cm) was found in T_1V_2 combination, but variation of plant height in other sampling dates were found insignificant (Table 4.2.1)

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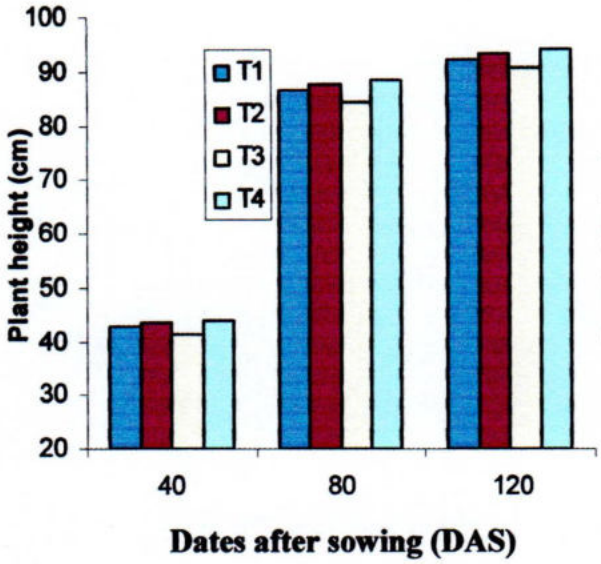


Fig 4.2.1 Effect of tree on plant height of wheat in 2006-07

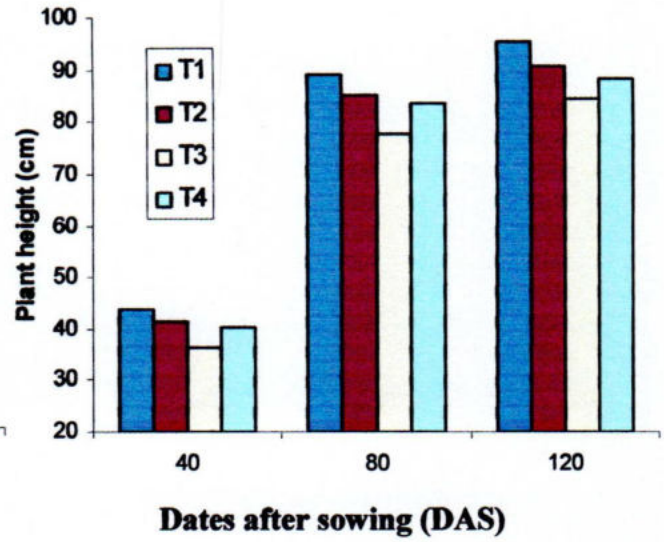


Fig 4.2.2 Effect of tree on plant height of wheat in 2007-08

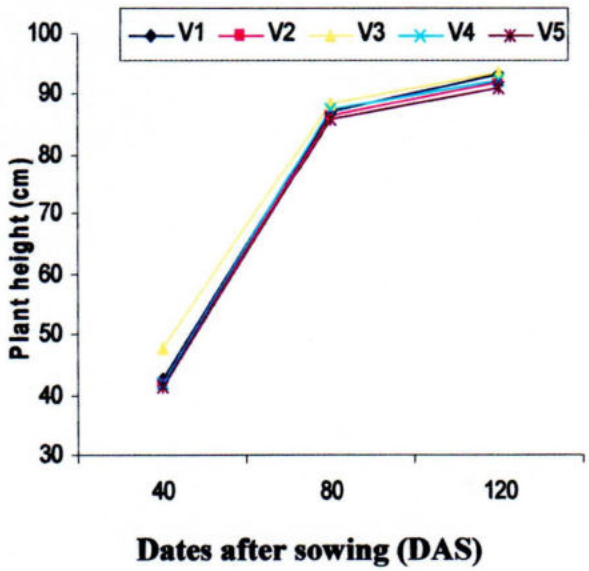


Fig 4.2.3 Effect of variety on plant height of wheat in 2006-07

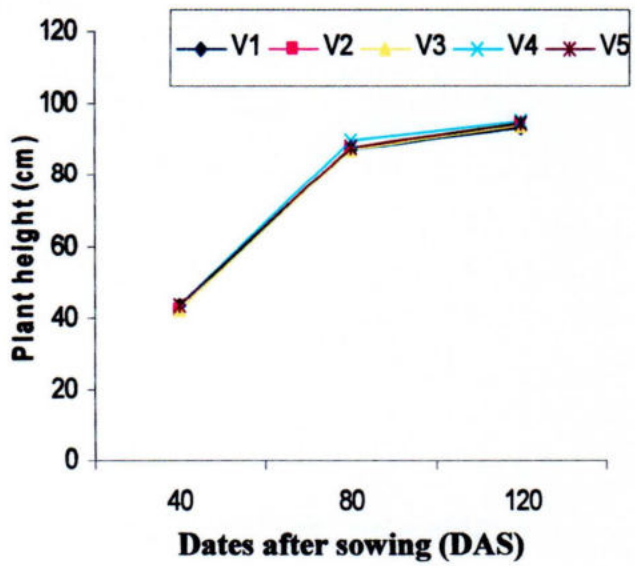
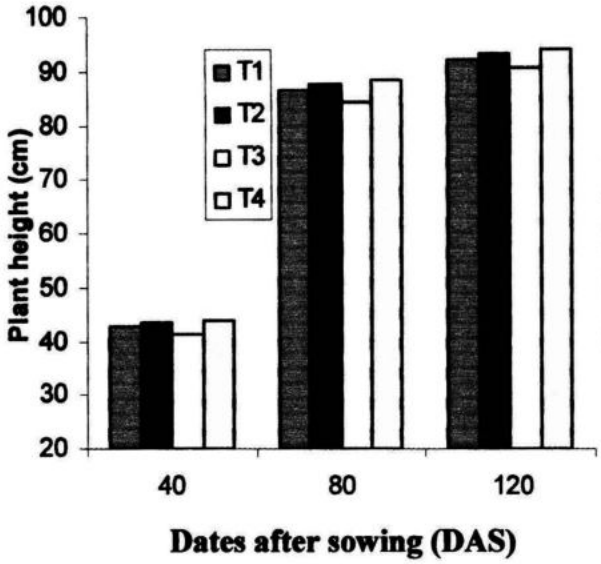


Fig 4.2.4 Effect of variety on plant height of wheat in 2007-08



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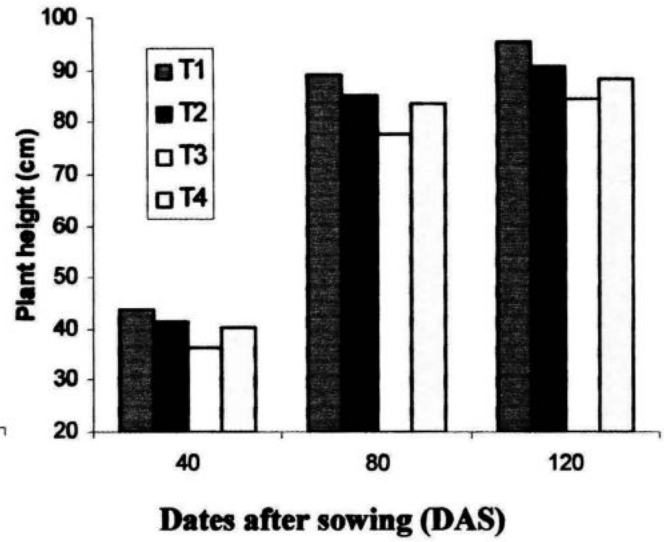
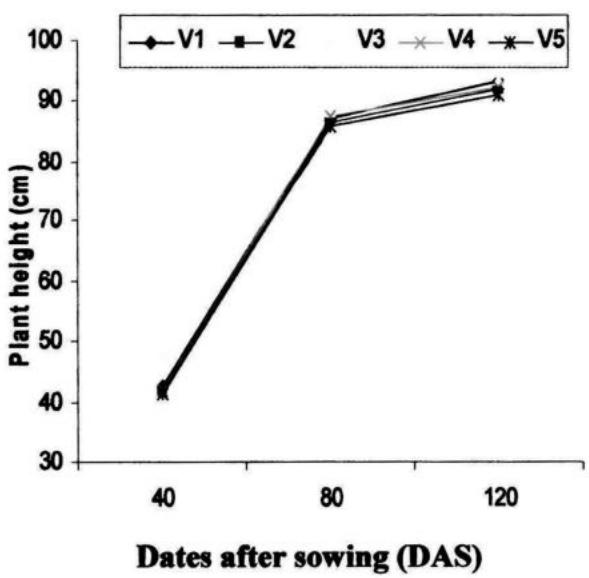


Fig 4.2.2 Effect of tree on plant height of wheat in 2007-08



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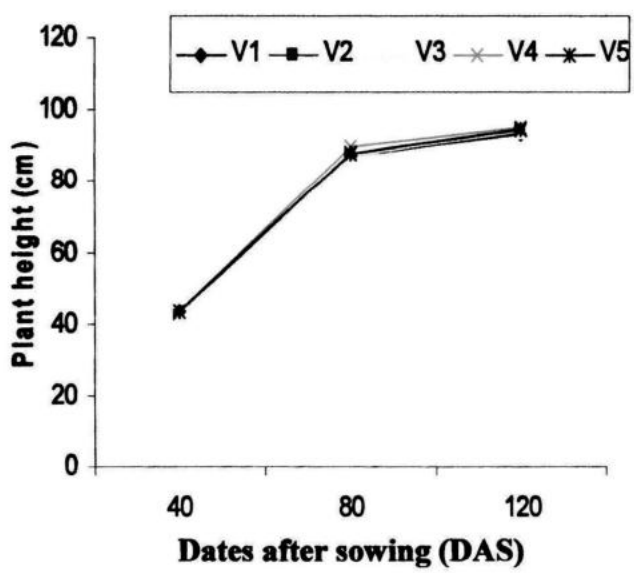

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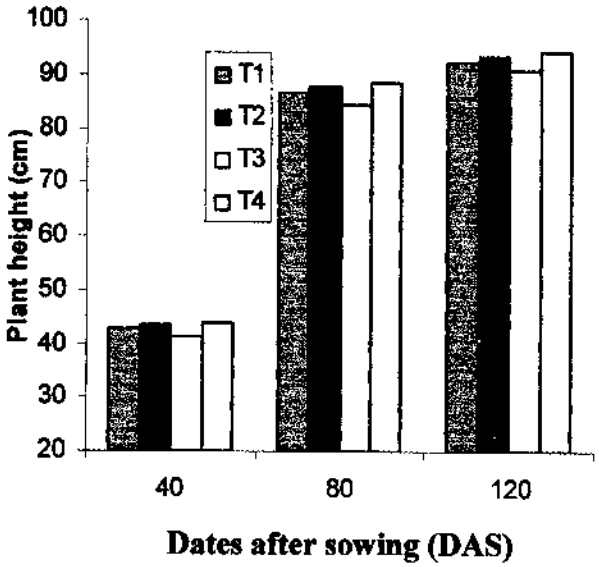

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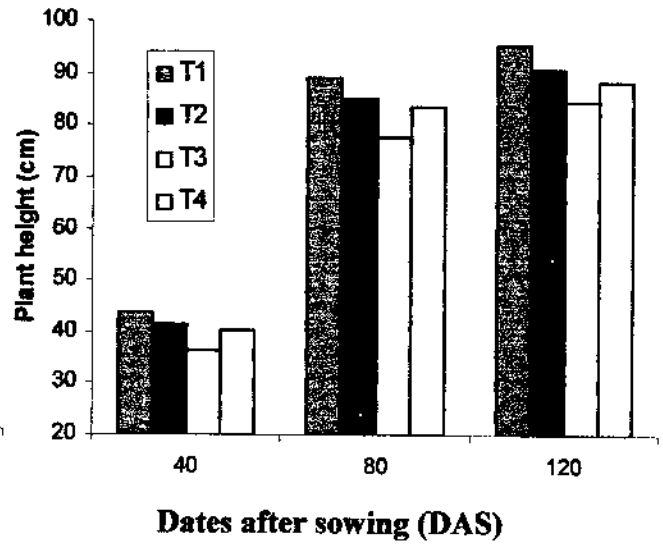

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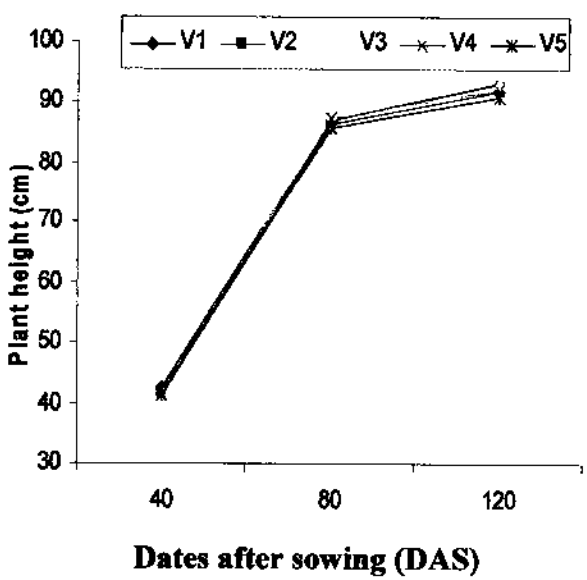

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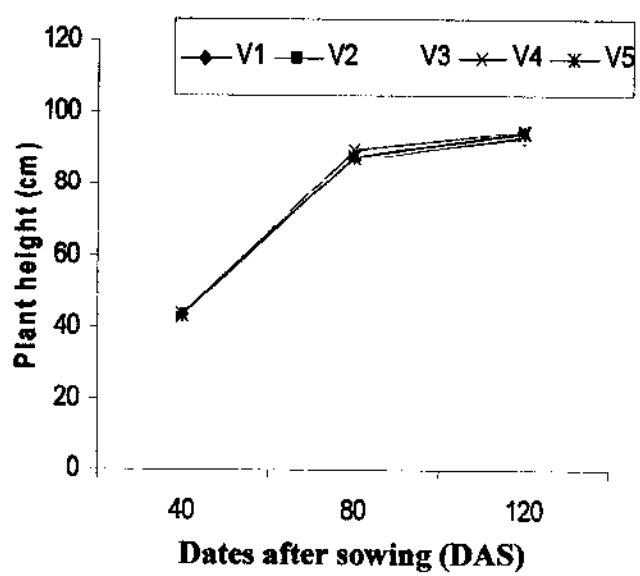

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Table 4.2.1. Interaction effect of tree species and wheat variety on plant height at different dates after sowing in 2006-07 and 2007-08

Treatment combination	Plant height (cm) 2006-07			Plant height (cm) 2007-08		
	40 DAS	80 DAS	120 DAS	40 DAS	80 DAS	120 DAS
T_1V_1	43.92cd	88.65	94.60	42.53 de	86.03	92.33
T_1V_2	41.68e	88.00	93.60	41.03 f	87.03	94.53
T_1V_3	47. 00ab	88.06	93.40	46.63 a	91.03	96.03
T_1V_4	42.07de	88.59	93.20	44.03 bc	90.03	92.33
T_1V_5	42.20de	87.00	94.10	42.03 de	88.03	93.53
T_2V_1	42.28de	87.10	93.60	41.83 ef	87.53	93.43
T_2V_2	40.99e	85.09	89.20	43.03 d	88.03	94.03
T_2V_3	48.45a	87.20	94.20	46.53 a	89.53	95.33
T_2V_4	41.91de	86.23	91.80	44.03 bc	87.53	97.03
T_2V_5	41.66de	68.30	93.10	42.16 de	88.33	96.03
T_3V_1	41.54de	85.30	92.40	42.53 de	89.03	95.53
T_3V_2	44.87bc	85.76	89.40	42.03 de	86.03	93.53
T_3V_3	47.10ab	88.35	92.20	43.03 cd	87.03	93.03
T_3V_4	42.46cde	86.29	90.28	43.03 cd	91.03	96.03
T_3V_5	40.19e	85.01	89.1	42.53 de	86.53	94.53
T_4V_1	42.79cde	88.09	93.30	42.03 de	86.03	93.53
T_4V_2	40.39e	87.78	92.70	43.03 cd	88.03	95.23
T_4V_3	49.27a	90.34	95.20	42.03 de	88.03	95.03
T_4V_4	42.06de	88.16	93.20	42.63 de	86.53	92.53
T_4V_5	41.50de	86.09	92.20	41.33 ef	87.03	95.03
CV%	7.5	9.8	5.3	3.25	9.13	10.4

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT. T_1= control (open field), T_2= Kala koroi, T_3= Guava, T_4= Mango trees. V_1 = Gourove, V_2 = Sourave, V_3 = Shatabdi, V_4 = Kanchan, V_5 = Protiva.

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T_3V_4	42.46cde	86.29	90.28	43.03 cd	91.03	96.03
T_3V_5	40.19e	85.01	89.1	42.53 de	86.53	94.53
T_4V_1	42.79cde	88.09	93.30	42.03 de	86.03	93.53
T_4V_2	40.39e	87.78	92.70	43.03 cd	88.03	95.23
T_4V_3	49.27a	90.34	95.20	42.03 de	88.03	95.03
T_4V_4	42.06de	88.16	93.20	42.63 de	86.53	92.53
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T_1V_4	42.07de	88.59	93.20	44.03 bc	90.03	92.33
T_1V_5	42.20de	87.00	94.10	42.03 de	88.03	93.53
T_2V_1	42.28de	87.10	93.60	41.83 ef	87.53	93.43
T_2V_2	40.99e	85.09	89.20	43.03 d	88.03	94.03
T_2V_3	48.45a	87.20	94.20	46.53 a	89.53	95.33
T_2V_4	41.91de	86.23	91.80	44.03 bc	87.53	97.03
T_2V_5	41.66de	68.30	93.10	42.16 de	88.33	96.03
T_3V_1	41.54de	85.30	92.40	42.53 de	89.03	95.53
T_3V_2	44.87bc	85.76	89.40	42.03 de	86.03	93.53
T_3V_3	47.10ab	88.35	92.20	43.03 cd	87.03	93.03
T_3V_4	42.46cde	86.29	90.28	43.03 cd	91.03	96.03
T_3V_5	40.19e	85.01	89.1	42.53 de	86.53	94.53
T_4V_1	42.79cde	88.09	93.30	42.03 de	86.03	93.53
T_4V_2	40.39e	87.78	92.70	43.03 cd	88.03	95.23
T_4V_3	49.27a	90.34	95.20	42.03 de	88.03	95.03
T_4V_4	42.06de	88.16	93.20	42.63 de	86.53	92.53
T_4V_5	41.50de	86.09	92.20	41.33 ef	87.03	95.03
CV%	7.5	9.8	5.3	3.25	9.13	10.4

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT. T_1= control (open field), T_2= Kala koroi, T_3= Guava, T_4= Mango trees. V_1 = Gourove, V_2 = Sourave, V_3 = Shatabdi, V_4 = Kanchan, V_5 = Protiva.

4.2.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} is one of the very important parameter for yield contribution of wheat, number of tillers hill^{-1} was greatly affected by trees, varieties and their combined effect which were given below-

Effect of tree species

Number of tillers hill^{-1} was not influenced significantly at 30 DAS in first year experiment (2006-07) but numerically highest number 2.6 was recorded in both T_1 and T_4. The influencing pattern of number of tillers at 45 and 60 DAS was quite similar. Significantly the maximum number 3.9 and 4.19 were recorded in 45 and 60 DAS respectively in T_1 followed by T_2 (Black siris). T_3 and T_4 produced the similar number of tiller to that of T_2 (Figure 4.2.5). In 2007-08, significantly the highest number of tiller was recorded in T_1 irrespective of sampling dates (2.7, 3.85 and 4.22 in 30, 45 and 60 DAS respectively) followed by T_2. Significantly the lowest number of tiller was produced in T_3 (under guava).

The above variation of number of tillers hill^{-1} might be due to various light intensities available under different treatments crops grown in T_1 (open field), T_2 (black siris), T_3 (guava) and T_4 (mango) experienced 100, 67.8, 45 and 49.12 % light intensities respectively.

Response of wheat varieties

Number of tillers hill^{-1} was greatly affected by the effect of variety except 30 DAS in both cropping seasons. At 30 DAS numerically highest number was recorded in V_3 (3 and 2.8 in 2006-07 and 2007-08, respectively) followed by V_4 (Kanchan). The lowest tiller number was found in V_2 (Sourave) in both the experimental years (2.4 and 2.15 in 2006-07 and 2007-08). Shatabdi produced significantly the highest number of tillers hill^{-1} irrespective of sampling dates and cropping seasons which was followed by V_4 (kanchan) V_3 and V_4 produced statistically identical number of tiller in most of the sampling dates except at 60 DAS in 2006-07. The lowest number of tiller was produced by V_2 (Sourave) in all cases which was statistically similar to those of V_2 and V_5 except at 60 DAS in 2006-07. This variation might be due to genetic make up of the varieties.

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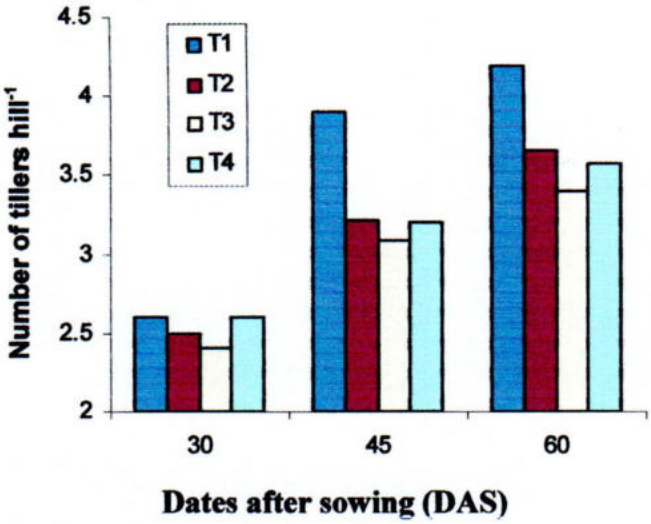


Fig 4.2.5 Effect of tree on number of tillers hill^{-1} in 2006-07

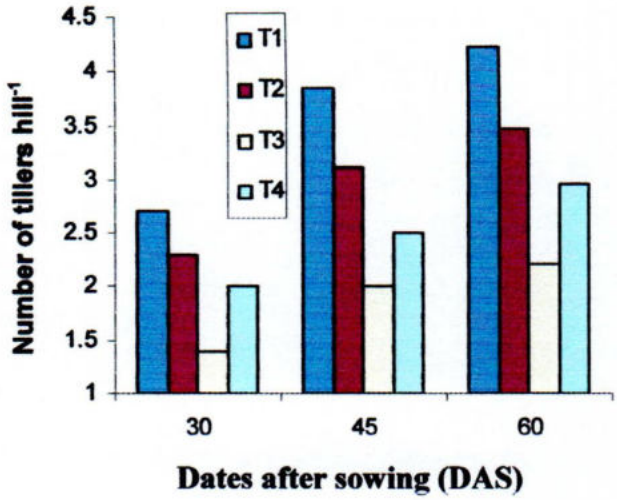


Fig 4.2.6 Effect of tree on number of tillers hill^{-1} in 2007-08

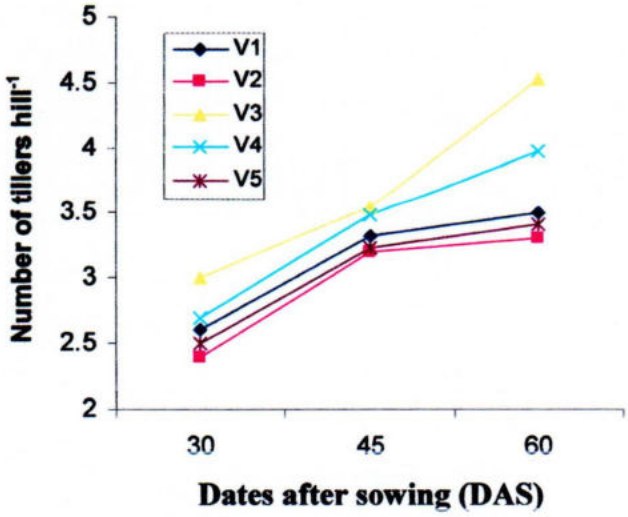


Fig 4.2.7 Effect of variety on number of tillers hill^{-1} in 2006-07

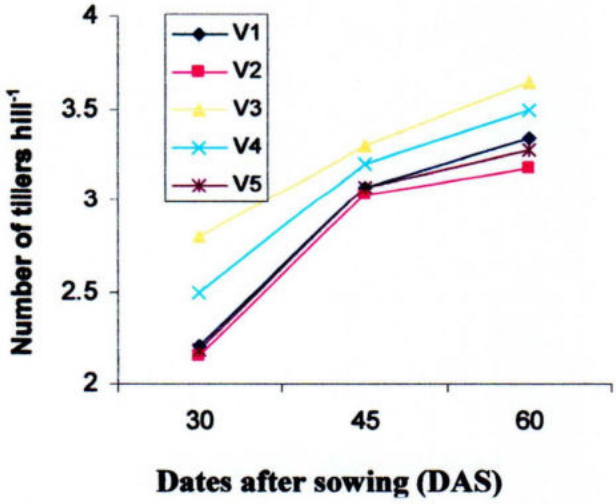


Fig 4.2.8 Effect of variety on number of tillers hill^{-1} in 2007-08

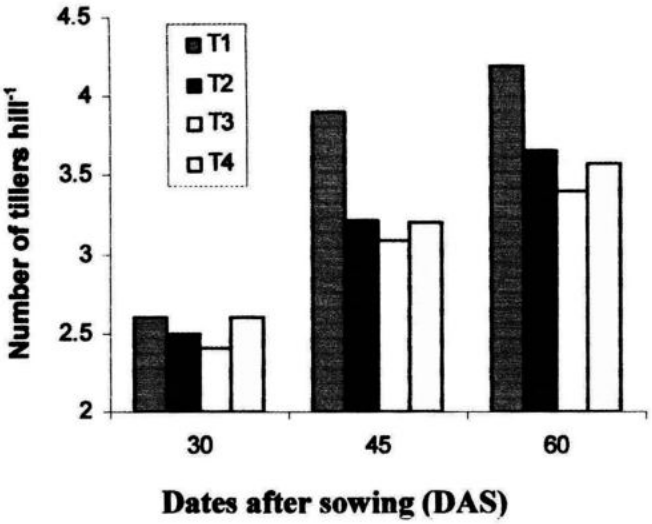


Fig 4.2.5 Effect of tree on number of tillers hill^{-1} in 2006-07

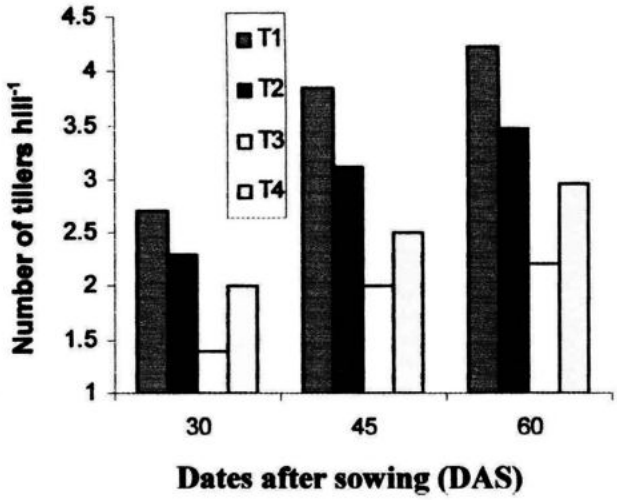


Fig 4.2.6 Effect of tree on number of tillers hill^{-1} in 2007-08

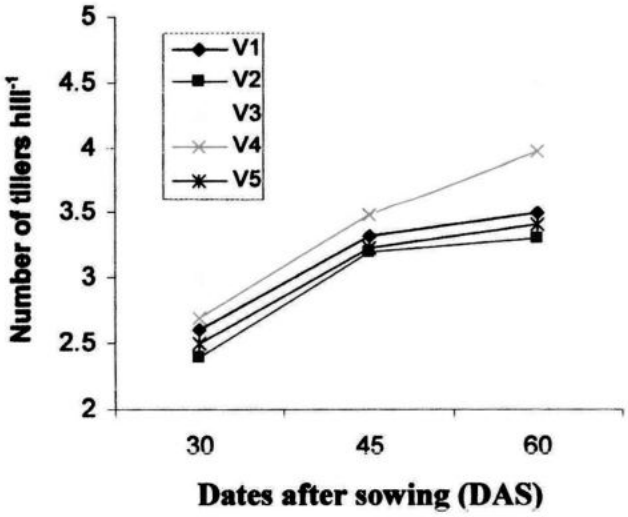


Fig 4.2.7 Effect of variety on number of tillers hill^{-1} in 2006-07

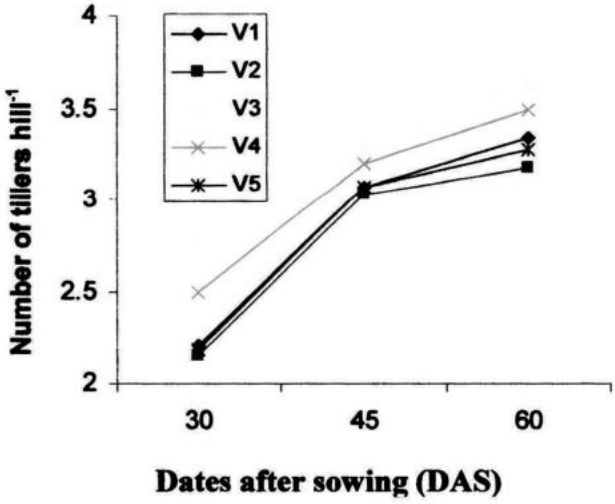
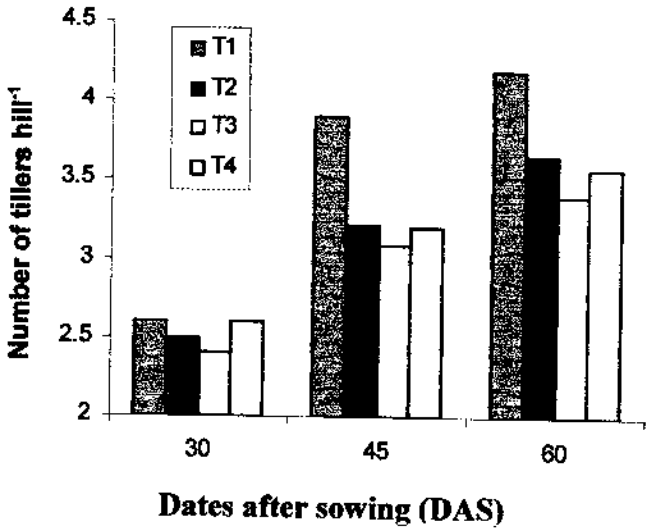


Fig 4.2.8 Effect of variety on number of tillers hill^{-1} in 2007-08



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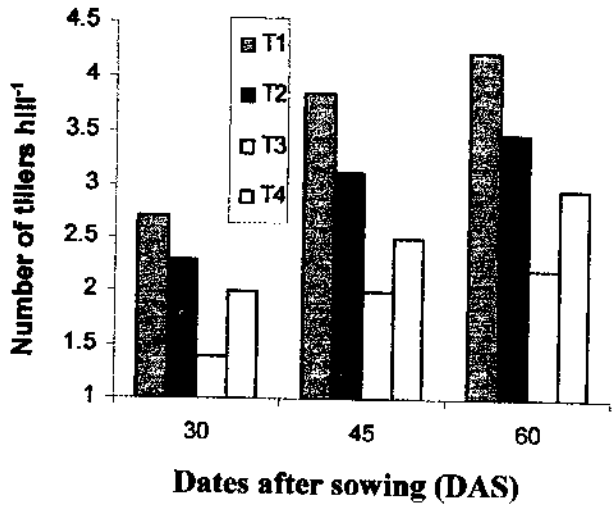

Fig 4.2.6 Effect of tree on number of tillers hill^{-1} in 2007-08

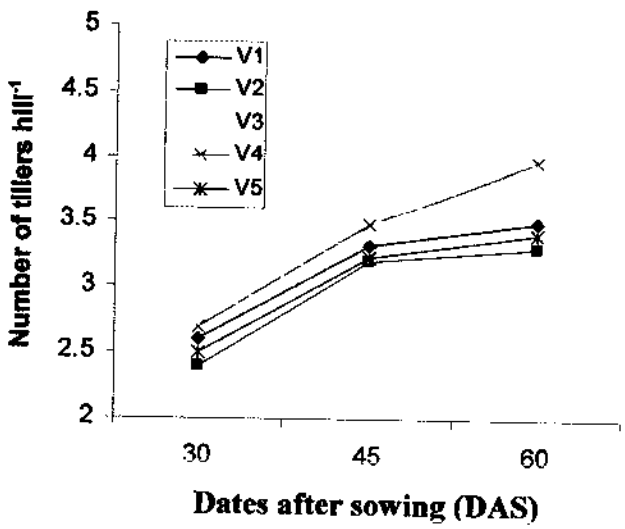

Fig 4.2.7 Effect of variety on number of tillers hill^{-1} in 2006-07

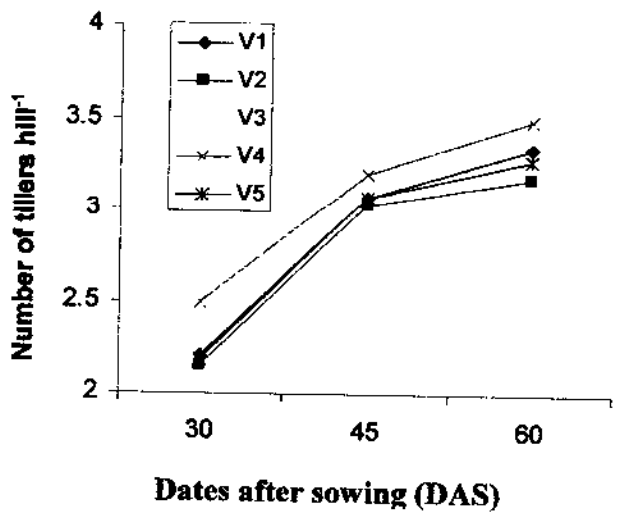

Fig 4.2.8 Effect of variety on number of tillers hill^{-1} in 2007-08

Interaction effect of tree species and wheat variety on number of tillers hill^{-1} Number of tillers hill^{-1} was significantly influenced by the combined effect of trees and wheat varieties in both cropping seasons except 30 DAS in 2006-07 (Table 4.2.2). The influencing pattern was almost similar irrespective of sampling dates and experimental years. Shatabdi (V_3) in open field (T_1V_3 combination) always produced the highest number of tillers hill^{-1} over other combination in all sampling dates of both the cropping seasons, which were followed by T_1V_4 combination (Kanchan in open field). Shatabdi (V_3) also produced the highest number of tiller per hill over other varieties under each treatment. Significantly the lowest number of tillers hill^{-1} was recorded for T_3V_2 combination (Sourave under guava) in all sampling dates of both experimental year (Table 4.2.2) Khan and Aslam (1974) reported that close proximity to trees adversely affected number of tillers m^{-2} in wheat.

4.2.3 Number of spikes per hill

Effect of tree species

Number of spikes per hill was not influenced by the effect of trees in first year experiment. In this year numerically highest number of spikes per hill (3.34) was recorded in open field (T_1) and lowest number (3.21) was found in T_3 (guava). This might be due to minimum variation of light availability under different tree canopy as the trees were very early aged.

In 2nd year experiment (2007-08) number of spikes per hill was affected significantly. The maximum number of spikes hill was recorded in open field (3.35) which was identical to T_2 (3.11) significantly the minimum number of spikes per hill (1.81) was counted in T_3 (guava). This significant variation might be due to remarkable variation of light intensities under different tree canopy, as there were 100, 67.8, 45 and 49.12 % average light intensities in T_1, T_2, T_3 and T_4, respectively (Appendix Table-1).

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Table 4.2.2. Interaction effect of tree species and wheat variety on number of tillers hill^{-1} at different days after sowing in 2006-07 and 2007-08

Treatment combination	Number of tillers hill^{-1} 2006-07			Number of tillers hill^{-1} 2007-08		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1V_1	2.6	3.61 b	3.85 ab	2.45 b	3.46 b	3.78 b
T_1V_2	2.5	3.55 c	3.75 ab	2.43 b	3.44 b	3.70 bc
T_1V_3	2.8	3.72 a	4.36 a	2.75 a	3.57 a	3.93 a
T_1V_4	2.65	3.69 a	4.09 a	2.60 a	3.52 a	3.86 ab
T_1V_5	2.55	3.56 c	3.8 ab	2.44 b	3.45 b	3.75 b
T_2V_1	2.5	3.27 efg	3.57 b	2.25 cd	3.10 cd	3.41 de
T_2V_2	2.45	3.20 fgh	3.48 c	2.23 cd	3.07 cd	3.33 e
T_2V_3	2.75	3.39 de	4.08 a	2.55 b	3.21 cd	3.56 cde
T_2V_4	2.6	3.34 ef	3.82 ab	2.40 b	3.16 cd	3.49 cde
T_2V_5	2.5	3.22 fgh	3.53 b	2.24 cd	3.10 cd	3.38 de
T_3V_1	2.5	3.21 fgh	3.45 cd	1.80 e	2.54 ef	2.78 h
T_3V_2	2.4	3.14 h	3.35 d	1.70 e	2.51 f	2.70 h
T_3V_3	2.7	3.32 ef	3.96 ab	2.10 d	2.65 e	2.93 gh
T_3V_4	2.55	3.29 efg	3.69 b	1.95 de	2.60 e	2.86 gh
T_3V_5	2.45	3.16 h	3.41 d	1.70 e	2.54 ef	2.75 h
T_4V_1	2.6	3.26 efg	3.54 b	2.1 d	2.79 d	3.15 fg
T_4V_2	2.5	3.20 fgh	3.44 cd	2.08 d	2.77 de	3.07 fg
T_4V_3	2.75	3.38 de	4.05 a	2.4 b	2.95 d	3.30 e
T_4V_4	2.6	3.34 ef	3.77 ab	2.25 cd	2.85 d	3.23 ef
T_4V_5	2.5	3.21 fgh	3.49 c	2.09 d	2.80 d	3.12 fg
CV%	8.28	6.28	9.70	7.93	4.5	5.28

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT. T_1 = control (open field), T_2 = Kala koroi, T_3 = Guava, T_4 = Mango trees. V_1 = Gourove, V_2 = Sourave, V_3 = Shatabdi, V_4 = Kanchan, V_5 = Protiva.

Table 4.2.2. Interaction effect of tree species and wheat variety on number of tillers hill^{-1} at different days after sowing in 2006-07 and 2007-08

Treatment combination	Number of tillers hill^{-1} 2006-07			Number of tillers hill^{-1} 2007-08		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1V_1	2.6	3.61 b	3.85 ab	2.45 b	3.46 b	3.78 b
T_1V_2	2.5	3.55 c	3.75 ab	2.43 b	3.44 b	3.70 bc
T_1V_3	2.8	3.72 a	4.36 a	2.75 a	3.57 a	3.93 a
T_1V_4	2.65	3.69 a	4.09 a	2.60 a	3.52 a	3.86 ab
T_1V_5	2.55	3.56 c	3.8 ab	2.44 b	3.45 b	3.75 b
T_2V_1	2.5	3.27 efg	3.57 b	2.25 cd	3.10 cd	3.41 de
T_2V_2	2.45	3.20 fgh	3.48 c	2.23 cd	3.07 cd	3.33 e
T_2V_3	2.75	3.39 de	4.08 a	2.55 b	3.21 cd	3.56 cde
T_2V_4	2.6	3.34 ef	3.82 ab	2.40 b	3.16 cd	3.49 cde
T_2V_5	2.5	3.22 fgh	3.53 b	2.24 cd	3.10 cd	3.38 de
T_3V_1	2.5	3.21 fgh	3.45 cd	1.80 e	2.54 ef	2.78 h
T_3V_2	2.4	3.14 h	3.35 d	1.70 e	2.51 f	2.70 h
T_3V_3	2.7	3.32 ef	3.96 ab	2.10 d	2.65 e	2.93 gh
T_3V_4	2.55	3.29 efg	3.69 b	1.95 de	2.60 e	2.86 gh
T_3V_5	2.45	3.16 h	3.41 d	1.70 e	2.54 ef	2.75 h
T_4V_1	2.6	3.26 efg	3.54 b	2.1 d	2.79 d	3.15 fg
T_4V_2	2.5	3.20 fgh	3.44 cd	2.08 d	2.77 de	3.07 fg
T_4V_3	2.75	3.38 de	4.05 a	2.4 b	2.95 d	3.30 e
T_4V_4	2.6	3.34 ef	3.77 ab	2.25 cd	2.85 d	3.23 ef
T_4V_5	2.5	3.21 fgh	3.49 c	2.09 d	2.80 d	3.12 fg
CV%	8.28	6.28	9.70	7.93	4.5	5.28

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT. T_1 = control (open field), T_2 = Kala koroi, T_3 = Guava, T_4 = Mango trees. V_1 = Gourove, V_2 = Sourave, V_3 = Shatabdi, V_4 = Kanchan, V_5 = Protiva.

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T_1V_1	2.6	3.61 b	3.85 ab	2.45 b	3.46 b	3.78 b
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T_1V_3	2.8	3.72 a	4.36 a	2.75 a	3.57 a	3.93 a
T_1V_4	2.65	3.69 a	4.09 a	2.60 a	3.52 a	3.86 ab
T_1V_5	2.55	3.56 c	3.8 ab	2.44 b	3.45 b	3.75 b
T_2V_1	2.5	3.27 efg	3.57 b	2.25 cd	3.10 cd	3.41 de
T_2V_2	2.45	3.20 fgh	3.48 c	2.23 cd	3.07 cd	3.33 e
T_2V_3	2.75	3.39 de	4.08 a	2.55 b	3.21 cd	3.56 cde
T_2V_4	2.6	3.34 ef	3.82 ab	2.40 b	3.16 cd	3.49 cde
T_2V_5	2.5	3.22 fgh	3.53 b	2.24 cd	3.10 cd	3.38 de
T_3V_1	2.5	3.21 fgh	3.45 cd	1.80 e	2.54 ef	2.78 h
T_3V_2	2.4	3.14 h	3.35 d	1.70 e	2.51 f	2.70 h
T_3V_3	2.7	3.32 ef	3.96 ab	2.10 d	2.65 e	2.93 gh
T_3V_4	2.55	3.29 efg	3.69 b	1.95 de	2.60 e	2.86 gh
T_3V_5	2.45	3.16 h	3.41 d	1.70 e	2.54 ef	2.75 h
T_4V_1	2.6	3.26 efg	3.54 b	2.1 d	2.79 d	3.15 fg
T_4V_2	2.5	3.20 fgh	3.44 cd	2.08 d	2.77 de	3.07 fg
T_4V_3	2.75	3.38 de	4.05 a	2.4 b	2.95 d	3.30 e
T_4V_4	2.6	3.34 ef	3.77 ab	2.25 cd	2.85 d	3.23 ef
T_4V_5	2.5	3.21 fgh	3.49 c	2.09 d	2.80 d	3.12 fg
CV%	8.28	6.28	9.70	7.93	4.5	5.28

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT. T_1 = control (open field), T_2 = Kala koroi, T_3 = Guava, T_4 = Mango trees. V_1 = Gourove, V_2 = Sourave, V_3 = Shatabdi, V_4 = Kanchan, V_5 = Protiva.

Response of wheat varieties

Number of spikes per hill was significantly influenced by the effect of variety in both the cropping seasons (Figure 4.2.11-12). In 2006-07, the highest number of spikes per hill (3.47) was recorded in V_3 (Shatabdi). Significantly the lowest number of spikes per hill (3.04) was recorded in V_2 (Sourave), V_1 (Gourove), V_4 (Kanchan) and V_5 (Protiva) produced the moderate number of spikes per hill and the values were statistically similar to those of V_2 and V_3. The influencing pattern of spikes number in 2007-08 was almost similar to previous year. Significantly the highest number of spikes per hill (2.86) was recorded in V_3 followed by V_1 (2.25) and then V_4 (2.24). Significantly the lowest number of spikes per hill was counted in V_2 (1.61) variation of number of spikes within the varieties might be due to their genetical capacity but variation between two years might be due to soil fertility and moisture content.

Interaction effect of tree species and wheat variety on number of spikes hill^{-1}

Number of spikes hill^{-1} was not varied significantly by combined effect of trees and varieties in first year experiment (2006-07) but that was varied significantly in the following year (2007-08). In 2006-07, maximum number of spikes hill^{-1} (3.4) was produced by Shatabdi (V_3) in open field (T_1), followed by T_4V_3 combination (Shatabdi under mango). 3rd and 4th highest number of spikes hill^{-1} were recorded 3.35 and 3.34 from T_2V_3 and T_3V_3 combinations respectively the lowest number of spike (3.12) was recorded for V_2 in T_3 (guava). In 2007-08 significantly the highest number of spikes hill^{-1} (3.10) was produced by V_3 in open field (T_1) which was identically followed by T_2V_3 (2.98) combination (Shatabdi under black siris). The third highest number of spike (2.8) was found in both T_1V_1 and T_4V_3 combinations. Significantly the lowest spike number per hill (1.71) was recorded in T_3V_5 (Protiva under guava) which was statistically similar to that of T_3V_2 (1.87). The study revealed that Shatabdi was more tolerant to shade over other varieties in case of spikes producing per hill.

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Interaction effect of tree species and wheat variety on number of spikes hill^{-1}

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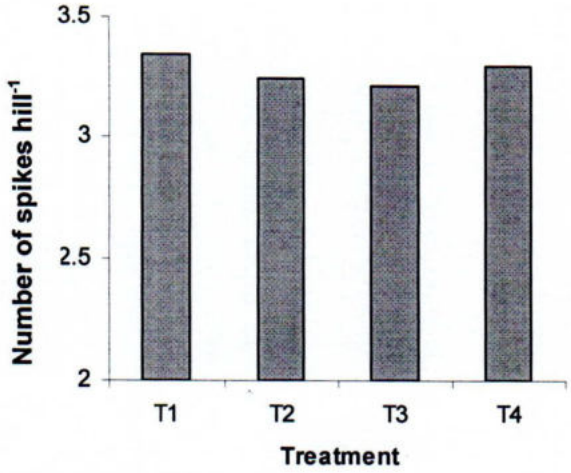


Fig 4.2.9 Effect of tree on number of spikes hill^{-1} in 2006-07

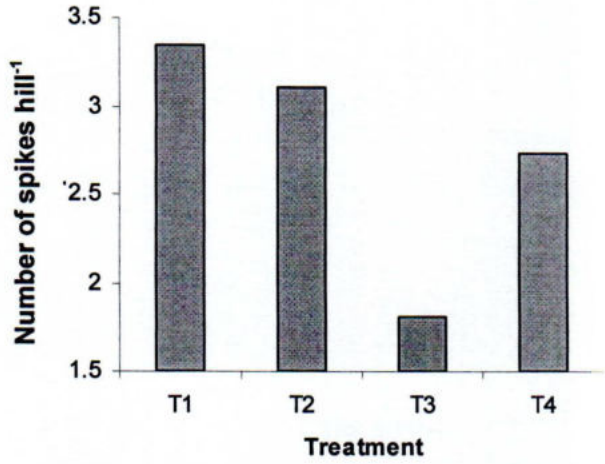


Fig 4.2.10 Effect of tree on number of spikes hill^{-1} in 2007-08

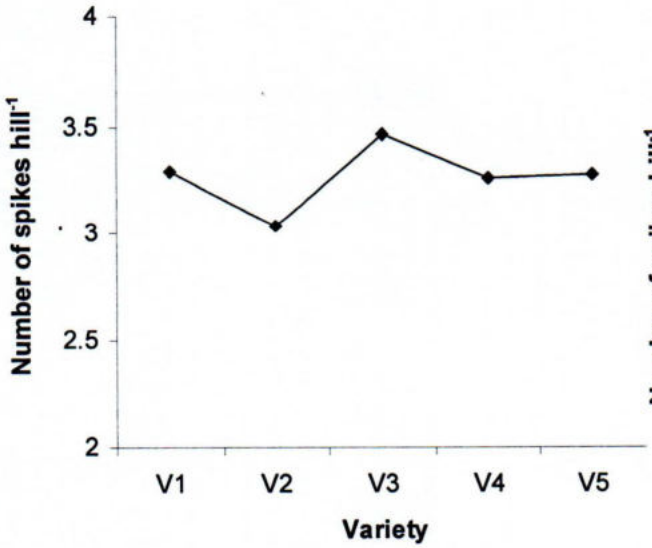
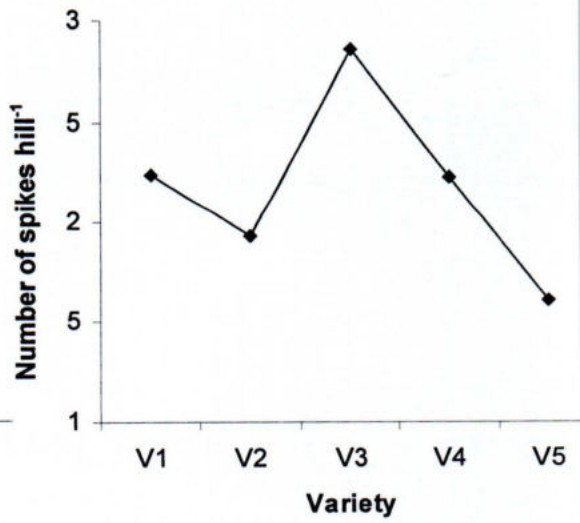


Fig 4.2.11 Effect of varieties on number of spikes hill^{-1} in 2006-07



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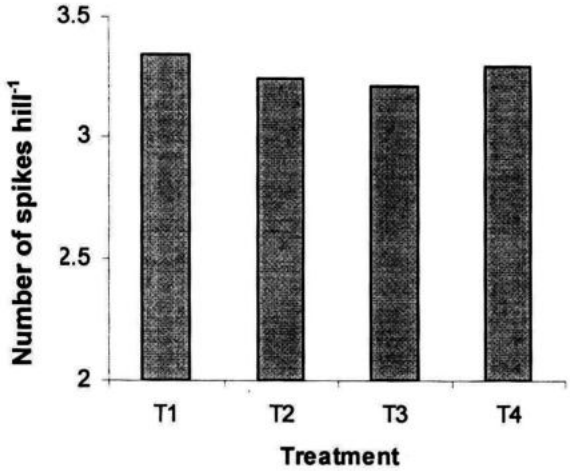


Fig 4.2.9 Effect of tree on number of spikes hill^{-1} in 2006-07

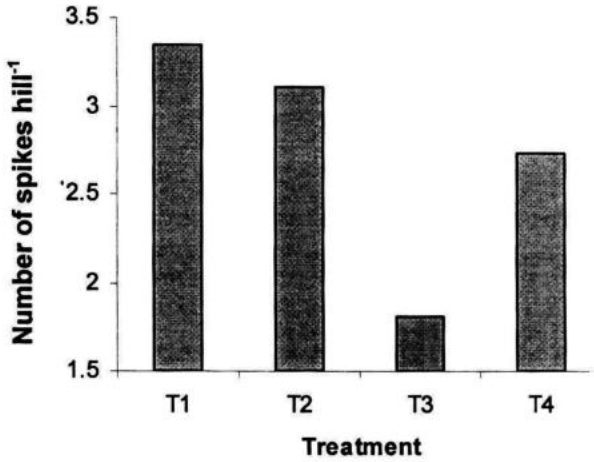
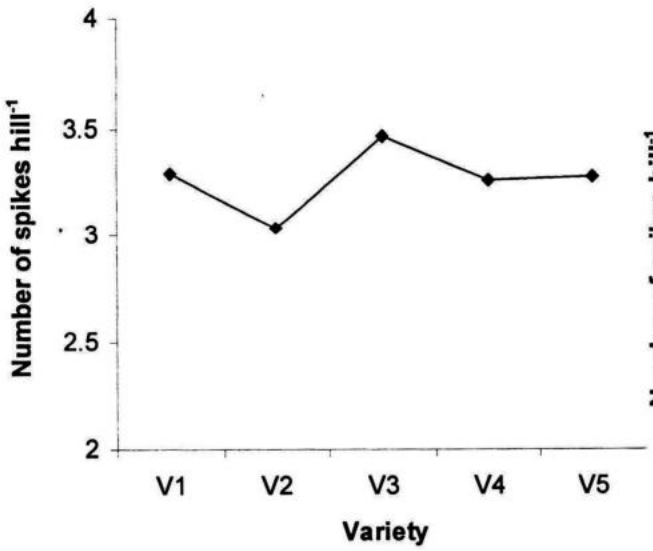


Fig 4.2.10 Effect of tree on number of spikes hill^{-1} in 2007-08



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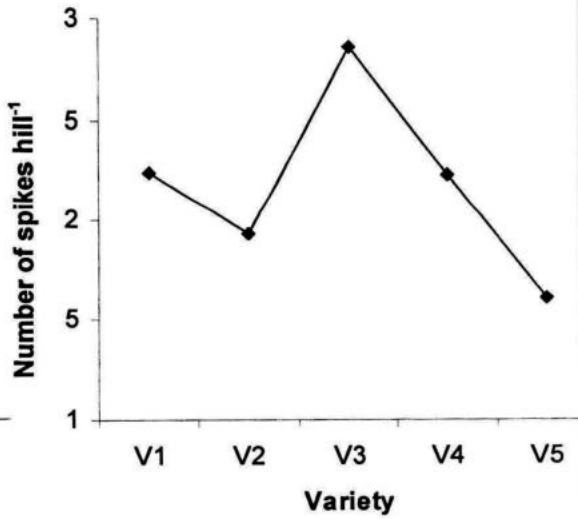


Fig 4.2.12 Effect of varieties on number of spikes hill^{-1} in 2007-08

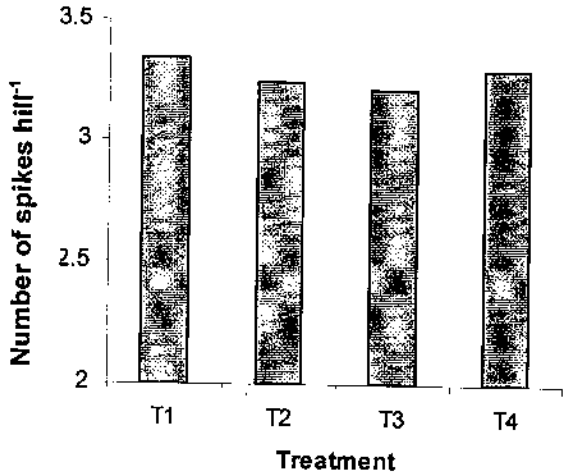


Fig 4.2.9 Effect of tree on number of spikes hill^{-1} in 2006-07

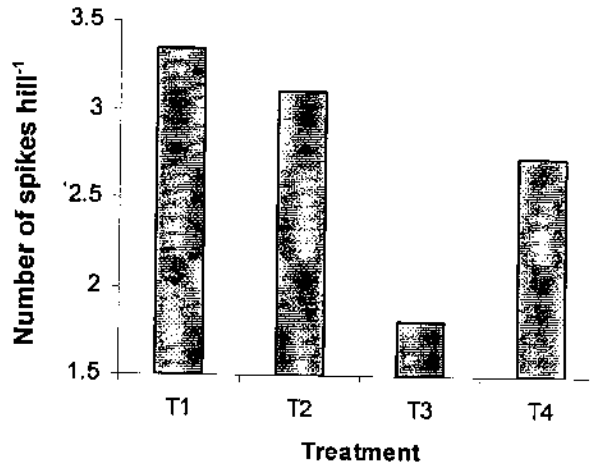
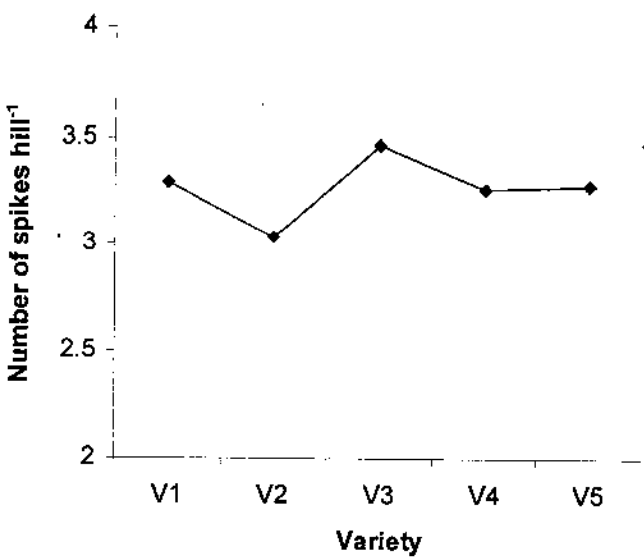


Fig 4.2.10 Effect of tree on number of spikes hill^{-1} in 2007-08



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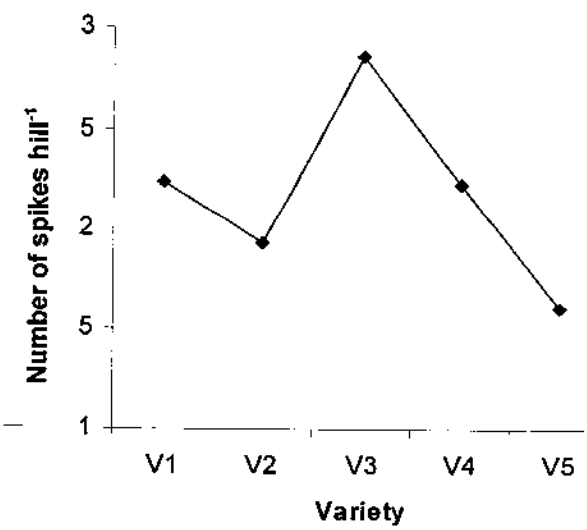

Fig 4.2.12 Effect of varieties on number of spikes hill^{-1} in 2007-08

Table 4.2.3. Interaction effect of tree species and wheat variety on yield and yield contributing characters in 2006-07 and 2007-08

Treatment combination	No. of spikes hill^{-1}		Length of spikes hill^{-1}		No. of .grain hill^{-1}		Grain wt.(g hill^{-1})		1000 grain- weight (g)		Grain yield (tha^{-1})	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
T_1V_1	3.31	2.8 b	10.35	10.27	118.96 b	113.58 b	5.03 ab	4.87	44.63	43.99	2.84	2.80
T_1V_2	3.19	2.64 c	10.18	10.27	119.90 b	114.96 b	4.49 d	4.32	43.59	42.91	2.79	2.63
T_1V_3	3.40	3.10 a	10.47	10.38	125.24 a	119.56 a	5.19 a	5.03	45.58	44.86	2.90	2.87
T_1V_4	3.30	2.79 b	9.99	9.82	117.91 b	113.83 b	4.68 bc	4.40	43.50	42.63	2.72	2.58
T_1V_5	3.31	2.48 a	9.97	9.81	113.93 c	108.14 c	4.61 cd	4.43	42.64	41.91	2.68	2.63
T_2V_1	3.26	2.68 bc	10.17	10.11	112.14 c	101.98 d	4.57 d	4.30	43.23	43.32	2.60	2.50
T_2V_2	3.14	2.52 d	10.01	10.11	113.09 c	103.36 d	4.03 g	3.75	42.19	42.25	2.56	2.33
T_2V_3	3.35	2.98 a	10.30	10.22	118.42 b	107.96 c	4.73 bc	4.46	44.18	44.19	2.66	2.57
T_2V_4	3.25	2.67 bc	9.82	9.66	111.09 c	102.23d	4.22 ef	3.82	42.15	41.96	2.49	2.28
T_2V_5	3.26	2.36 ef	9.80	9.65	107.12d	96.54 e	4.15 fg	3.85	41.24	41.25	2.44	2.33
T_3V_1	3.25	2.03 fg	10.06	10.03	110.65c	88.08 f	4.46 d	3.52	42.82	40.92	2.54	2.09
T_3V_2	3.12	1.87 h	9.90	10.03	111.60c	89.46 f	3.92 gh	2.97	41.78	39.85	2.49	1.92
T_3V_3	3.34	2.33 ef	10.19	10.14	116.93bc	94.06 e	4.62 cd	3.68	43.77	41.79	2.60	2.16
T_3V_4	3.24	2.02 fgh	9.71	9.58	109.60 d	88.335 f	4.11 fg	3.04	41.7	39.56	2.42	1.87
T_3V_5	3.24	1.71 h	9.69	9.57	105.63 de	82.64 g	4.04 g	3.07	40.84	38.85	2.38	1.92
T_4V_1	3.29	2.49 d	10.26	10.04	112.36 c	94.58 e	4.61 cd	4.02	43.52	43.22	2.62	2.35
T_4V_2	3.17	2.33 ef	10.09	10.03	113.31c	95.96 e	4.07 g	3.47	42.48	42.15	2.57	2.18
T_4V_3	3.38	2.80 b	10.38	10.14	118.64b	100.56 d	4.77 bc	4.18	44.47	44.09	2.68	2.42
T_4V_4	3.28	2.49 d	9.90	9.58	111.31c	94.83 e	4.26 ef	3.54	42.39	41.86	2.50	2.14
T_4V_5	3.29	2.17 fg	9.88	9.58	107.34d	89.14 ef	4.19 fg	3.57	41.53	41.15	2.46	2.19
CV%	10.25	5.20	7.80	6.8	5.40	3.57	9.89	6.77	8.50	9.20	4.30	5.50

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT. T_1 = control (open field), T_2= Black siris, T_3 = Guava, T_4 = Mango trees. V_1 = Gourove, V_2 = Sourave, V_3 = Shatabdi, V_4 = Kanchan, V_5 = Protiva.

Table 4.2.3. Interaction effect of tree species and wheat variety on yield and yield contributing characters in 2006-07 and 2007-08

Treatment combination	No. of spikes hill^{-1}		Length of spikes hill^{-1}		No. of .grain hill^{-1}		Grain wt.(g hill^{-1})		1000 grain- weight (g)		Grain yield (tha^{-1})	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
T_1V_1	3.31	2.8 b	10.35	10.27	118.96 b	113.58 b	5.03 ab	4.87	44.63	43.99	2.84	2.80
T_1V_2	3.19	2.64 c	10.18	10.27	119.90 b	114.96 b	4.49 d	4.32	43.59	42.91	2.79	2.63
T_1V_3	3.40	3.10 a	10.47	10.38	125.24 a	119.56 a	5.19 a	5.03	45.58	44.86	2.90	2.87
T_1V_4	3.30	2.79 b	9.99	9.82	117.91 b	113.83 b	4.68 bc	4.40	43.50	42.63	2.72	2.58
T_1V_5	3.31	2.48 a	9.97	9.81	113.93 c	108.14 c	4.61 cd	4.43	42.64	41.91	2.68	2.63
T_2V_1	3.26	2.68 bc	10.17	10.11	112.14 c	101.98 d	4.57 d	4.30	43.23	43.32	2.60	2.50
T_2V_2	3.14	2.52 d	10.01	10.11	113.09 c	103.36 d	4.03 g	3.75	42.19	42.25	2.56	2.33
T_2V_3	3.35	2.98 a	10.30	10.22	118.42 b	107.96 c	4.73 bc	4.46	44.18	44.19	2.66	2.57
T_2V_4	3.25	2.67 bc	9.82	9.66	111.09 c	102.23d	4.22 ef	3.82	42.15	41.96	2.49	2.28
T_2V_5	3.26	2.36 ef	9.80	9.65	107.12d	96.54 e	4.15 fg	3.85	41.24	41.25	2.44	2.33
T_3V_1	3.25	2.03 fg	10.06	10.03	110.65c	88.08 f	4.46 d	3.52	42.82	40.92	2.54	2.09
T_3V_2	3.12	1.87 h	9.90	10.03	111.60c	89.46 f	3.92 gh	2.97	41.78	39.85	2.49	1.92
T_3V_3	3.34	2.33 ef	10.19	10.14	116.93bc	94.06 e	4.62 cd	3.68	43.77	41.79	2.60	2.16
T_3V_4	3.24	2.02 fgh	9.71	9.58	109.60 d	88.335 f	4.11 fg	3.04	41.7	39.56	2.42	1.87
T_3V_5	3.24	1.71 h	9.69	9.57	105.63 de	82.64 g	4.04 g	3.07	40.84	38.85	2.38	1.92
T_4V_1	3.29	2.49 d	10.26	10.04	112.36 c	94.58 e	4.61 cd	4.02	43.52	43.22	2.62	2.35
T_4V_2	3.17	2.33 ef	10.09	10.03	113.31c	95.96 e	4.07 g	3.47	42.48	42.15	2.57	2.18
T_4V_3	3.38	2.80 b	10.38	10.14	118.64b	100.56 d	4.77 bc	4.18	44.47	44.09	2.68	2.42
T_4V_4	3.28	2.49 d	9.90	9.58	111.31c	94.83 e	4.26 ef	3.54	42.39	41.86	2.50	2.14
T_4V_5	3.29	2.17 fg	9.88	9.58	107.34d	89.14 ef	4.19 fg	3.57	41.53	41.15	2.46	2.19
CV%	10.25	5.20	7.80	6.8	5.40	3.57	9.89	6.77	8.50	9.20	4.30	5.50

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT. T_1 = control (open field), T_2= Black siris, T_3 = Guava, T_4 = Mango trees. V_1 = Gourove, V_2 = Sourave, V_3 = Shatabdi, V_4 = Kanchan, V_5 = Protiva.

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T_1V_1	3.31	2.8 b	10.35	10.27	118.96 b	113.58 b	5.03 ab	4.87	44.63	43.99	2.84	2.80
T_1V_2	3.19	2.64 c	10.18	10.27	119.90 b	114.96 b	4.49 d	4.32	43.59	42.91	2.79	2.63
T_1V_3	3.40	3.10 a	10.47	10.38	125.24 a	119.56 a	5.19 a	5.03	45.58	44.86	2.90	2.87
T_1V_4	3.30	2.79 b	9.99	9.82	117.91 b	113.83 b	4.68 bc	4.40	43.50	42.63	2.72	2.58
T_1V_5	3.31	2.48 a	9.97	9.81	113.93 c	108.14 c	4.61 cd	4.43	42.64	41.91	2.68	2.63
T_2V_1	3.26	2.68 bc	10.17	10.11	112.14 c	101.98 d	4.57 d	4.30	43.23	43.32	2.60	2.50
T_2V_2	3.14	2.52 d	10.01	10.11	113.09 c	103.36 d	4.03 g	3.75	42.19	42.25	2.56	2.33
T_2V_3	3.35	2.98 a	10.30	10.22	118.42 b	107.96 c	4.73 bc	4.46	44.18	44.19	2.66	2.57
T_2V_4	3.25	2.67 bc	9.82	9.66	111.09 c	102.23d	4.22 ef	3.82	42.15	41.96	2.49	2.28
T_2V_5	3.26	2.36 ef	9.80	9.65	107.12d	96.54 e	4.15 fg	3.85	41.24	41.25	2.44	2.33
T_3V_1	3.25	2.03 fg	10.06	10.03	110.65c	88.08 f	4.46 d	3.52	42.82	40.92	2.54	2.09
T_3V_2	3.12	1.87 h	9.90	10.03	111.60c	89.46 f	3.92 gh	2.97	41.78	39.85	2.49	1.92
T_3V_3	3.34	2.33 ef	10.19	10.14	116.93bc	94.06 e	4.62 cd	3.68	43.77	41.79	2.60	2.16
T_3V_4	3.24	2.02 fgh	9.71	9.58	109.60 d	88.335 f	4.11 fg	3.04	41.7	39.56	2.42	1.87
T_3V_5	3.24	1.71 h	9.69	9.57	105.63 de	82.64 g	4.04 g	3.07	40.84	38.85	2.38	1.92
T_4V_1	3.29	2.49 d	10.26	10.04	112.36 c	94.58 e	4.61 cd	4.02	43.52	43.22	2.62	2.35
T_4V_2	3.17	2.33 ef	10.09	10.03	113.31c	95.96 e	4.07 g	3.47	42.48	42.15	2.57	2.18
T_4V_3	3.38	2.80 b	10.38	10.14	118.64b	100.56 d	4.77 bc	4.18	44.47	44.09	2.68	2.42
T_4V_4	3.28	2.49 d	9.90	9.58	111.31c	94.83 e	4.26 ef	3.54	42.39	41.86	2.50	2.14
T_4V_5	3.29	2.17 fg	9.88	9.58	107.34d	89.14 ef	4.19 fg	3.57	41.53	41.15	2.46	2.19
CV%	10.25	5.20	7.80	6.8	5.40	3.57	9.89	6.77	8.50	9.20	4.30	5.50

In a column, Figure having the similar letter (s) or without letter (s) do not differ significantly as per DMRT. T_1 = control (open field), T_2= Black siris, T_3 = Guava, T_4 = Mango trees. V_1 = Gourove, V_2 = Sourave, V_3 = Shatabdi, V_4 = Kanchan, V_5 = Protiva.

4.2.4 Length of spike hill^{-1}

Effect of tree species

Length of spike was not varied significantly in first year (2006-07) experiment. The longest spike (10.35 cm) was recorded in T_1 and shortest (9.78 cm) one was found in T_3. T_2 and T_4 produced moderate size of spike. But in 2007-08 spike length varied significantly by the effect of trees. Significantly the longest spike (10.22 cm) was also recorded in T_1 and shortest (9.47 cm) spike was obtained from T_3. T_2 andT_4 produced the similar length of spike to T_3. Variation of spike length of wheat under different tree might be due to above ground competition for light and below ground competition for water and nutrient between tree and crops.

Response of wheat varieties

Length of spike was significantly influenced by the effect of variety in both cropping seasons and influencing pattern was almost similar. Significantly the longest spike was produced by V_3 (10.6 and 10.54 cm in 2006-07 and 2007-08 respectively). In 2006-07, V_1 (10.35 cm) produced the alike length of spike to V_2 and V_3. On the other hand length of spike produced by V_1 and V_2 were statistically identical to that of V_3 in 2007-08 (Figure 4.2.15-16). Significantly the lowest length of spike produced by V_5 (9.6 and 9.41 cm in first and 2nd year respectively), which was statistically similar to that of V_4 in both the cropping year. These variations of spike length might be due to their varietals character. Similar variation was found by Hossain *et al.* (2005).

Interaction effect of tree species and wheat variety on length of spike hill^{-1}

Length of spike was not significantly influenced by the interaction effect of trees and varieties, although influencing pattern was almost similar to that of number of spike per hill in 2006-07. The longest spike length (10.47 and 10.38 cm in 2006-07 and 2007-08 respectively) was recorded from T_1V_3 combination. The 2nd highest spike length in 2006-07 was 10.38 cm measured from T_4V_3 but in 2007-08, it was 10.22 cm recorded from T_2V_3 (Shatabdi under black siris). The shortest spike length was produced by T_3V_5 combination in both the cropping seasons (9.69 and 9.57 cm in 2006-07 and 2007-08 respectively.

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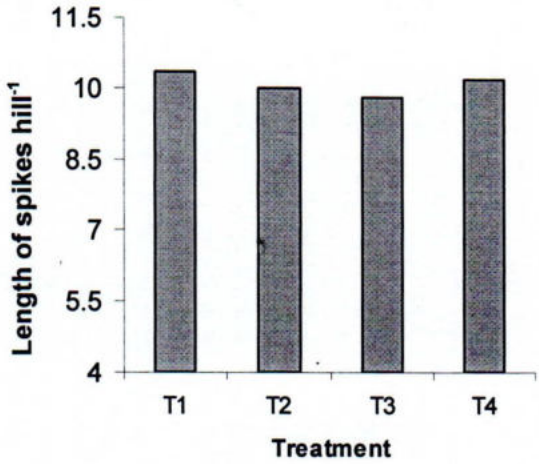


Fig 4.2.13 Effect of tree on length of spike hill^{-1} in 2006-07

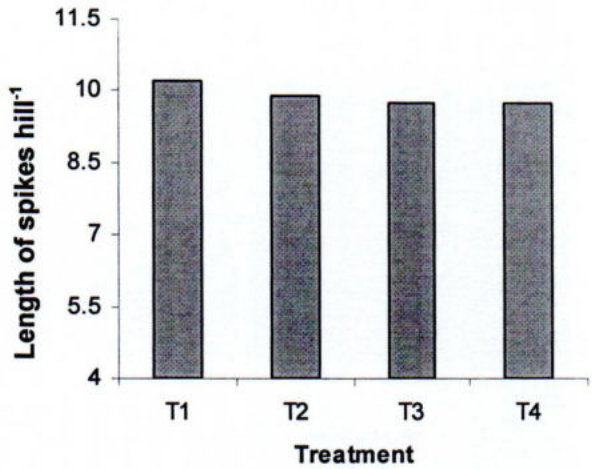


Fig 4.2.14 Effect of tree on length of spike hill^{-1} in 2007-08

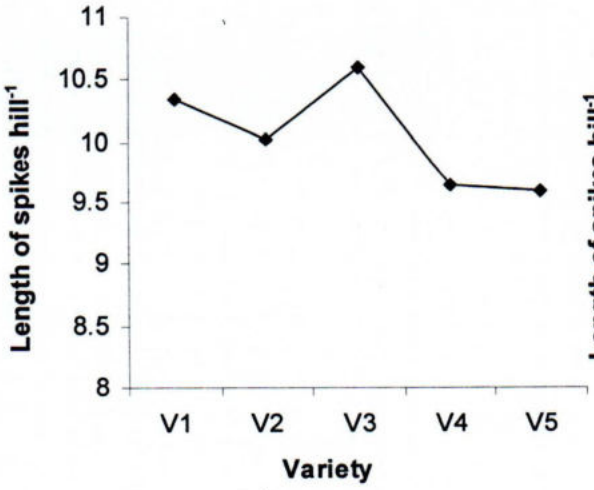


Fig 4.2.15 Effect of varieties on length of spike hill^{-1} in 2006-07

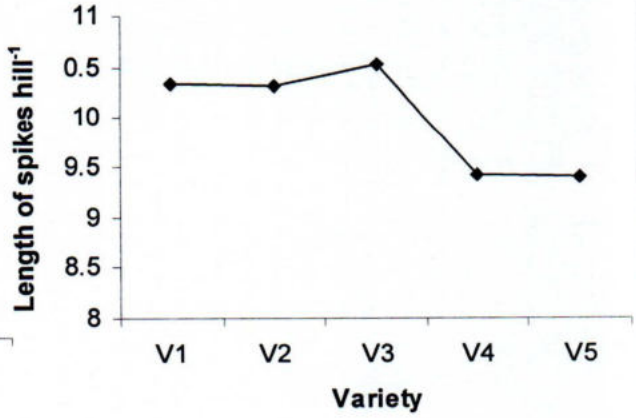


Fig 4.2.16 Effect of varieties on length of spike hill^{-1} in 2007-08

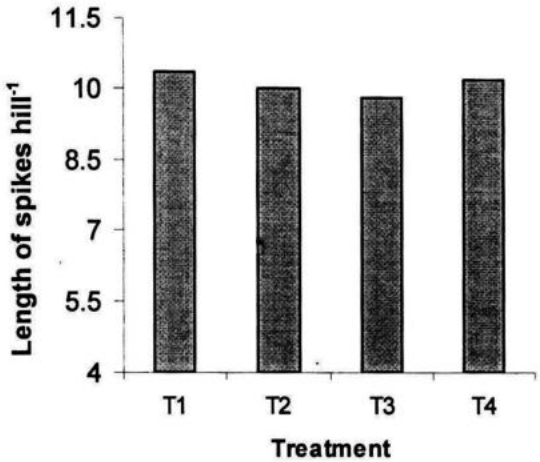


Fig 4.2.13 Effect of tree on length of spike hill^{-1} in 2006-07

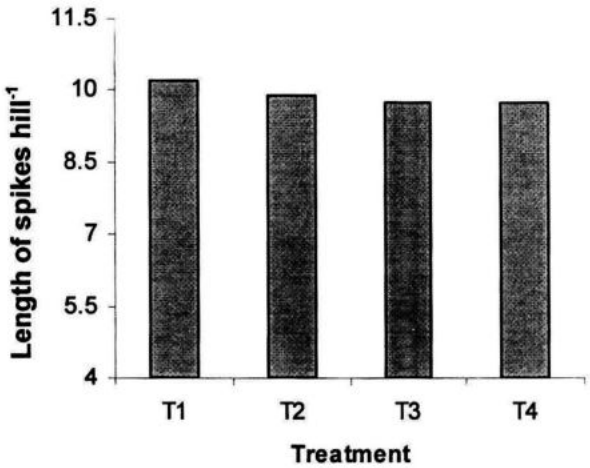


Fig 4.2.14 Effect of tree on length of spike hill^{-1} in 2007-08

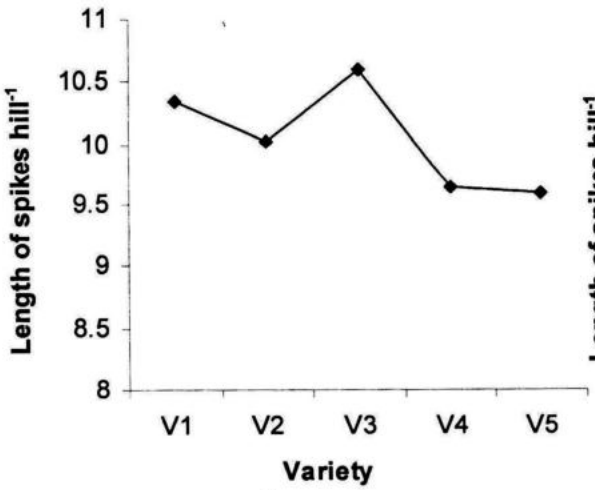


Fig 4.2.15 Effect of varieties on length of spike hill^{-1} in 2006-07

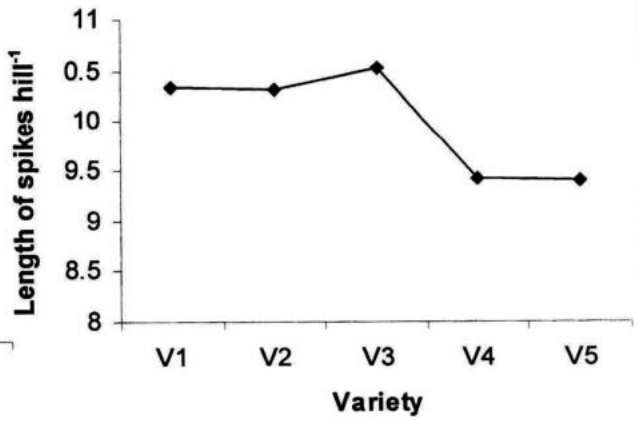


Fig 4.2.16 Effect of varieties on length of spike hill^{-1} in 2007-08

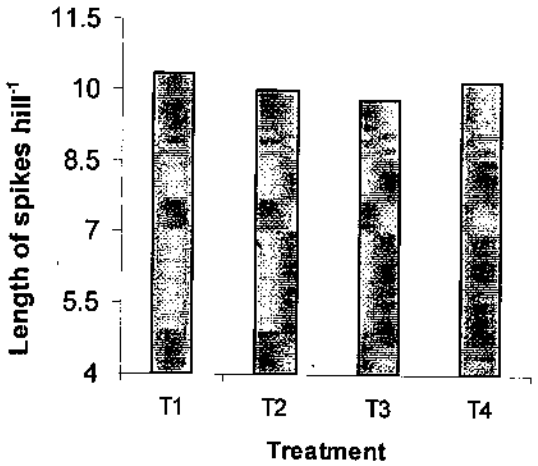
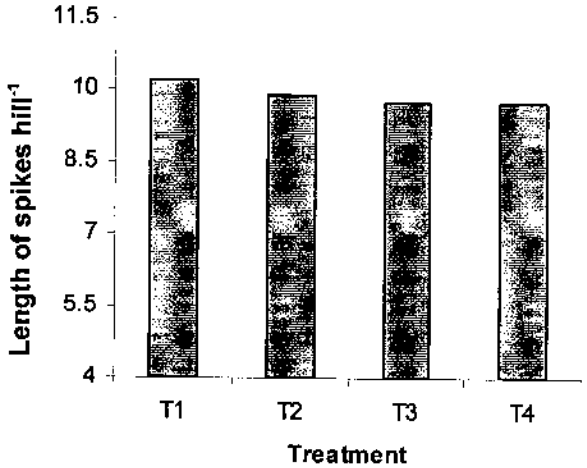


Fig 4.2.13 Effect of tree on length of spike hill^{-1} in 2006-07



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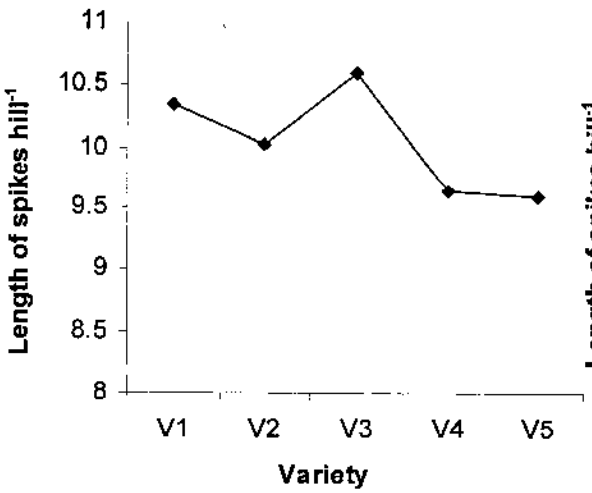

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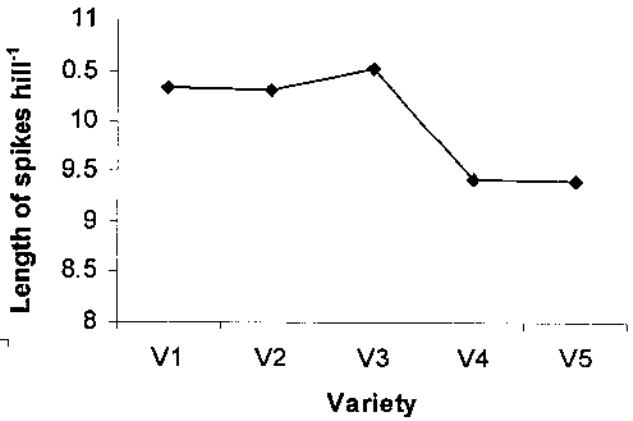

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4.2.5 Number of grains hill^{-1}

Effect of tree species

Number of grains hill^{-1} was significantly influenced by the effect of trees. The influencing pattern was quite similar in both cropping seasons. Significantly the highest number of grains was counted from T_1 (open field) in both the cropping years (124.6 and 128.9 in 2006-07 and 2007-08, respectively). Moderate number of grains hill^{-1} was recorded from T_2 and T_4. Significantly the minimum number of grains (108.01 and 77.9 in 2006-07 and 2006-07 respectively) was recorded from T_3 (guava). These variation might be due to variation of light intensities among the treatments. T_1 always experienced 100% sunlight which caused more photosynthesis as well as highest number of grains. Black siris (T_2) and Mango (T_4) ensured moderated light intensity (Appendix-I) and Guava (T_3) always produced maximum shade as a result, T_3 produced significantly lowest number of grains. The result revealed that there was a relationship between light availability and number of grains hill^{-1}

Response of wheat varieties

Number of grains hill^{-1} was also varied from variety to variety. The variation was quite similar in both the experimental years (Figure 4.2.19-20) Shatabdi produced significantly the highest no. of grains hill^{-1} in both the years (125.86 and 110.23 in 2006-07 and 2007-08, respectively) followed by V_2 (115.19 and 101.02 in 2006-07 and 2007-08 respectively). Number of grains produced by V_1 and V_4 were statistically identical to that of V_2. Significantly the lowest number of grains (103.25 and 87.38 in 2006-07 and 2007-08, respectively) was counted from V_5 (Protiva).

Interaction effect of tree species and wheat variety on number of grains hill^{-1}

Number of grains hill^{-1} was significantly affected by the combined effects of trees and varieties of wheat in both the cropping years (Table 4.2.3). Significantly the highest no. of grains per hill was produced by Shatabdi (V_3) in open field (T_1) in the experimental years (125.24 and 119.56 in 2006-07 and 2007-08, respectively) followed by T_1V_2 (119.9 and 114.96 in first and 2nd year, respectively. No. of grains hill^{-1}produced by T_1V_1, T_1V_4 in both the cropping years were statistically similar to that of T_1V_2 combination. Significantly the lowest number of grains hill^{-1}in first year was recorded in T_3V_5 (105.63) but in 2nd year it was found in T_3V_1 (88.08) combination. All the varieties showed their poor performance under guava (T_3) might be due to its dense shade.

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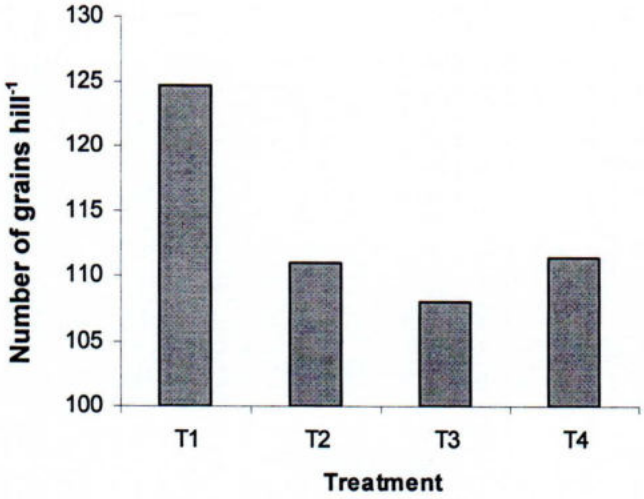


Fig 4.2.17 Effect of tree on number of grains hill^{-1}in 2006-07

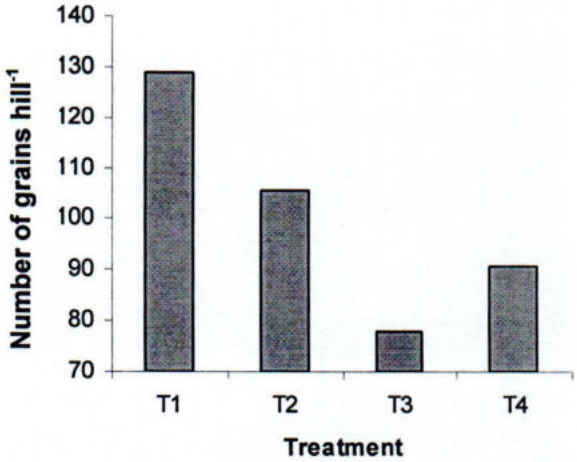


Fig 4.2.18 Effect of tree on number of grains hill^{-1}in 2007-08

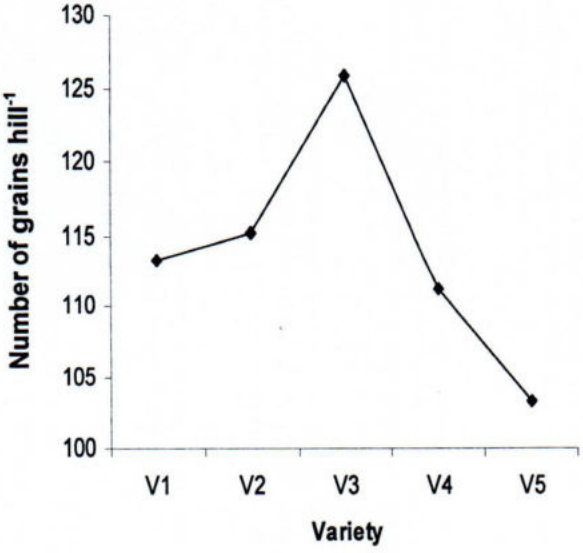


Fig 4.2.19 Effect of variety on number of grains hill^{-1}in 2006-07

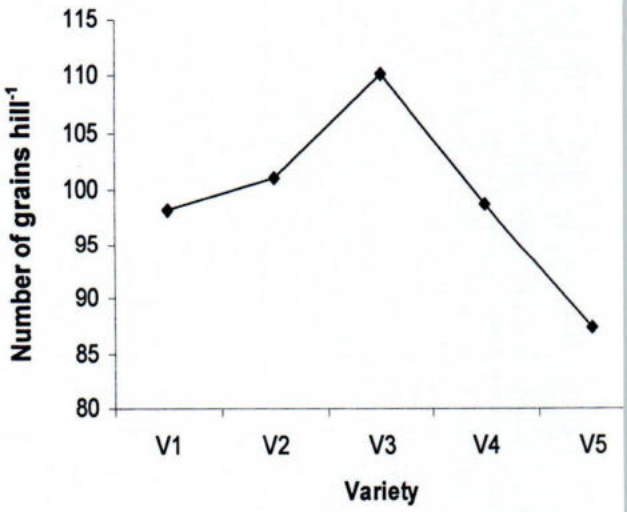


Fig 4.2.20 Effect of variety on number of grains hill^{-1}in 2007-08

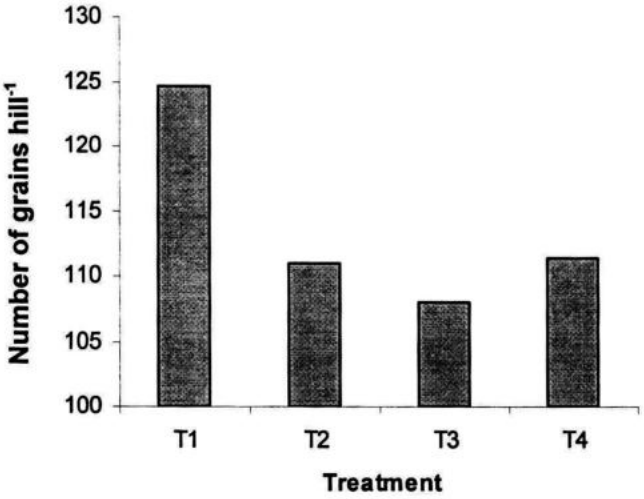


Fig 4.2.17 Effect of tree on number of grains hill^{-1}in 2006-07

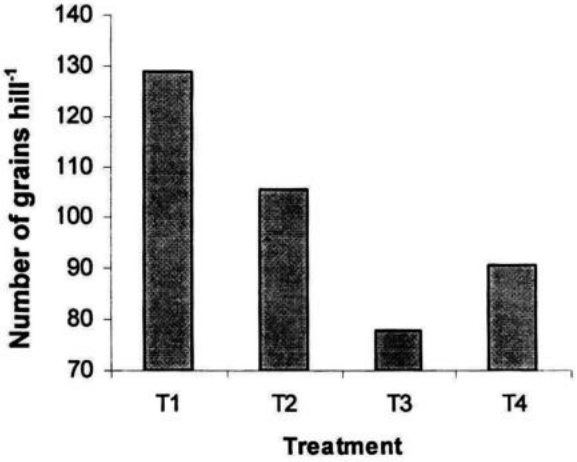


Fig 4.2.18 Effect of tree on number of grains hill^{-1}in 2007-08

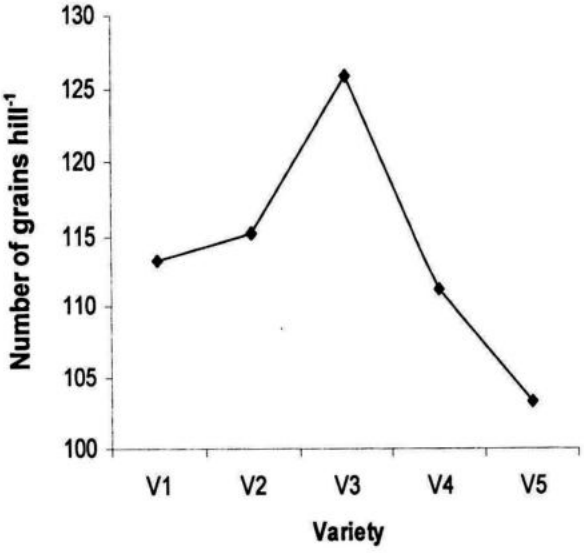


Fig 4.2.19 Effect of variety on number of grains hill^{-1}in 2006-07

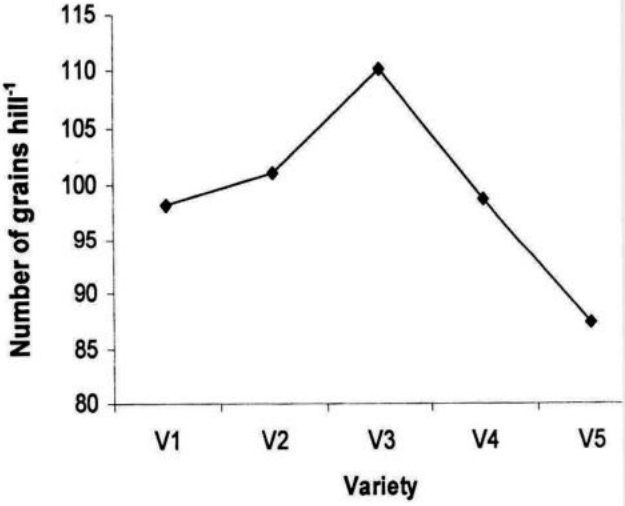


Fig 4.2.20 Effect of variety on number of grains hill^{-1}in 2007-08

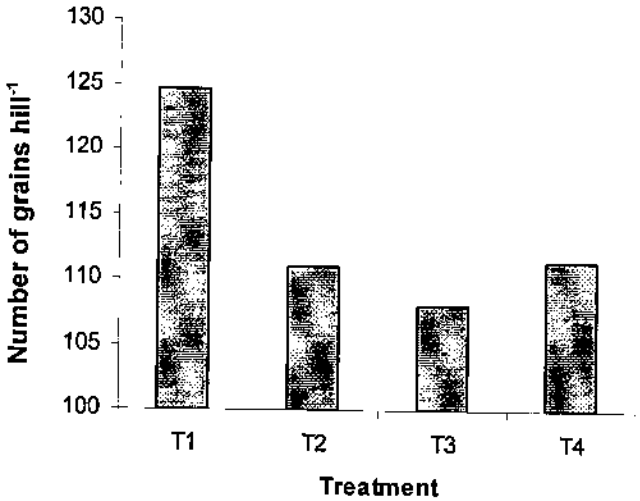
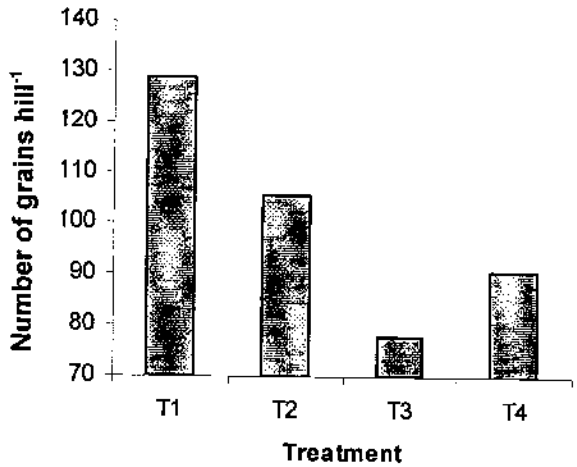


Fig 4.2.17 Effect of tree on number of grains hill^{-1}in 2006-07



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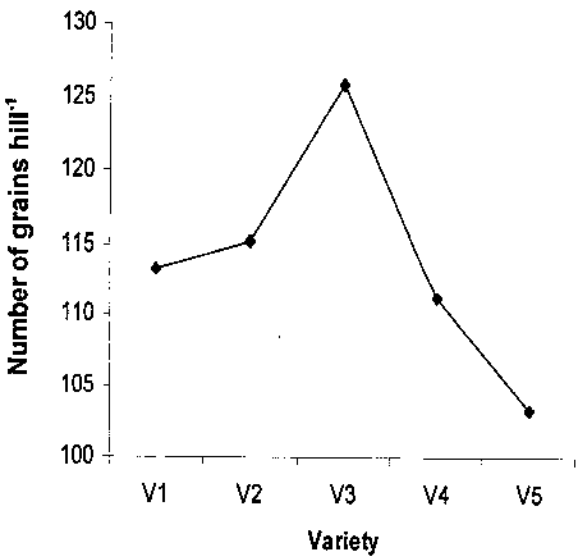

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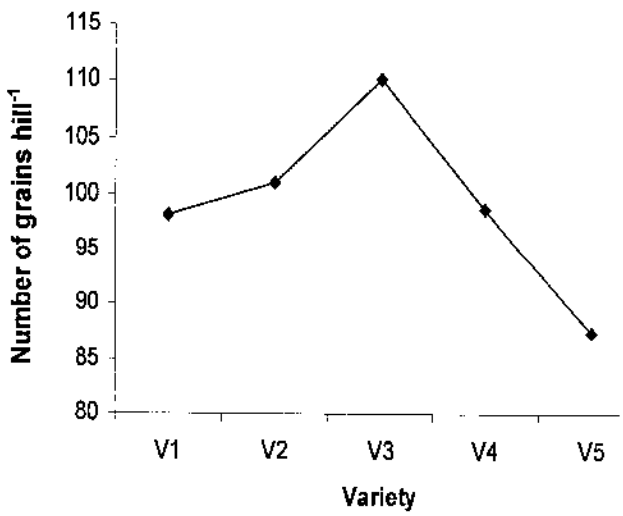

Fig 4.2.20 Effect of variety on number of grains hill^{-1}in 2007-08

4.2.6 Grain weight of wheat hill^{-1}

Effect of tree species

Grain weight hill^{-1} was significantly influenced by the effect of trees. In 2006-07 significantly the highest grain yield per hill (5.61 g) was recorded in T_1 which was followed by T_4 (4.77 g), T_2 (4.69 g) and T_3 (4.47 g) produced statistically similar amount of grain yield to that of T_4. In 2007-08 influencing pattern of grain yield per hill by trees was quite similar to that of number of grains per hill. The highest weight of grain (5.65 g hill^{-1}) was recorded in T_1 and significantly the lowest weight (2.94 g hill^{-1}) was obtained from T_3.

Response of wheat varieties

There was significant effect of variety on grain weight (g hill^{-1}) in both experimental years. Significantly the highest weight of grain per hill was produced by V_3 (4.788 and 4.42 g in 2006-07 and 2007-08, respectively) followed by V_1 (4.46 and 4.1 g hill^{-1} in first and 2nd year, respectively). Significantly the lowest grain weight per hill was recorded in V_2 (3.38 and 3.00 g hill^{-1} in first and 2nd year, respectively) which were statistically similar to that of V_4 and V_5 in 2007-08 experiment. This variation might be due to varietal characteristics of wheat.

Interaction effect of tree species and wheat variety on grain weight per hill

Grain weight per hill of wheat was influenced significantly by the combined effect of trees and varieties. Significantly the highest grain weight was recorded for T_1V_3 combination in both cropping years (5.19 and 5.03 g hill^{-1} in first and 2nd year experiment, respectively), followed by T_1V_1 combination (Table 4.2.3). Significantly the lowest grain weight (g hill^{-1} was found in T_3V_2 combination (3.92 and 2.97 g hill^{-1} in 2006-07 and 2007-08, respectively). Moderate grain weight was recorded in T_2 and T_4 irrespective of varieties. Satabdi (V_3) was found superior in production of highest grain weight per hill in every treatment combination over other varieties.

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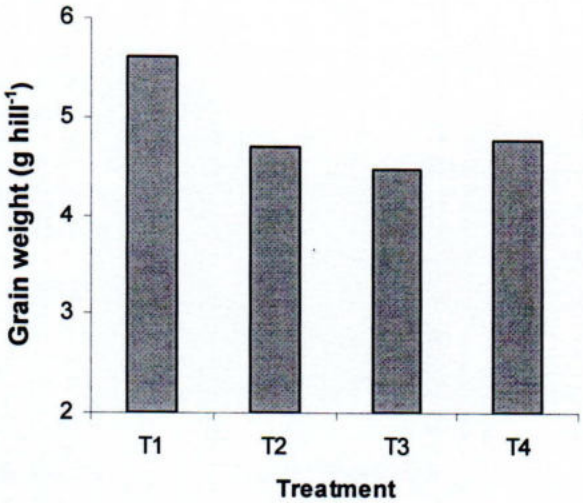


Fig 4.2.21 Effect of tree on grain weight g hill^{-1} in 2006-07

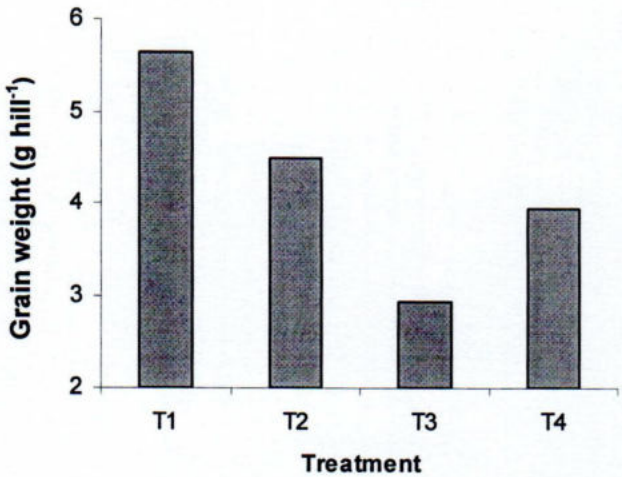
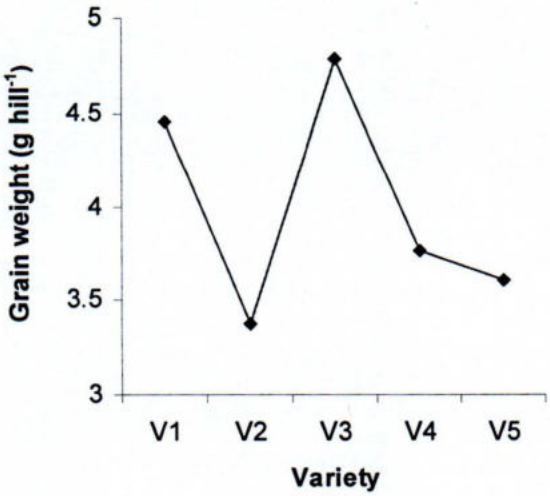


Fig 4.2.22 Effect of tree on grain weight g hill^{-1} in 2007-08



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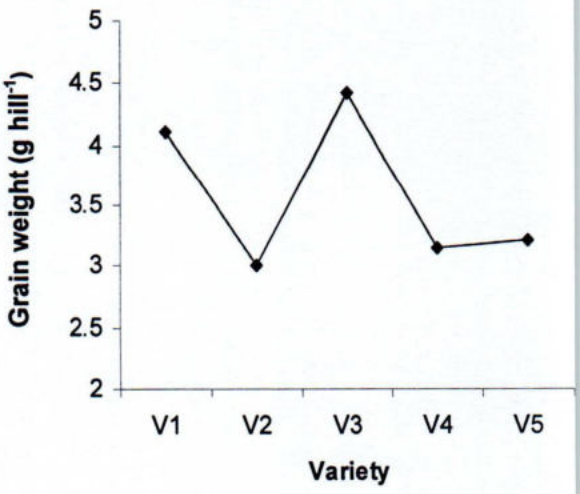


Fig 4.2.24 Effect of varieties on grai weight g hill^{-1} in 2007-08

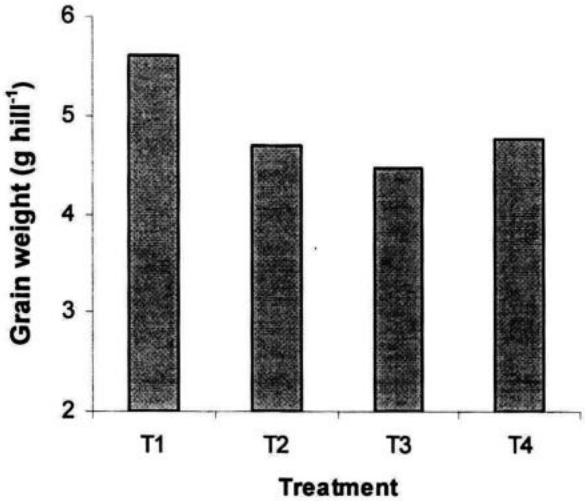


Fig 4.2.21 Effect of tree on grain weight g hill^{-1} in 2006-07

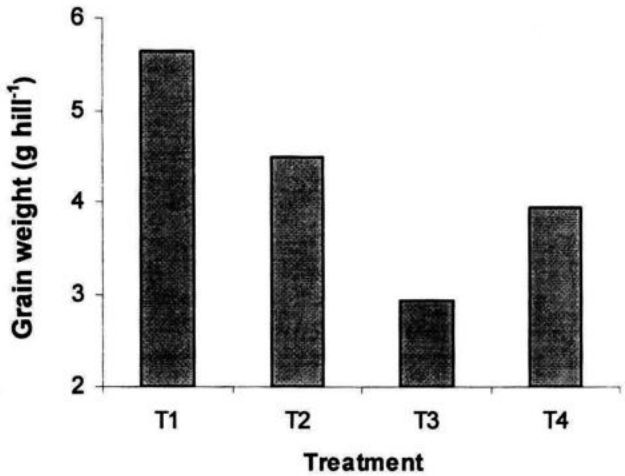


Fig 4.2.22 Effect of tree on grain weight g hill^{-1} in 2007-08

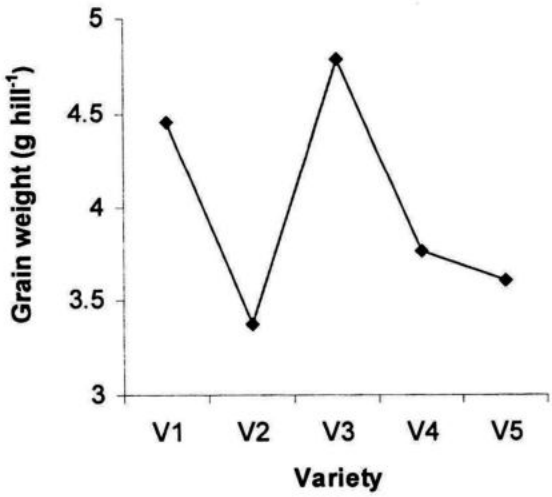
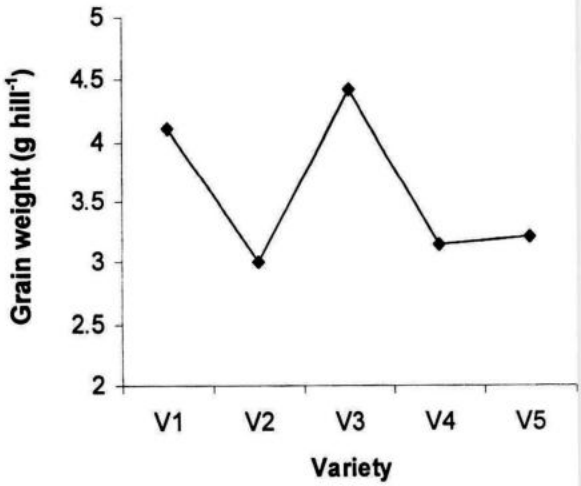


Fig 4.2.23 Effect of varieties on grain weight g hill^{-1} in 2006-07



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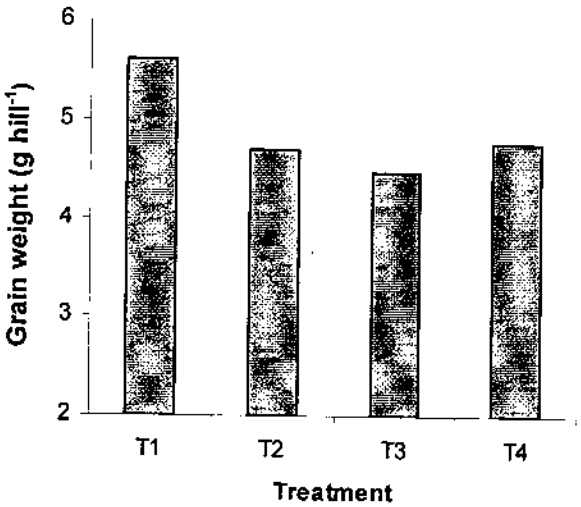
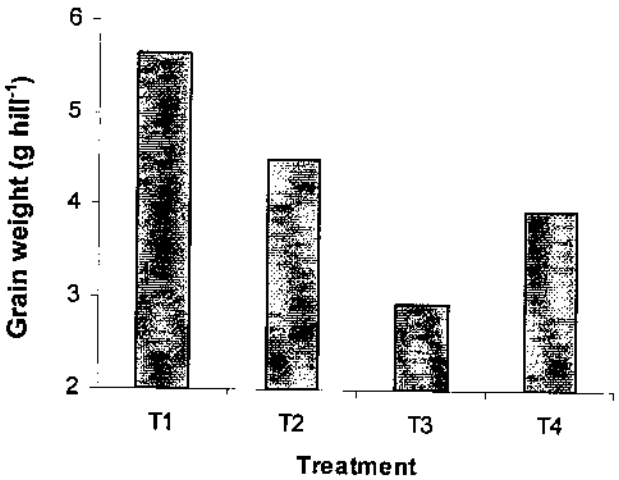


Fig 4.2.21 Effect of tree on grain weight g hill^{-1} in 2006-07



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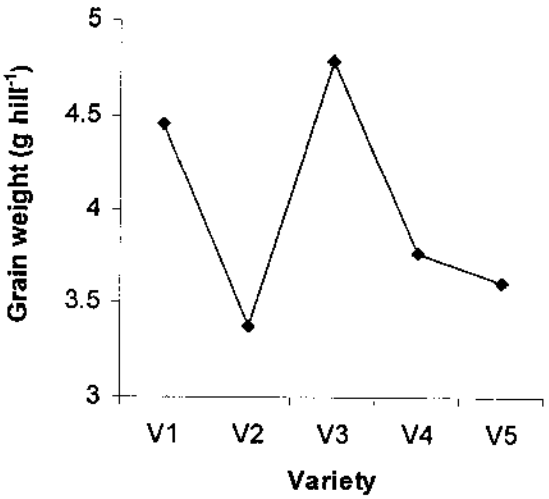

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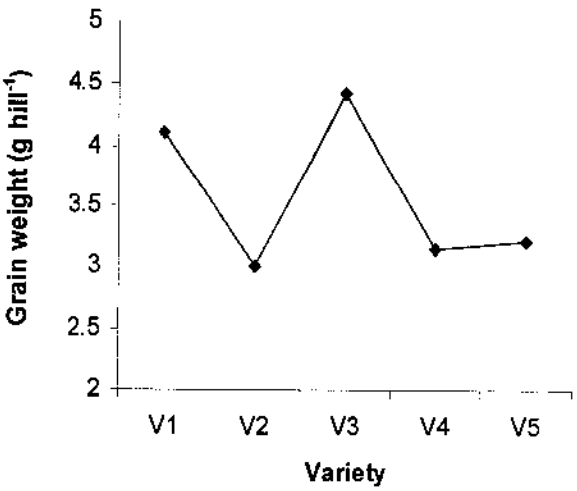

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4.2.7 Thousand grain weight

Effect of tree species

Thousand grain weights (g) were also influenced by the tree association in both the cropping years. In 2006-07, significantly the highest weight of 1000 grain (45.07 g) was recorded in T_1 followed by T_4. Although 1000 grain weight under T_2 and T_3 were statistically similar to that of T_4 (Figure 4.2.25). In 2007-08, highest 1000 grain weight (43.83g) was recorded in T_1 which was statistically identical to that of T_2 (42.50 g) and T_4 (42.30 g) significantly the lowest 1000 grain weight (37.37 g) was recorded under T_3 (guava)

Response of wheat varieties

Varietal effects on 1000 grain weight of wheat was highly significant in both the experimental years. Significantly the highest value of 1000 grain weight were 46.09 and 45.89 g in 2006-07 and 2007-08, respectively recorded for V_3, followed by V_1 (44.19 and 44.15 g in 2005-05 and 2007-08, respectively). Significantly the lowest 1000 grain weight was found for V_5. The moderate weight of 1000 grain were recorded for V_2 and V_4. These two varieties produced statistically similar grain weight in both the cropping seasons.

Interaction effect of tree species and wheat variety on 1000 grain weight

From the combined effect, it was found that there was no significant variation of 1000 grain weight among the twenty treatment combination in both the cropping years. The numerically highest 1000 grain weight was obtained from T_1V_3 i.e. shatabdi in open field (45.58 and 44.86 g in 2006-07 and 2007-08, respectively) and the lowest 40.84 and 38.85 g in 2006-07 and 2007-08, respectively for T_3V_5 combination.

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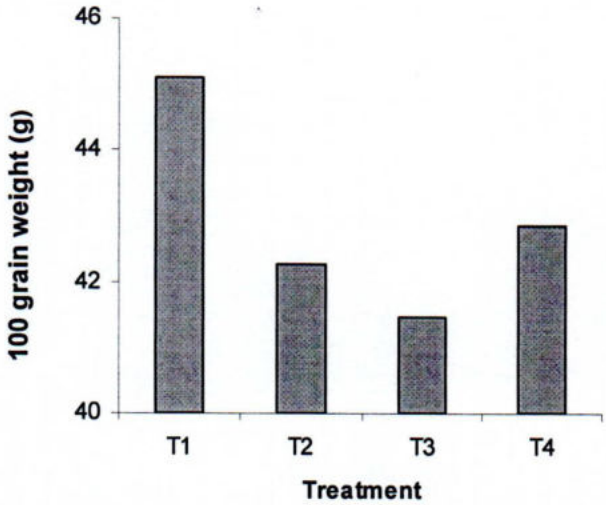


Fig 4.2.25 Effect of tree on 1000 grain weight in 2006-07

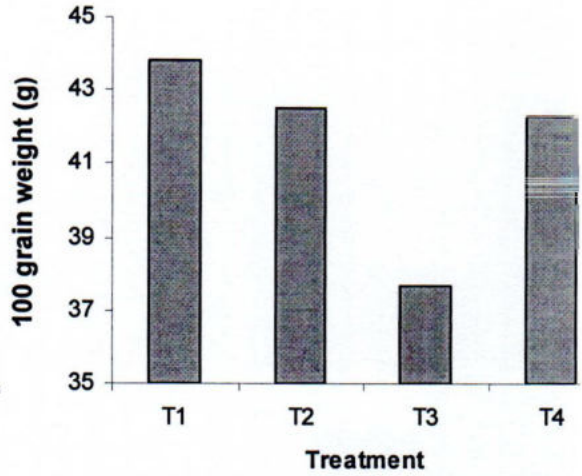


Fig 4.2.26 Effect of tree on 1000 grai weight in 2007-08

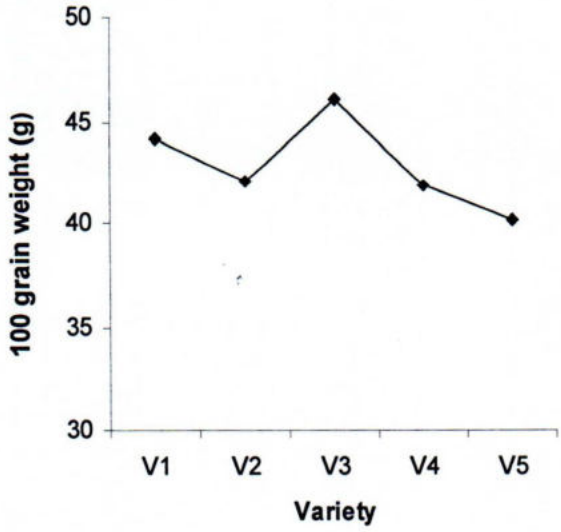


Fig 4.2.27 Effect of varieties on 1000 grain weight in 2006-07

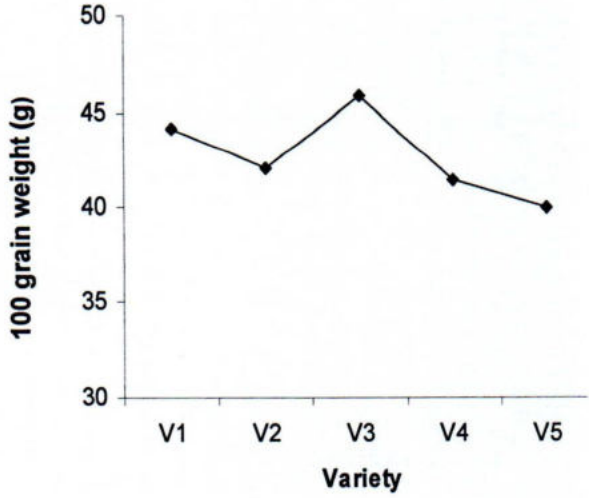
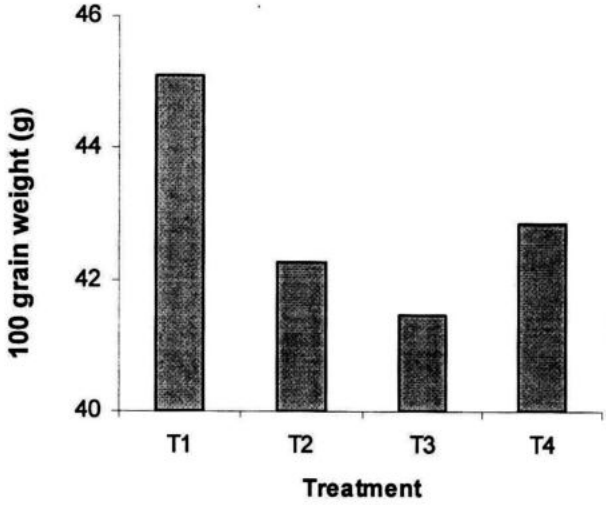


Fig 4.2.28 Effect of varieties on 1000 grai weight in 2007-08



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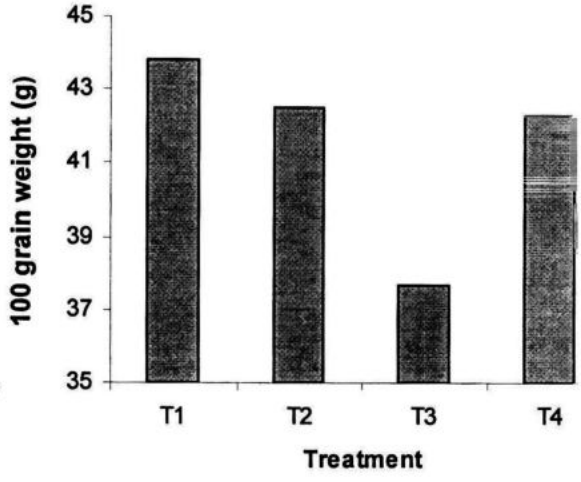
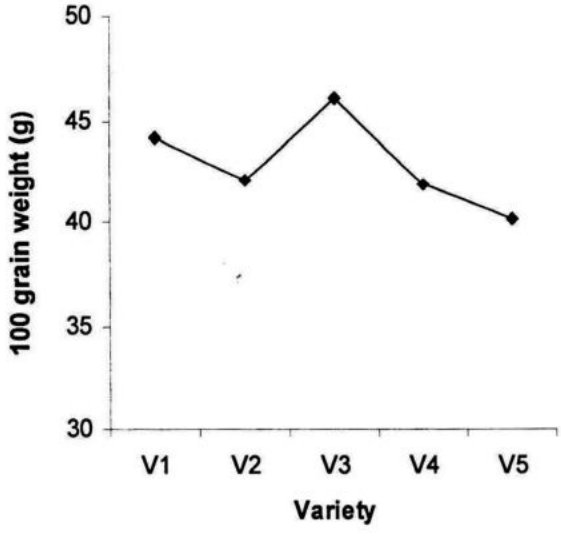


Fig 4.2.26 Effect of tree on 1000 grai weight in 2007-08



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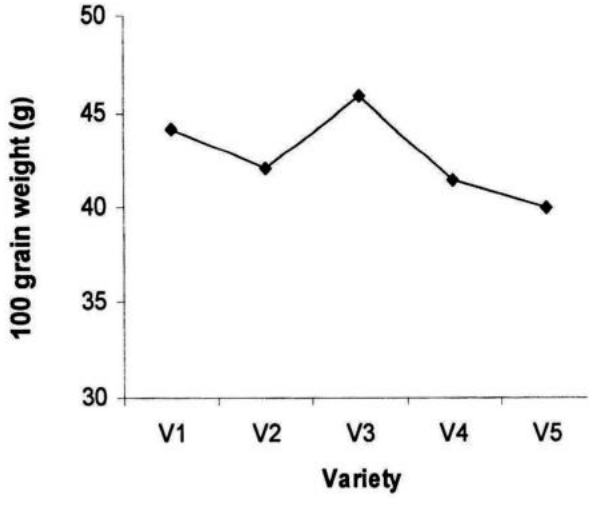

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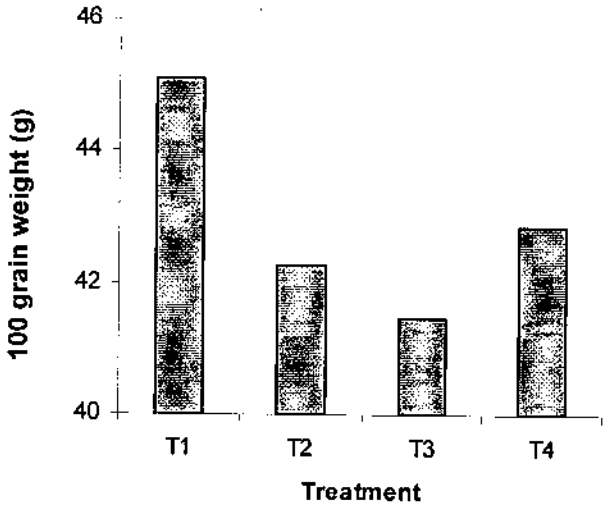

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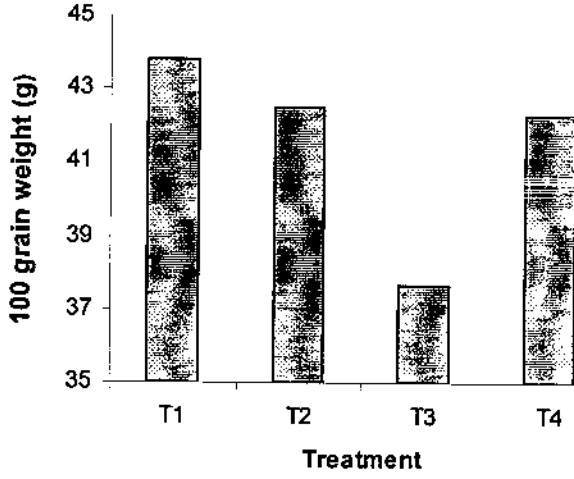

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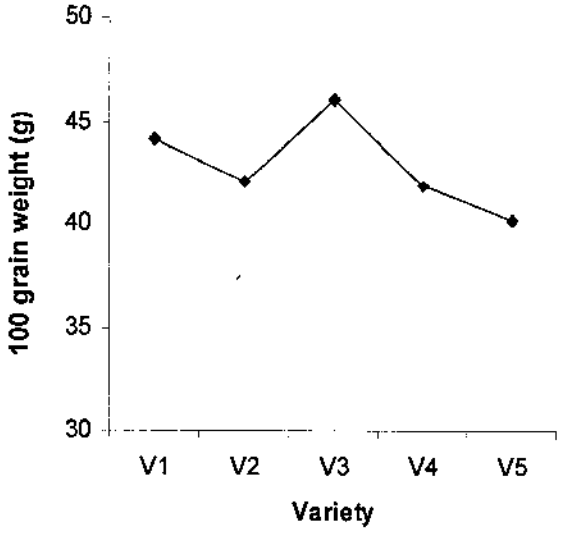

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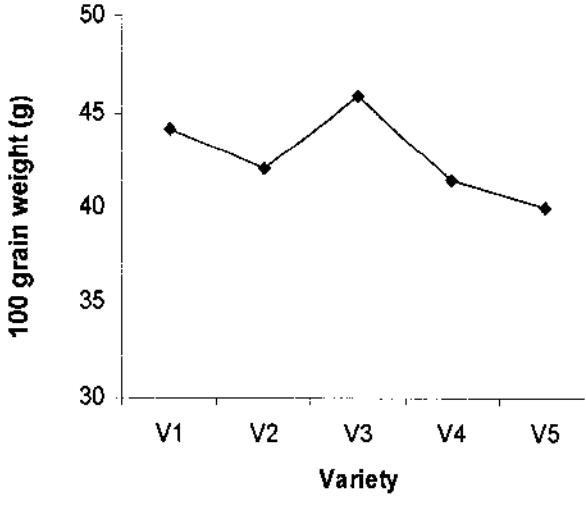

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4.2.8 Grain yield

Effect of tree species

Grain yield of wheat (t ha^{-1}) was significantly influenced by the effect of trees in both the experimental years. In 2006-07, significantly the highest yield (2.92 t ha^{-1}) was recorded in open field (T_1) followed by T_2 (2.48 t ha^{-1}). The lowest yield was recorded in T_3 (2.32 t ha^{-1}. Although grain yield under T_4 (2.45 t ha^{-1}) was statistically similar to those of T_2 and T_3. Grain yield of wheat in 2007-08 was highly affected by the trees. Significantly the highest yield (2.94 t ha^{-1}) was obtained from T_1 followed by T_2 (2.34 t ha^{-1}). Significantly the lowest yield was recorded in T_3 (1.52 t ha^{-1}). The yield found under T_4 (mango) was statistically similar to those of T_2 and T_3. In first year experiment grain yield was slightly affected as there were minimum variations of light levels created by different tree species (Appendix-I). But in the following year (2007-08) the available light under different tree canopies varied severely i.e. T_1' T_2' T_3 and T_4 allowed 100, 67.8, 45 and 49.12 % average light intensities for crop growth.

Response of wheat varieties

Varietals effect on grain yield (t ha^{-1}) was found significant in 2006-07 but it was not significant in the following year (2007-08) although trend of variation of grain yield (t ha^{-1}) among the varieties was similar in both the cropping seasons. In 2006-07, significantly the highest grain yield (2.88 t ha^{-1}) was recorded for V_3 followed by V_1 (2.76 t/ha). V_1 produced statistically same grain yield to V_3 and V_2.

The lowest grain yield (2.44 t ha^{-1}) was recorded for V_5 which was similar to that of V_4 (2.53 t ha^{-1}). In 2007-08, V_3 produced highest yield (2.80 t ha^{-1}) followed by V_1 (2.66 t ha^{-1}) and lowest yield was recorded for V_4 (2.33 t ha^{-1}).

Interaction effect of tree species and wheat variety

Combined effects of trees and varieties on grain yield (t ha^{-1}) was found insignificant in both the cropping years. The highest grain yields (2.9 and 2.87 t ha^{-1} in 2006-07 and 2007-08, respectively) were produced by V_3 (Shatabdi) in open field condition (T_1V_3 combination) for both the cropping seasons which was followed by T_1V_1 combination. V_3 always produced the highest grain yield over other varieties in each treatment combination. Protiva (V_5) and Kanchan (V_4) produced the lowest grain yields 2.38 t $ha^{-1}$and 1.87 t ha^{-1} in 2006-07 and 2007-08, respectively under guava tree (Table 4.2.3). The result in the present study is in agreement with the findings of Akber *et al.* (1990) Sharma (1992) and Nandal *et al.* (1999).

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4.2.8 Grain yield

Effect of tree species

Grain yield of wheat (t ha^{-1}) was significantly influenced by the effect of trees in both the experimental years. In 2006-07, significantly the highest yield (2.92 t ha^{-1}) was recorded in open field (T_1) followed by T_2 (2.48 t ha^{-1}). The lowest yield was recorded in T_3 (2.32 t ha^{-1}. Although grain yield under T_4 (2.45 t ha^{-1}) was statistically similar to those of T_2 and T_3. Grain yield of wheat in 2007-08 was highly affected by the trees. Significantly the highest yield (2.94 t ha^{-1}) was obtained from T_1 followed by T_2 (2.34 t ha^{-1}). Significantly the lowest yield was recorded in T_3 (1.52 t ha^{-1}). The yield found under T_4 (mango) was statistically similar to those of T_2 and T_3. In first year experiment grain yield was slightly affected as there were minimum variations of light levels created by different tree species (Appendix-I). But in the following year (2007-08) the available light under different tree canopies varied severely i.e. T_1' T_2' T_3 and T_4 allowed 100, 67.8, 45 and 49.12 % average light intensities for crop growth.

Response of wheat varieties

Varietals effect on grain yield (t ha^{-1}) was found significant in 2006-07 but it was not significant in the following year (2007-08) although trend of variation of grain yield (t ha^{-1}) among the varieties was similar in both the cropping seasons. In 2006-07, significantly the highest grain yield (2.88 t ha^{-1}) was recorded for V_3 followed by V_1 (2.76 t/ha). V_1 produced statistically same grain yield to V_3 and V_2.

The lowest grain yield (2.44 t ha^{-1}) was recorded for V_5 which was similar to that of V_4 (2.53 t ha^{-1}). In 2007-08, V_3 produced highest yield (2.80 t ha^{-1}) followed by V_1 (2.66 t ha^{-1}) and lowest yield was recorded for V_4 (2.33 t ha^{-1}).

Interaction effect of tree species and wheat variety

Combined effects of trees and varieties on grain yield (t ha^{-1}) was found insignificant in both the cropping years. The highest grain yields (2.9 and 2.87 t ha^{-1} in 2006-07 and 2007-08, respectively) were produced by V_3 (Shatabdi) in open field condition (T_1V_3 combination) for both the cropping seasons which was followed by T_1V_1 combination. V_3 always produced the highest grain yield over other varieties in each treatment combination. Protiva (V_5) and Kanchan (V_4) produced the lowest grain yields 2.38 t $ha^{-1}$and 1.87 t ha^{-1} in 2006-07 and 2007-08, respectively under guava tree (Table 4.2.3). The result in the present study is in agreement with the findings of Akber *et al.* (1990) Sharma (1992) and Nandal *et al.* (1999).

Akber *et al.* (1990) reported that wheat yield under different tree species (Eucalyptus, Mulberry, Siris and ipil-ipil) did not show any significant difference as compared to control yield. Hossain *et al.*, 2006 reported that Shatabdi produce the maximum grain yield 2.88 t ha^{-1} under Black siris over Sourav, Gourav, Protiva and Kanchan. Although Gourav produce the statistically identical yield to that of Shatabdi. They also found insignificant effect of tree crop interaction on grain yield. They also reported that variety Shatabdi produced highest yield (3.16 t ha^{-1}) in the open field.

All the tree species were statistically indifferent in their effect on grain yield. So the result indicated that cultivation of wheat crop in association with the tree species like *Albizia lebbeck, Mangifera indica and Pisdium guajava* in their early years of establishment is possible without having significant loss in the yield.

4.2.9 Productivity evaluation of wheat in Agroforestry practice

There are two major indices for evaluation of productivity i.e. harvest index (HI) and land equivalent ratio (LER). For intercrop productivity evaluation HI is commonly used in agronomy but in Agroforestry LER is important. These two land use indices are described bellow on the basis of obtained results.

Harvest Index (HI)

The highest HI was calculated for T_1V_1 combination (35.01 and 35.57% in 2006-07 and 2007-08, respectively) followed by T_1V_2 and T_1V_3 in first and second year respectively (Table 4.2.5). The lowest HI was recorded for T_3V_4 in both the cropping years (32.79 and 31.21 in first and second year respectively). The values of HI showed that under shaded treatments (T_2, T_3 and T_4), V_1 and V_3 performed better in both the cropping seasons.

Land Equivalent Ratio (LER)

In 2006-07 cropping season the range of LER was 2.12-2.55 but in 2007-08 cropping seasons it was 2.0 to 2.69. It indicates that all the varieties of wheat under every selected tree species have more than two times land use efficiency. Although highest LER (2.54) was recorded for all varieties under guava in 2006-07 but in 2007-08 it was 2.69 for T_3V_5. The lowest LER was found for T_4V_5 (2.12 and 2.01 for 2006-07 and 2007-08).

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Akber *et al.* (1990) reported that wheat yield under different tree species (Eucalyptus, Mulberry, Siris and ipil-ipil) did not show any significant difference as compared to control yield. Hossain *et al.*, 2006 reported that Shatabdi produce the maximum grain yield 2.88 t ha^{-1} under Black siris over Sourav, Gourav, Protiva and Kanchan. Although Gourav produce the statistically identical yield to that of Shatabdi. They also found insignificant effect of tree crop interaction on grain yield. They also reported that variety Shatabdi produced highest yield (3.16 t ha^{-1}) in the open field.

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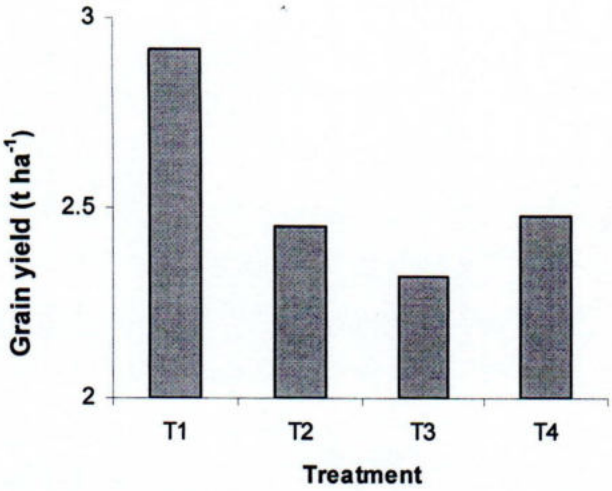


Fig 4.2.29 Effect of tree on grain yield ($t\ ha^{-1}$) in 2006-07

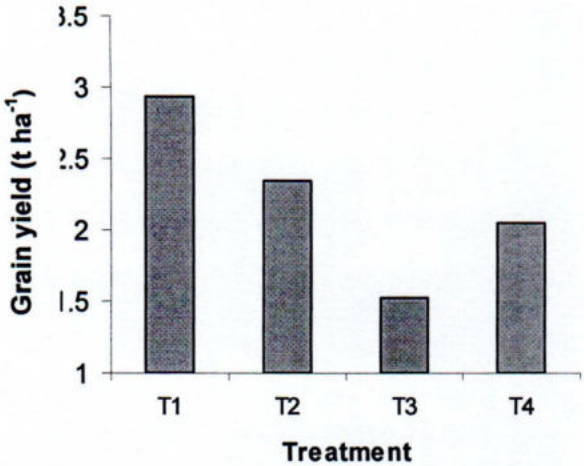


Fig 4.2.30 Effect of tree on grain yiel ($t\ ha^{-1}$) in 2007-08

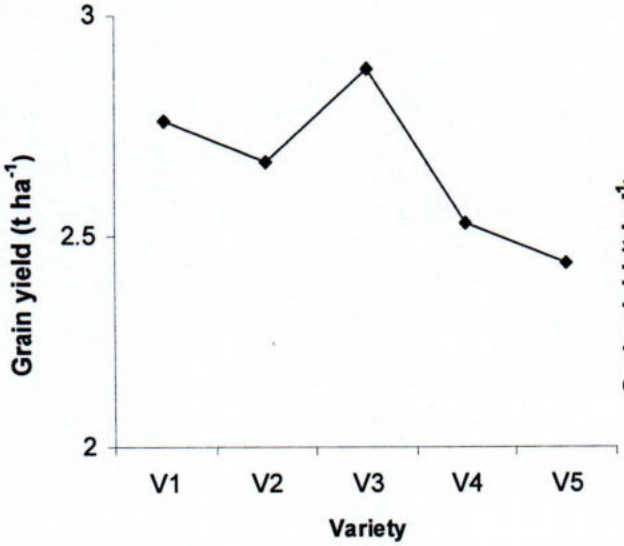


Fig 4.2.31 Effect of variety on grain yield in 2006-07

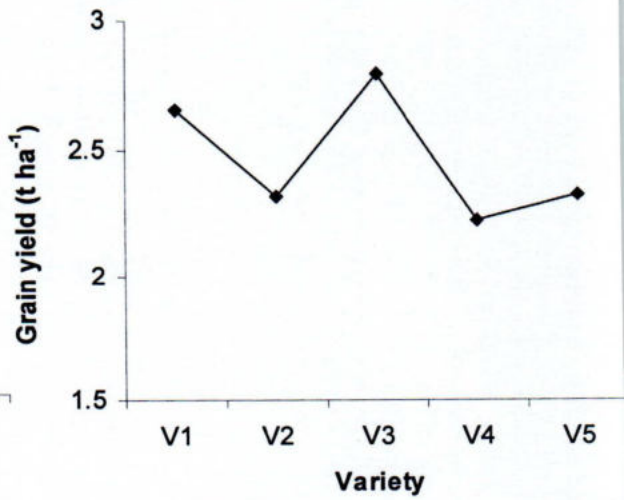


Fig 4.2.32 Effect of variety on grain yield in 2007-08

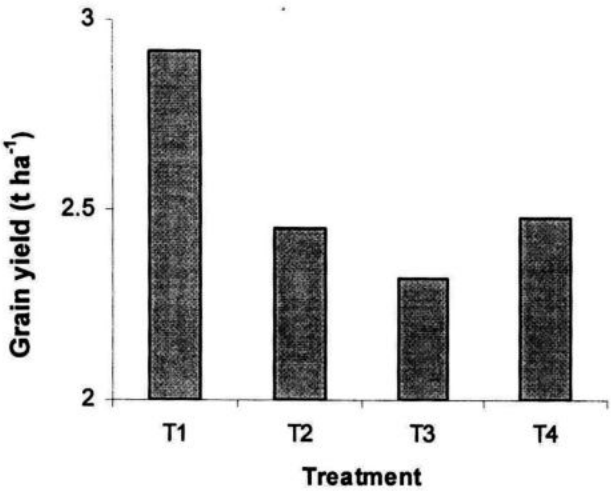


Fig 4.2.29 Effect of tree on grain yield ($t\ ha^{-1}$) in 2006-07

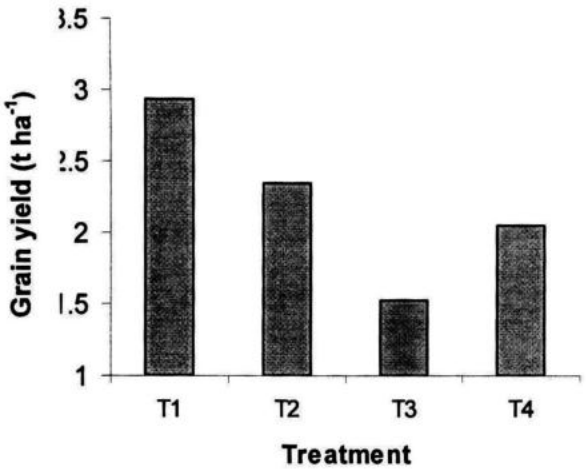


Fig 4.2.30 Effect of tree on grain yiel ($t\ ha^{-1}$) in 2007-08

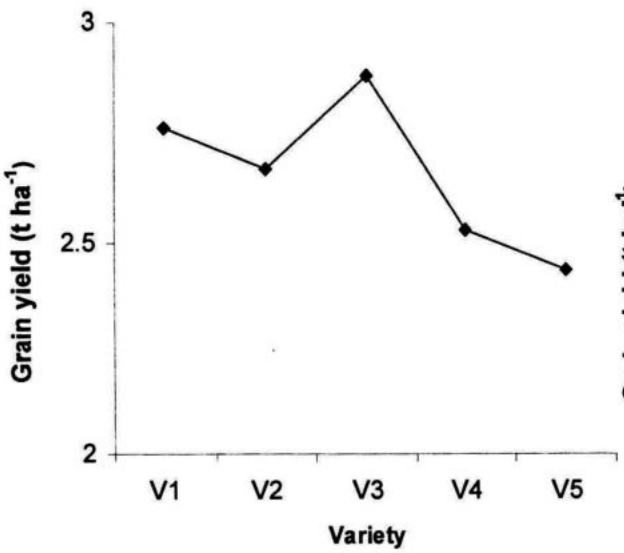


Fig 4.2.31 Effect of variety on grain yield in 2006-07

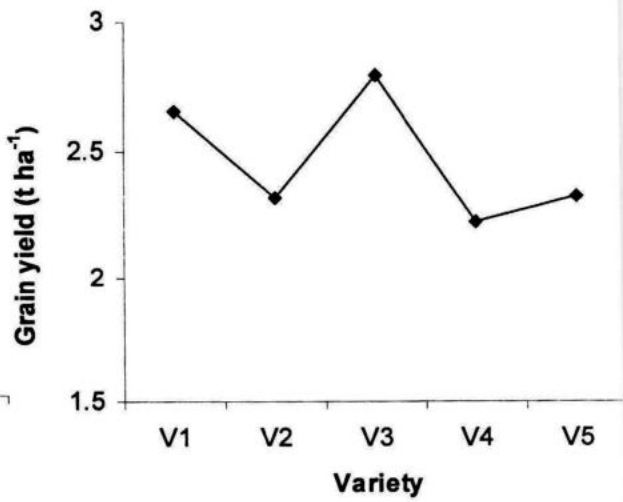


Fig 4.2.32 Effect of variety on grain yield in 2007-08

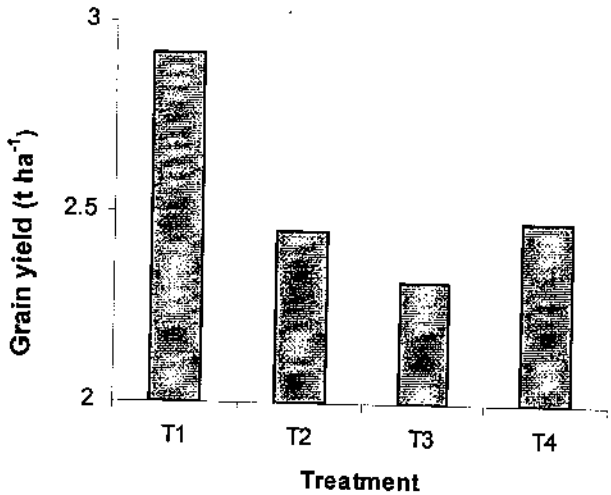
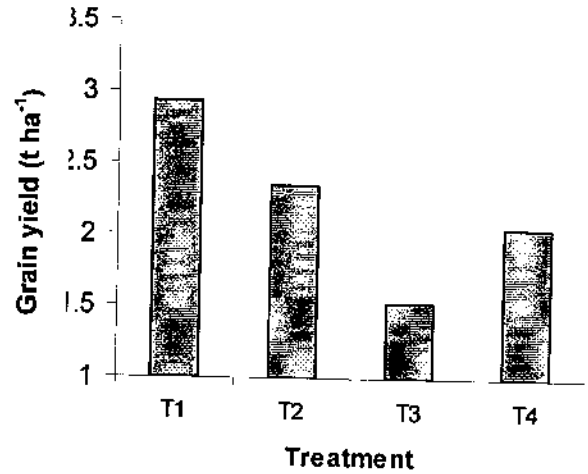


Fig 4.2.29 Effect of tree on grain yield ($t\ ha^{-1}$) in 2006-07



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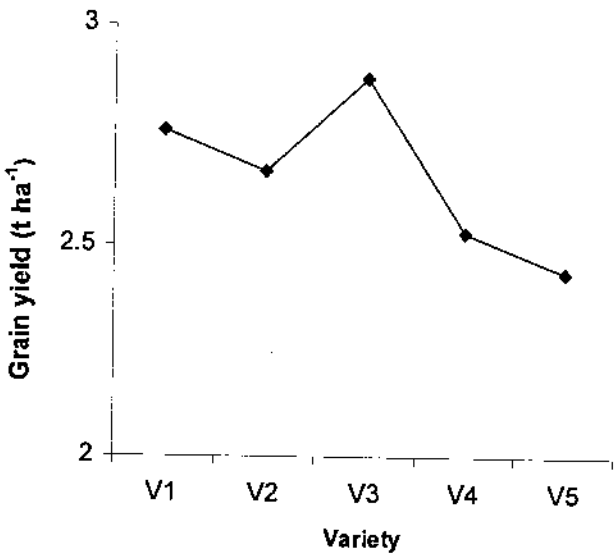

Fig 4.2.31 Effect of variety on grain yield in 2006-07

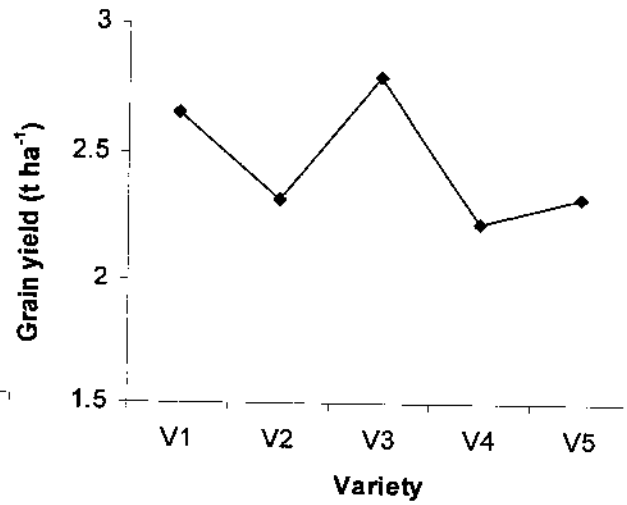

Fig 4.2.32 Effect of variety on grain yield in 2007-08

Table 4.2.4: Productivity evaluation through HI and LER of wheat in agroforestry practices in 2006-2007 and 2007-2008

Treatment combination	Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest Index (%)		Ci/Cs		Ti/Ts		LER	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
T_1V_1	5.27	5.07	8.11	7.87	35.01	35.57	-	-	-	-	-	-
T_1V_2	5.17	5.06	7.96	7.69	35.05	34.2	-	-	-	-	-	-
T_1V_3	5.39	5.21	8.29	8.08	34.98	35.51	-	-	-	-	-	-
T_1V_4	5.32	5.12	8.04	7.70	33.83	33.5	-	-	-	-	-	-
T_1V_5	5.02	4.99	7.70	7.62	34.8	34.51	-	-	-	-	-	-
T_2V_1	4.96	4.62	7.56	7.12	34.39	35.11	0.94	0.91	1.27	1.22	2.21	2.13
T_2V_2	4.85	4.62	7.41	6.95	34.54	33.52	0.94	0.91	1.27	1.22	2.21	2.13
T_2V_3	5.08	4.76	7.74	7.33	34.36	35.06	0.94	0.91	1.27	1.22	2.21	2.13
T_2V_4	5.00	4.67	7.49	6.95	33.24	32.8	0.94	0.91	1.27	1.22	2.21	2.13
T_2V_5	4.7	4.54	7.14	6.87	34.17	33.91	0.94	0.91	1.27	1.22	2.21	2.13
T_3V_1	4.91	4.07	7.45	6.16	34.09	33.92	0.93	0.80	1.47	1.43	2.40	2.23
T_3V_2	4.81	4.07	7.30	5.99	34.1	32.05	0.93	0.80	1.47	1.43	2.40	2.23
T_3V_3	5.03	4.21	7.63	6.37	34.07	33.9	0.93	0.81	1.47	1.43	2.40	2.24
T_3V_4	4.96	4.12	7.38	5.99	32.79	31.21	0.93	0.80	1.47	1.43	2.40	2.23
T_3V_5	4.66	3.95	7.04	5.87	33.8	32.7	0.93	0.79	1.47	1.43	2.40	2.22
T_4V_1	4.99	4.4	7.61	6.75	34.42	34.81	0.95	0.87	1.07	0.87	2.02	1.74
T_4V_2	4.88	4.39	7.45	6.57	34.49	33.18	0.94	0.87	1.07	0.87	2.01	1.74
T_4V_3	5.11	4.54	7.79	6.96	34.4	34.77	0.95	0.87	1.07	0.87	2.02	1.74
T_4V_4	5.03	4.45	7.53	6.59	33.20	32.47	0.95	0.87	1.07	0.87	2.02	1.74
T_4V_5	4.73	4.32	7.19	6.51	34.21	33.64	0.94	0.87	1.07	0.87	2.01	1.74

Table 4.2.4: Productivity evaluation through HI and LER of wheat in agroforestry practices in 2006-2007 and 2007-2008

Treatment combination	Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest Index (%)		Ci/Cs		Ti/Ts		LER	
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T_1V_1	5.27	5.07	8.11	7.87	35.01	35.57	-	-	-	-	-	-
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T_1V_3	5.39	5.21	8.29	8.08	34.98	35.51	-	-	-	-	-	-
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T_3V_2	4.81	4.07	7.30	5.99	34.1	32.05	0.93	0.80	1.47	1.43	2.40	2.23
T_3V_3	5.03	4.21	7.63	6.37	34.07	33.9	0.93	0.81	1.47	1.43	2.40	2.24
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T_1V_3	5.39	5.21	8.29	8.08	34.98	35.51	-	-	-	-	-	-
T_1V_4	5.32	5.12	8.04	7.70	33.83	33.5	-	-	-	-	-	-
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T_4V_5	4.73	4.32	7.19	6.51	34.21	33.64	0.94	0.87	1.07	0.87	2.01	1.74

4.2.10 Economic evaluation of wheat varieties in agroforestry practice

The economic analysis of wheat varieties under different tree canopies as well as sole crop (Table 4.2.6) showed that highest BCR (1.47) in 2006-07 was obtained for V_3 (shatabdi) in sole crop (T_1V_3 combination), which was followed by T_1V_1 (1.43) combination . The result showed that V_3 (shatabdi) always produced highest BCR over other varieties in each treatment condition. The rank order was sole (1.47) > mango (1.36) > black siris (1.35) > guava (1.32). The lowest BCR (1.21) was recorded for T_3V_5 combination V_5 (protiva) always showed minimum value of BCR in all treatment condition. The changing pattern of BCR in 2007-08 was quite similar to that of 2006-07 but the value of BCR was lower in each treatment condition than previous cropping season. The highest BCR was 1.45 for Shatabdi in sole crop and the lowest BCR was 0.97 found for T_3V_4 combination. In 2006-07 al treatment combinations showed positive net return but in 2nd year (2007-08) T_3V_5, T_3V_4 and T_3V_2 combination showed negative net return. It indicate that V_5 (protiva), V_4 (karamcha) and V_2 (sourav) are not capable to produce economically profitable yield under heaviest shade of guava (T_3). The result revealed that the most suitable variety of wheat for agroforestry was V_3 (Shatabdi) followed by V_1 (Gourave).

Table 4.2.5: Economic evaluation of through BCR of wheat in agroforestry practices at 2006-07 and 2007-08

Treatment combination	Total cost of production (Tk ha^{-1})		Gross return (Tk ha^{-1})		Net return (Tk ha^{-1})		BCR	
	2006-07	2006-07	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
T_1V_1	33309	33309	47870	47070	14561	13761	1.43	1.41
T_1V_2	33309	33309	47020	44510	13711	11201	1.41	1.33
T_1V_3	33309	33309	48890	48260	15581	14951	1.47	1.45
T_1V_4	33309	33309	46120	43820	12811	10511	1.38	1.32
T_1V_5	33309	33309	45220	44440	11911	11131	1.36	1.33
T_2V_1	33309	33309	43960	42120	10651	8811	1.32	1.26
T_2V_2	33309	33309	43250	39570	9941	6261	1.30	1.19
T_2V_3	33309	33309	44980	43310	11671	10001	1.35	1.30
T_2V_4	33309	33309	42350	38870	9041	5561	1.27	1.67
T_2V_5	33309	33309	41300	39490	7991	6181	1.24	1.19
T_3V_1	33309	33309	43010	35420	9701	2111	1.29	1.06
T_3V_2	33309	33309	42160	32870	8851	-439	1.27	0.99
T_3V_3	33309	33309	44030	36610	10721	3301	1.32	1.10
T_3V_4	33309	33309	41260	32170	7951	-1139	1.24	0.97
T_3V_5	33309	33309	40360	32750	7051	-559	1.21	0.98
T_4V_1	33309	33309	44290	39650	10981	6341	1.33	1.19
T_4V_2	33309	33309	43430	37090	10121	3781	1.30	1.11
T_4V_3	33309	33309	45310	40840	12001	7531	1.36	1.22
T_4V_4	33309	33309	42530	36550	9221	3241	1.28	1.10
T_4V_5	33309	33309	41630	37170	8321	3861	1.25	1.12

Note: Considering straw price @ 2 Tk kg^{-1} and grain price @ 15 Tk kg^{-1}

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Note: Considering straw price @ 2 Tk kg^{-1} and grain price @ 15 Tk kg^{-1}

T_1

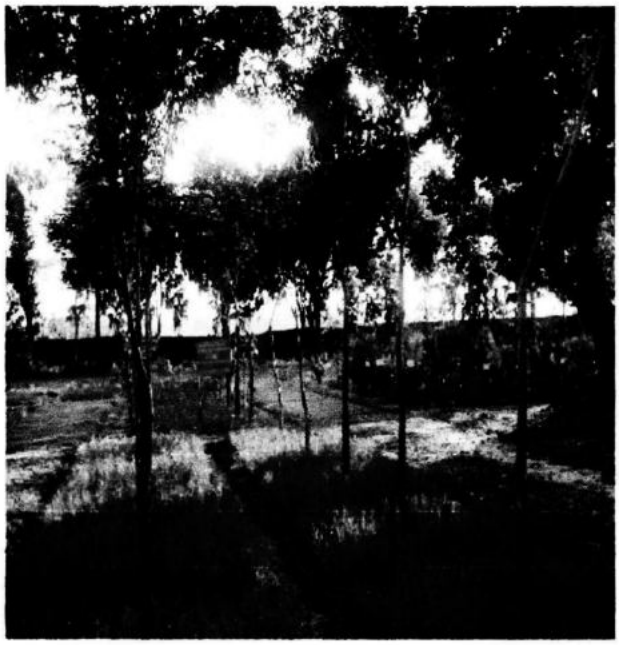
T_2

T_3

T_4

Plate 4.2.1. Different wheat varieties were shown in different treatment at 30 DAS (T_1 = open field, T_2 = Under black siris, T_3 = Under guava and T_4 = Under mango)

T_1



T_2

T_3

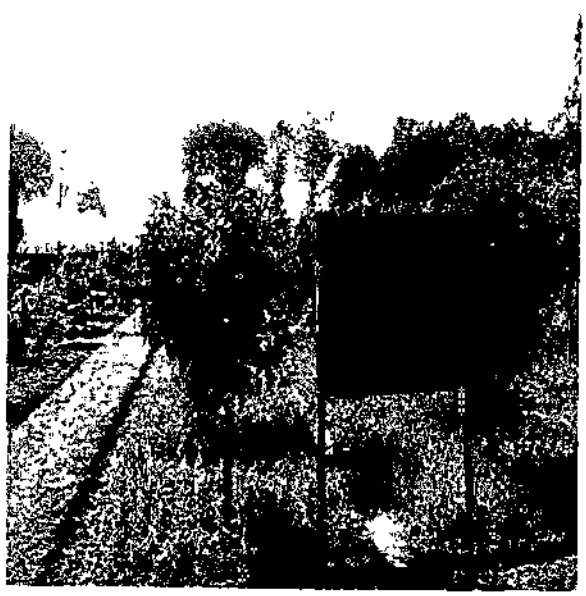
T_4

Plate 4.2.1. Different wheat varieties were shown in different treatment at 30 DAS (T_1 = open field, T_2 = Under black siris, T_3 = Under guava and T_4 = Under mango)

T_1

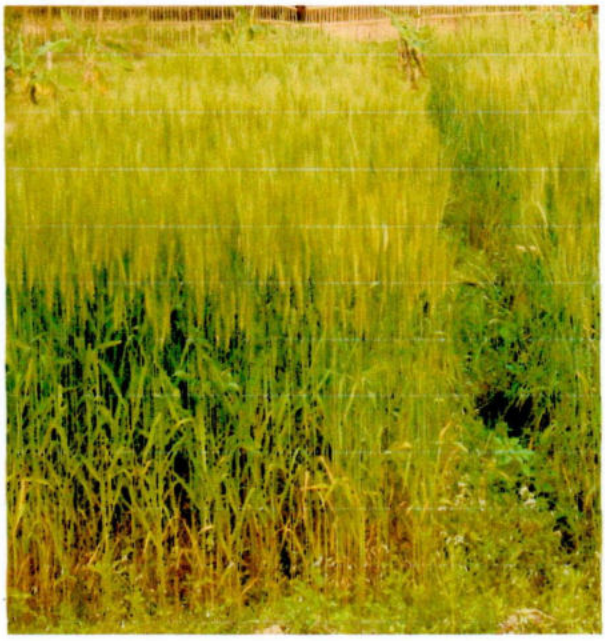
T_2

T_3



T_4

Plate 4.2.1. Different wheat varieties were shown in different treatment at 30 DAS (T_1 = open field, T_2 = Under black siris, T_3 = Under guava and T_4 = Under mango)



T_1

T_2

T_4

T_3

Plate 4.2.2. Different wheat varieties were shown in different treatment at 80 DAS (T_1 = open field, T_2 = Under black siris, T_3 = Under guava and T_4 = Under mango)

T_1

T_2

T_4

T_3

Plate 4.2.2. Different wheat varieties were shown in different treatment at 80 DAS (T_1 = open field, T_2 = Under black siris, T_3 = Under guava and T_4 = Under mango)

T_1

T_2

T_4

T_3

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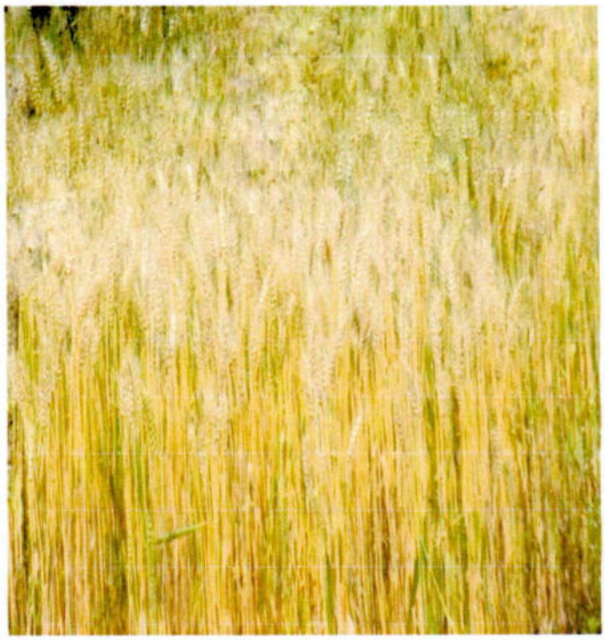


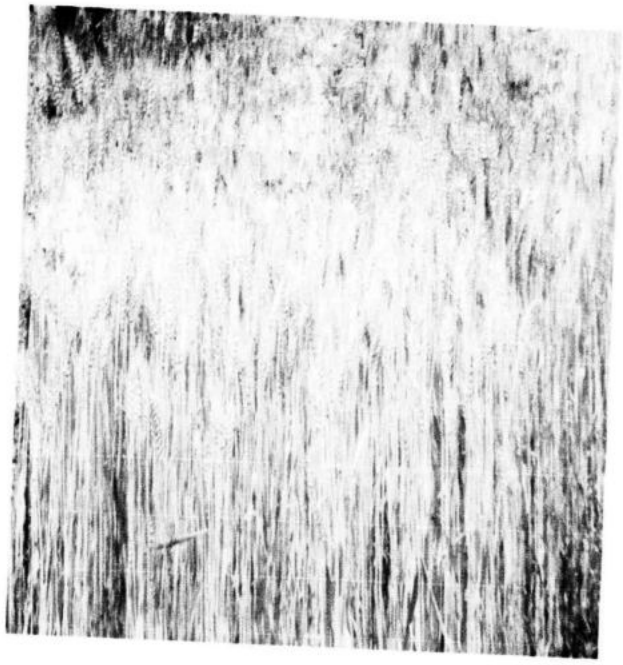
T_1

T_2

T_3

T_4

Plate 4.2.3 Different wheat varieties were shown in different treatment at 120 DAS (T_1 = open field, T_2 = Under black siris, T_3 = Under guava and T_4 = Under mango)



T_1

T_2

T_3

T_4

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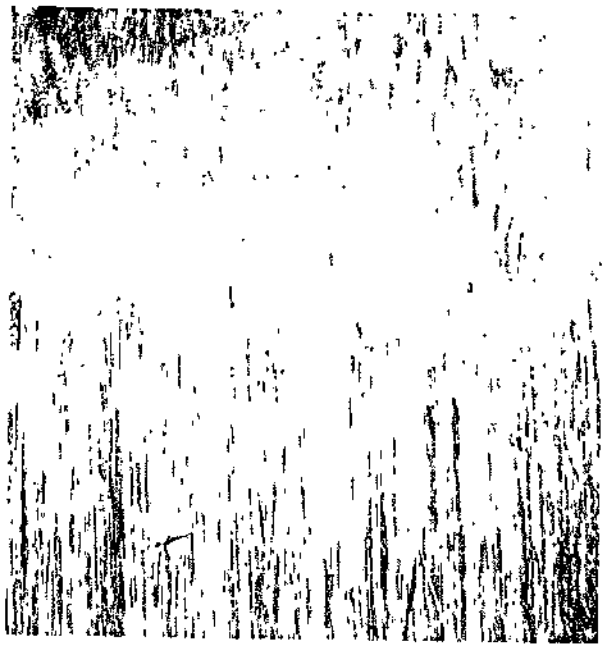

T_1

T_2

T_3

T_4

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Experiment # 3 Performance of Mungbean in Agroforestry System

4.3.1 Plant height

Effects of tree species

Plant height of mungbean is an important morphological characteristic that was significantly influenced by the multipurpose tree species. Different varieties responded differently under different tree species of various shade levels. In 2007, significantly the longest plant (66.79 cm) was recorded in T_3 (guava) followed by T_4 (66.01 cm). Significantly the lowest plant height (63.48 cm) was recorded in T_1 (open field). In 2008, significantly the longest plant (71.49 cm) was recorded in T_2 (black siris) followed by T_1 (69.74 cm).Plant height found under T_4 (68.94 cm) was statistically identical to both of T_1 and T_2 (Figure 4.3.3).Significantly the lowest plant height (60.40cm) was recorded in T_3 (guava).

Response of mungbean varieties

Plant height of mungbean was significantly varied by the varietals characteristics. In 2007, significantly the longest plant (69.68cm) was produced by V_2 followed by V_4 (67.28cm). Significantly the lowest plant height (61.29cm) was recorded in V_5. In 2008, significantly the longest plant (72.82cm) was produced by V_2 followed by V_4 (70.89cm). Significantly the lowest plant height (66.09cm) was recorded in V_5. These variations of plant height among different varieties might be due to their various genetic make up.

Interaction effect of tree species and mungbean variety on plant height

Plant height of mungbean was significantly influenced by the combined effect of tree and variety. The influencing pattern found in different combination at 2007 was almost similar to that of following year. Significantly the highest plant heights (70.87 and 76.1 cm in 2007 and 2008 respectively) were recorded for V_4 (BARI Mug-6) under guava (T_3) followed by T_4V_2 (71.07 cm) combination in 2006 and T_3V_4 (73.5 cm) combination in 2007. Significantly the lowest plant height (59.97 cm) was found in T_1V_1 combination in 2007 which was statistically similar to that of T_1V_5 (60.3 cm) combination, but in 2007, significantly the shortest plant height (64.0 cm) was recorded in T_1V_5 combination. The combined effect showed that BARI Mug 6 (V_4) performed better in all shaded conditions followed by V_2. Where as V_1 and V_5 showed the poorest performance in case of plant height. The present study revealed that plant height increased with the decrease of light intensities. Plant height depends on a number of factors such as availability of required quantity of water, mineral nutrients, quantity , quality and duration of light, temperature, area of growing space (aerial and edaphic) and genetic set up of the plants. Plant grown in low light levels was found to be exhibited apical dominance than those grown in high light environment resulting in taller plants under shade (Hillman, 1984), Miah (2001) observed taller tomato plant under reduced PAR levels. Similarly higher plant height under reduced light levels was also observed in mungbean (Ali, 1998, Islam, 1996) this nay be attributed to the stimulation of cellular expansion and cell division under shaded condition (Schoch, 1972)

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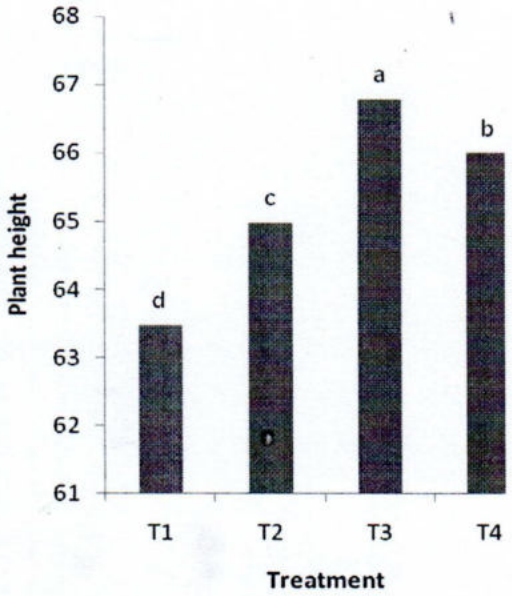

Fig4.3.1.Effect of trees on plant height of mungbean in 2007

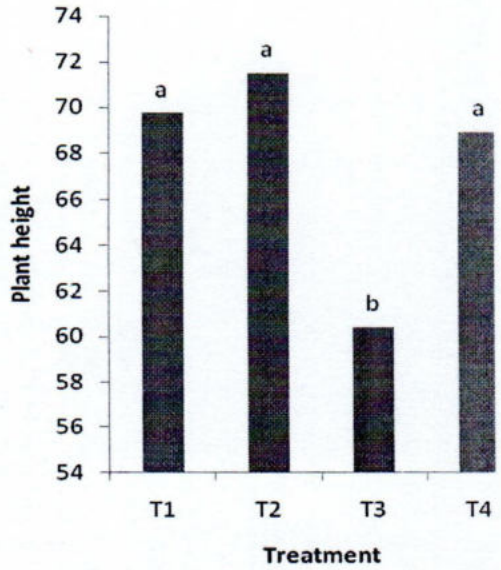

Fig4.3.2. Effect of trees on plant height of mungbean in 2008

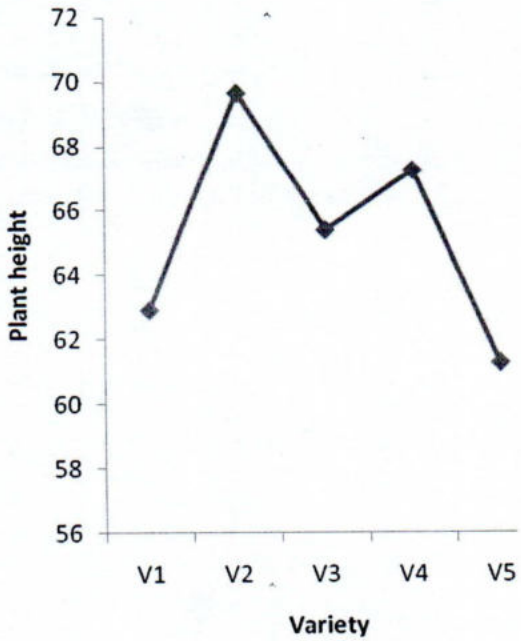

Fig4.3.3.Effect of variety on plant height of mungbean in 2007

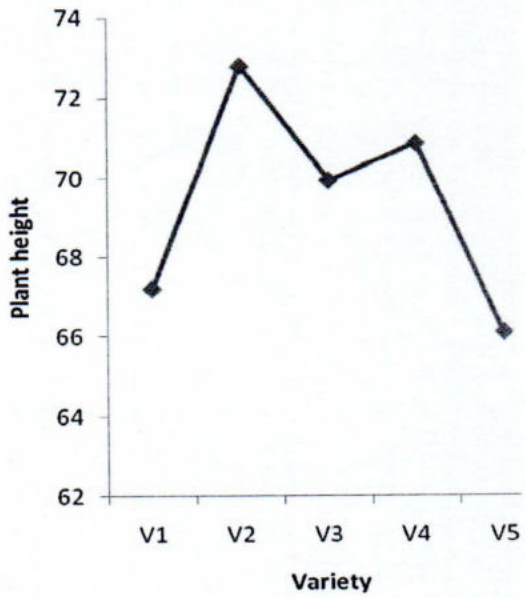

Fig4.3.4.Effect of variety on plant height of mungbean in 2008

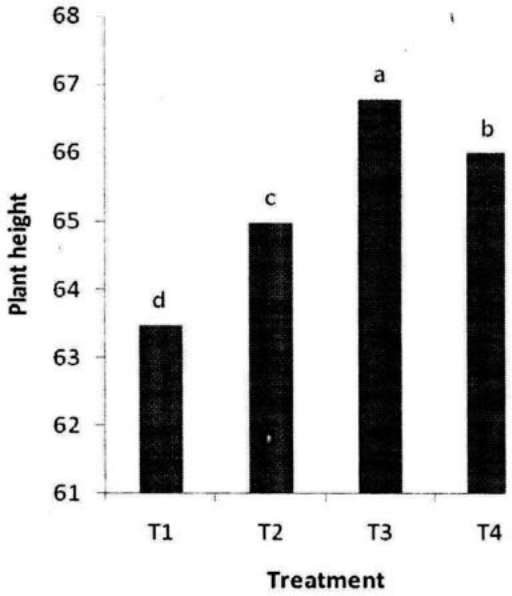

Fig4.3.1.Effect of trees on plant height of mungbean in 2007

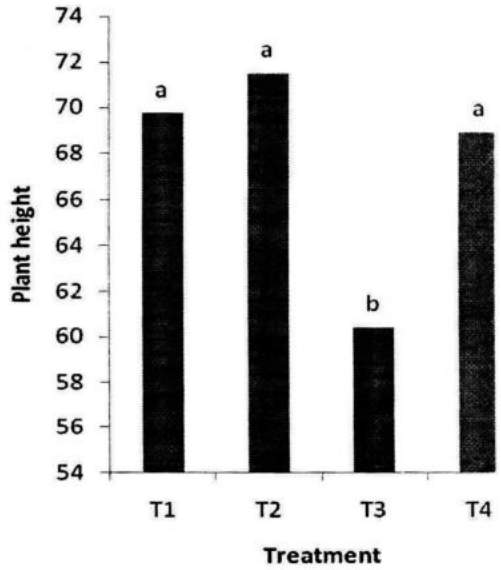

Fig4.3.2. Effect of trees on plant height of mungbean in 2008

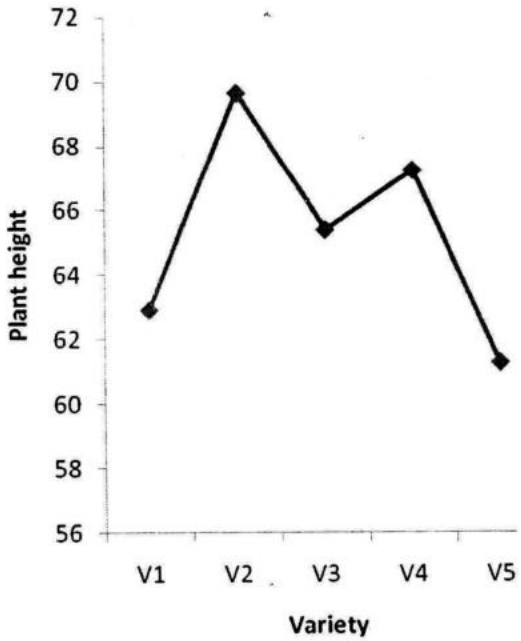

Fig4.3.3.Effect of variety on plant height of mungbean in 2007

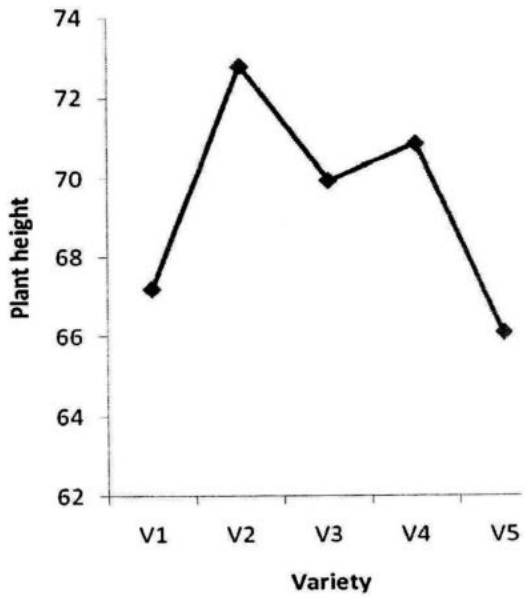

Fig4.3.4.Effect of variety on plant height of mungbean in 2008

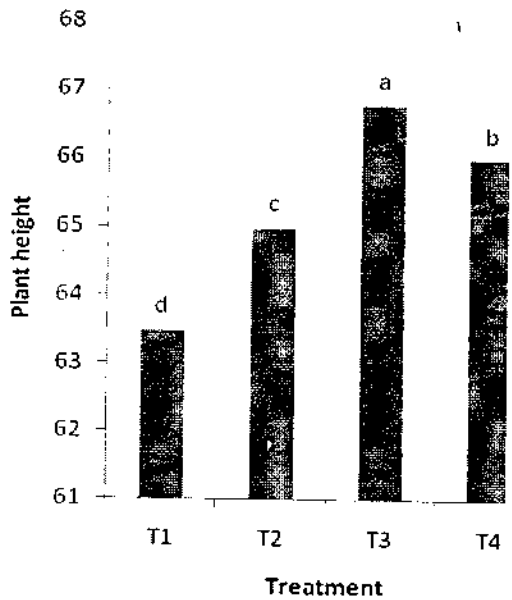

Fig4.3.1.Effect of trees on plant height of mungbean in 2007

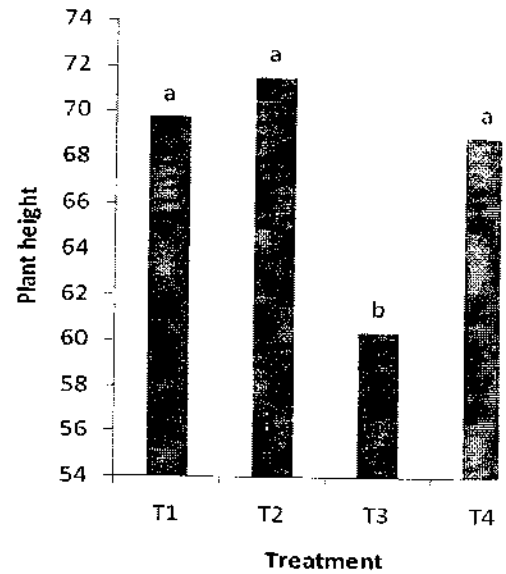

Fig4.3.2. Effect of trees on plant height of mungbean in 2008

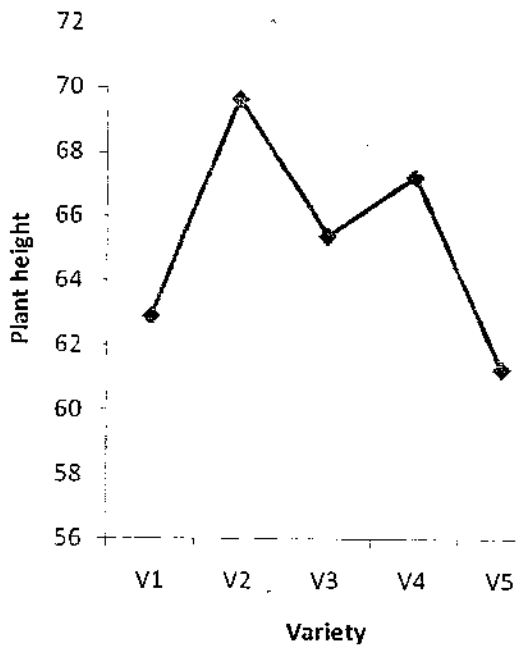

Fig4.3.3.Effect of variety on plant height of mungbean in 2007

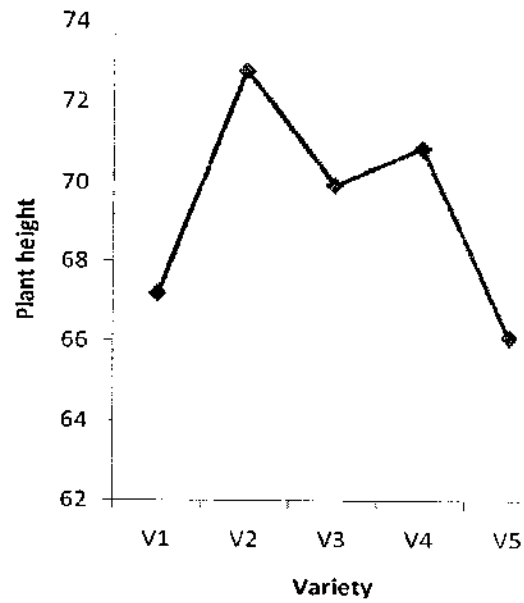

Fig4.3.4.Effect of variety on plant height of mungbean in 2008

Table 4.3.1 Interaction effect of tree species and mungbean variety on plant height, number of pod plant^{-1}, pod length, seed pod^{-1}and 1000 seed weight in 2007 and 2008

Treatment combination	Plant height (cm)		Number of pod plant^{-1}		Pod length (cm)		Seed pod^{-1}		Thousand seed wt (g)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1V_1	59.97 n	65.3 m	7.42 e	7.2 e	6.37 efg	6.10 cde	11.10 de	10.7 cdef	26.43 f	26.00 f
T_1V_2	67.03 e	70.00 e	9.73 bcd	9.7 bc	6.47defg	6.35abcd	11.53 d	11.0 bcd	29.17 e	28.83 e
T_1V_3	63.93 i	68.0 i	11.10 a	11.0 a	6.82 ab	6.63 abc	12.53 b	11.90 ab	39.1 c	39.2 c
T_1V_4	66.17fg	69.5 f	11.12 a	10.5ab	6.90 ab	6.67 ab	13.47 a	12.53 a	49.80 a	49.27 a
T_1V_5	60.3 mn	64.0 n	4.83 g	4.50 gh	5.05 h	4.90 f	8.50 h	8.00 i	20.40 j	19.83gh
T_2V_1	61.87 k	66.7 k	7.00 ef	6.23 ef	6.27 fg	6.47 abc	10.53efg	10.07efgh	24.33 h	24.67 f
T_2V_2	69.77 b	72.0 c	9.23 d	8.53 d	6.63 bcde	6.47 abc	11.07 de	10.60 cdef	28.17 e	28.50 e
T_2V_3	65.47 h	69.20 g	10.47abc	9.63 bc	6.87 ab	6.72 a	11.73 cd	10.93 cde	38.53 c	38.67 c
T_2V_4	67.37de	70.67 d	10.67 ab	9.83 bc	6.97 a	6.77 a	12.53 b	11.53 bc	48.6 a	48.37 a
T_2V_5	60.43 m	66.10 l	4.27 g	3.83 hi	5.17 h	4.80 f	7.83 hi	7.37 ij	18.83 k	18.67 hi
T_3V_1	65.77gh	68.50 h	6.27 f	5.33 fg	6.20 g	5.70 e	8.50 h	7.97 i	22.00 i	21.17 g
T_3V_2	70.87 a	76.10 a	7.67 e	7.00 e	6.52 cdef	5.90 de	9.87 g	9.27 h	26.17fg	25.00 f
T_3V_3	66.23 f	72.10 c	9.53 cd	8.87 cd	6.76 abc	6.13bcde	10.10 fg	9.50 gh	34.97 d	34.00 d
T_3V_4	68.07 c	73.50 b	10.07 bcd	8.77 cd	6.82 ab	6.17bcde	10.37efg	9.83 fgh	45.00 b	43.50 b
T_3V_5	63.00 j	67.23 j	3.00 h	2.10 j	5.03 h	4.80 f	7.33 i	6.97 j	18.57 k	17.67 i
T_4V_1	64.03 i	68.17hi	7.40 e	7.10 e	6.73 abcd	6.47 abc	10.03 fg	9.60 gh	24.63gh	24.23 f
T_4V_2	71.07 a	73.20 b	9.43 d	8.87 cd	6.733 abcd	6.57 abc	10.63 ef	10.23 defg	28.53 e	27.97 e
T_4V_3	65.97fg	70.50 d	10.20 abcd	9.73 bc	6.85 ab	6.63 abc	11.70 cd	10.83 cde	38.87 c	38.43 c
T_4V_4	67.53 d	69.83 ef	10.17 abcd	9.50 cd	6.97 a	6.73 a	12.37 bc	11.93 ab	49.50 a	48.83 a
T_4V_5	61.43 l	67.00 jk	4.333 g	3.23 i	5.13 h	4.90 f	8.17 h	7.67 ij	18.50 k	18.13 hi
CV%	0.42	0.30	7.32	7.50	2.83	4.60	4.48	5.14	2.95	3.57

T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

Table 4.3.1 Interaction effect of tree species and mungbean variety on plant height, number of pod plant^{-1}, pod length, seed pod^{-1}and 1000 seed weight in 2007 and 2008

Treatment combination	Plant height (cm)		Number of pod plant^{-1}		Pod length (cm)		Seed pod^{-1}		Thousand seed wt (g)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1V_1	59.97 n	65.3 m	7.42 e	7.2 e	6.37 efg	6.10 cde	11.10 de	10.7 cdef	26.43 f	26.00 f
T_1V_2	67.03 e	70.00 e	9.73 bcd	9.7 bc	6.47defg	6.35abcd	11.53 d	11.0 bcd	29.17 e	28.83 e
T_1V_3	63.93 i	68.0 i	11.10 a	11.0 a	6.82 ab	6.63 abc	12.53 b	11.90 ab	39.1 c	39.2 c
T_1V_4	66.17fg	69.5 f	11.12 a	10.5ab	6.90 ab	6.67 ab	13.47 a	12.53 a	49.80 a	49.27 a
T_1V_5	60.3 mn	64.0 n	4.83 g	4.50 gh	5.05 h	4.90 f	8.50 h	8.00 i	20.40 j	19.83gh
T_2V_1	61.87 k	66.7 k	7.00 ef	6.23 ef	6.27 fg	6.47 abc	10.53efg	10.07efgh	24.33 h	24.67 f
T_2V_2	69.77 b	72.0 c	9.23 d	8.53 d	6.63 bcde	6.47 abc	11.07 de	10.60 cdef	28.17 e	28.50 e
T_2V_3	65.47 h	69.20 g	10.47abc	9.63 bc	6.87 ab	6.72 a	11.73 cd	10.93 cde	38.53 c	38.67 c
T_2V_4	67.37de	70.67 d	10.67 ab	9.83 bc	6.97 a	6.77 a	12.53 b	11.53 bc	48.6 a	48.37 a
T_2V_5	60.43 m	66.10 l	4.27 g	3.83 hi	5.17 h	4.80 f	7.83 hi	7.37 ij	18.83 k	18.67 hi
T_3V_1	65.77gh	68.50 h	6.27 f	5.33 fg	6.20 g	5.70 e	8.50 h	7.97 i	22.00 i	21.17 g
T_3V_2	70.87 a	76.10 a	7.67 e	7.00 e	6.52 cdef	5.90 de	9.87 g	9.27 h	26.17fg	25.00 f
T_3V_3	66.23 f	72.10 c	9.53 cd	8.87 cd	6.76 abc	6.13bcde	10.10 fg	9.50 gh	34.97 d	34.00 d
T_3V_4	68.07 c	73.50 b	10.07 bcd	8.77 cd	6.82 ab	6.17bcde	10.37efg	9.83 fgh	45.00 b	43.50 b
T_3V_5	63.00 j	67.23 j	3.00 h	2.10 j	5.03 h	4.80 f	7.33 i	6.97 j	18.57 k	17.67 i
T_4V_1	64.03 i	68.17hi	7.40 e	7.10 e	6.73 abcd	6.47 abc	10.03 fg	9.60 gh	24.63gh	24.23 f
T_4V_2	71.07 a	73.20 b	9.43 d	8.87 cd	6.733 abcd	6.57 abc	10.63 ef	10.23 defg	28.53 e	27.97 e
T_4V_3	65.97fg	70.50 d	10.20 abcd	9.73 bc	6.85 ab	6.63 abc	11.70 cd	10.83 cde	38.87 c	38.43 c
T_4V_4	67.53 d	69.83 ef	10.17 abcd	9.50 cd	6.97 a	6.73 a	12.37 bc	11.93 ab	49.50 a	48.83 a
T_4V_5	61.43 l	67.00 jk	4.333 g	3.23 i	5.13 h	4.90 f	8.17 h	7.67 ij	18.50 k	18.13 hi
CV%	0.42	0.30	7.32	7.50	2.83	4.60	4.48	5.14	2.95	3.57

T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

Table 4.3.1 Interaction effect of tree species and mungbean variety on plant height, number of pod plant^{-1}, pod length, seed pod^{-1} and 1000 seed weight in 2007 and 2008

Treatment combination	Plant height (cm)		Number of pod plant^{-1}		Pod length (cm)		Seed pod^{-1}		Thousand seed wt (g)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1V_1	59.97 n	65.3 m	7.42 e	7.2 e	6.37 efg	6.10 cde	11.10 de	10.7 cdef	26.43 f	26.00 f
T_1V_2	67.03 e	70.00 e	9.73 bcd	9.7 bc	6.47defg	6.35abcd	11.53 d	11.0 bcd	29.17 e	28.83 e
T_1V_3	63.93 i	68.0 i	11.10 a	11.0 a	6.82 ab	6.63 abc	12.53 b	11.90 ab	39.1 c	39.2 c
T_1V_4	66.17fg	69.5 f	11.12 a	10.5ab	6.90 ab	6.67 ab	13.47 a	12.53 a	49.80 a	49.27 a
T_1V_5	60.3 mn	64.0 n	4.83 g	4.50 gh	5.05 h	4.90 f	8.50 h	8.00 i	20.40 j	19.83gh
T_2V_1	61.87 k	66.7 k	7.00 ef	6.23 ef	6.27 fg	6.47 abc	10.53efg	10.07efgh	24.33 h	24.67 f
T_2V_2	69.77 b	72.0 c	9.23 d	8.53 d	6.63 bcde	6.47 abc	11.07 de	10.60 cdef	28.17 e	28.50 e
T_2V_3	65.47 h	69.20 g	10.47abc	9.63 bc	6.87 ab	6.72 a	11.73 cd	10.93 cde	38.53 c	38.67 c
T_2V_4	67.37de	70.67 d	10.67 ab	9.83 bc	6.97 a	6.77 a	12.53 b	11.53 bc	48.6 a	48.37 a
T_2V_5	60.43 m	66.10 l	4.27 g	3.83 hi	5.17 h	4.80 f	7.83 hi	7.37 ij	18.83 k	18.67 hi
T_3V_1	65.77gh	68.50 h	6.27 f	5.33 fg	6.20 g	5.70 e	8.50 h	7.97 i	22.00 i	21.17 g
T_3V_2	70.87 a	76.10 a	7.67 e	7.00 e	6.52 cdef	5.90 de	9.87 g	9.27 h	26.17fg	25.00 f
T_3V_3	66.23 f	72.10 c	9.53 cd	8.87 cd	6.76 abc	6.13bcde	10.10 fg	9.50 gh	34.97 d	34.00 d
T_3V_4	68.07 c	73.50 b	10.07 bcd	8.77 cd	6.82 ab	6.17bcde	10.37efg	9.83 fgh	45.00 b	43.50 b
T_3V_5	63.00 j	67.23 j	3.00 h	2.10 j	5.03 h	4.80 f	7.33 i	6.97 j	18.57 k	17.67 i
T_4V_1	64.03 i	68.17hi	7.40 e	7.10 e	6.73 abcd	6.47 abc	10.03 fg	9.60 gh	24.63gh	24.23 f
T_4V_2	71.07 a	73.20 b	9.43 d	8.87 cd	6.733 abcd	6.57 abc	10.63 ef	10.23 defg	28.53 e	27.97 e
T_4V_3	65.97fg	70.50 d	10.20 abcd	9.73 bc	6.85 ab	6.63 abc	11.70 cd	10.83 cde	38.87 c	38.43 c
T_4V_4	67.53 d	69.83 ef	10.17 abcd	9.50 cd	6.97 a	6.73 a	12.37 bc	11.93 ab	49.50 a	48.83 a
T_4V_5	61.43 l	67.00 jk	4.333 g	3.23 i	5.13 h	4.90 f	8.17 h	7.67 ij	18.50 k	18.13 hi
CV%	0.42	0.30	7.32	7.50	2.83	4.60	4.48	5.14	2.95	3.57

T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

4.3.2 Number of pods plant^{-1}

Effect of tree species

Number of pods plant^{-1}is one of the important components of the yield production process of mungbean which was significantly influenced by the multipurpose tree species. In 2007, significantly the highest number of pods (8.841) was recorded in T_1 (open field) followed by T_2 (8.33) and then T_4 (8.31). Significantly the lowest number of pods (7.31) was recorded in T_3 (guava). In 2008, T_4(mango), T_2 (black-siris), and T_1(open field) produced maximum and statistically identical number of pod/plant (6.26,6.24 and 6.13, respectively). Significantly the lowest number of pods plant^{-1} (5.74) was recorded in T_3 (guava). The mungbean grown under guava in 2nd year (2008) experienced heaviest shade (Appendix 2) that's why number of pods plant^{-1} under guava was found significantly lowest.

Response of mungbean varieties

Number of pods plant^{-1}of mungbean was also significantly varied by the varieties. In 2007, both V_4 and V_3 produced maximum and statistically identical number of pods plant^{-1} (10.51 and 10.32, respectively).Significantly the lowest number of pods (4.11) was recorded in V_5. In 2008, both V_3 and V_4 produced maximum and statistically identical number of pods plant^{-1} (9.83 and 9.67 respectively).Significantly the lowest number of pods (3.42) was recorded in V_5. The result revealed that BARI Mug 5 (V_3) and BARI Mug 6 (V_4) were found superior for producing highest number of pods plant^{-1}.

Interaction effect of tree species and mungbean variety on number of pods plant^{-1} of mungbean

The interaction effect of different tree species and varieties on the number of pods per plant of mungbean was highly significant (Table 4.3.1) and the influencing pattern in the two consecutive years was almost similar. The highest number of pod (11.2 and 11.0 in 2007 and 2008, respectively) was recorded for BARI Mug 5 in open field (T_1V_3 combination) which was statistically similar to that of T_1V_4 combination (BARI Mug 6 in open field) and the values were 11.10 and 10.5 in 2007 and 2008, respectively. In 2007, number of pod per plant recorded in T_2V_3 (10.47), T_2V_4 (10.67), T_4V_3 (10.2) and T_4V_4 (10.17) combinations were similar to that of T_1V_3, but in 2008, these combination produced statistically different number of pod per plant. Significantly the lowest number of pod per plant was found for V_5 under guava (T_3) in both the cropping seasons (3.0 and 2.1 in 2007 and 2008, respectively). The lower number of pod plant^{-1} grown under relatively more and prolong shaded conditions was probably due to poor photosynthetic capacity of plant and poor partitioning of that photosynthesis.

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Response of mungbean varieties

Number of pods plant^{-1}of mungbean was also significantly varied by the varieties. In 2007, both V_4 and V_3 produced maximum and statistically identical number of pods plant^{-1} (10.51 and 10.32, respectively).Significantly the lowest number of pods (4.11) was recorded in V_5. In 2008, both V_3 and V_4 produced maximum and statistically identical number of pods plant^{-1} (9.83 and 9.67 respectively).Significantly the lowest number of pods (3.42) was recorded in V_5. The result revealed that BARI Mug 5 (V_3) and BARI Mug 6 (V_4) were found superior for producing highest number of pods plant^{-1}.

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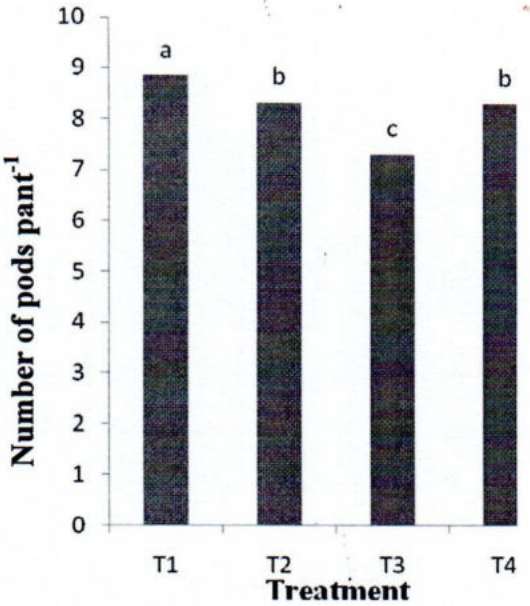


Fig 4.3.5 Effect of trees on number of pods plant^{-1}of mungbean in 2007

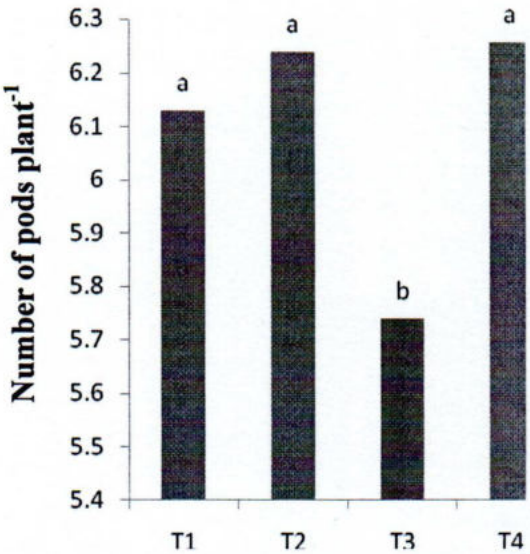


Fig 4.3.6 Effect of trees on number of pods plant^{-1}of mungbean in 2008

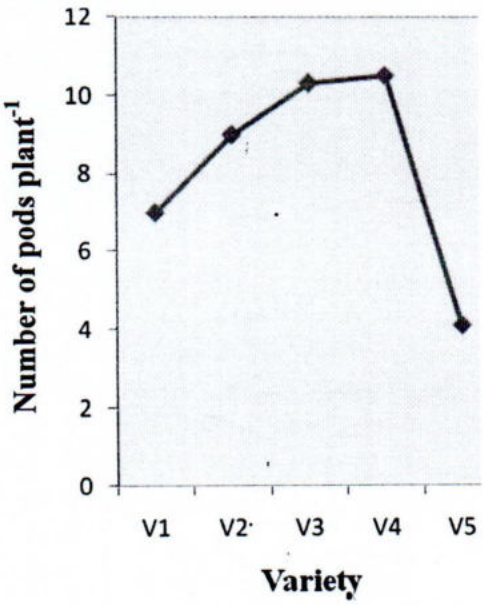


Fig 4.3.7 Effect of variety on number of pods plant^{-1}of mungbean in 2007

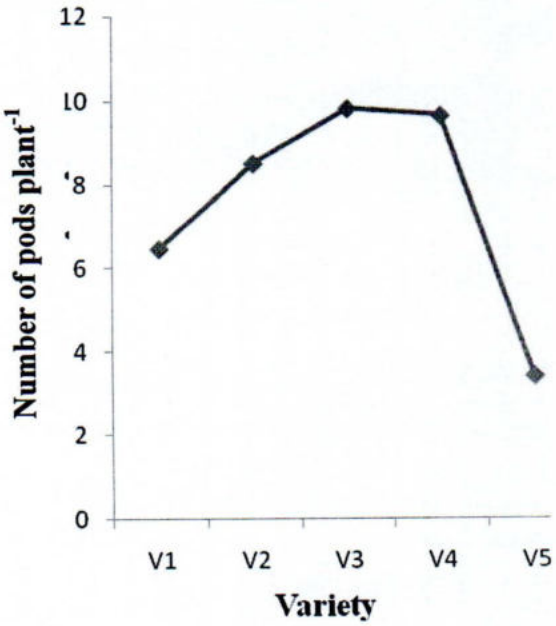


Fig 4.3.8 Effect of variety on number of pods plant^{-1} of mungbean in 2008

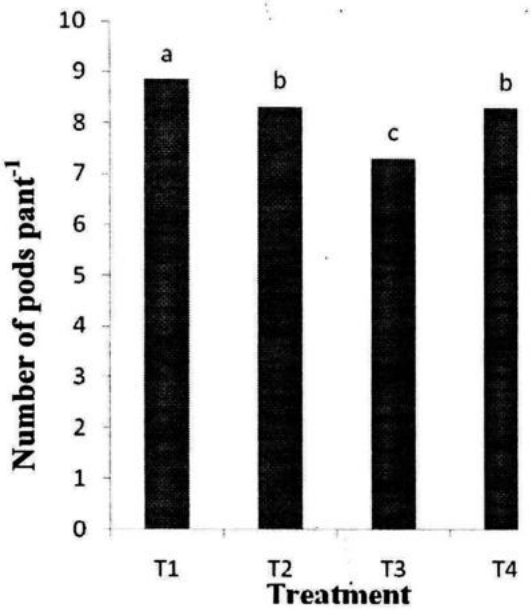


Fig 4.3.5 Effect of trees on number of pods plant^{-1}of mungbean in 2007

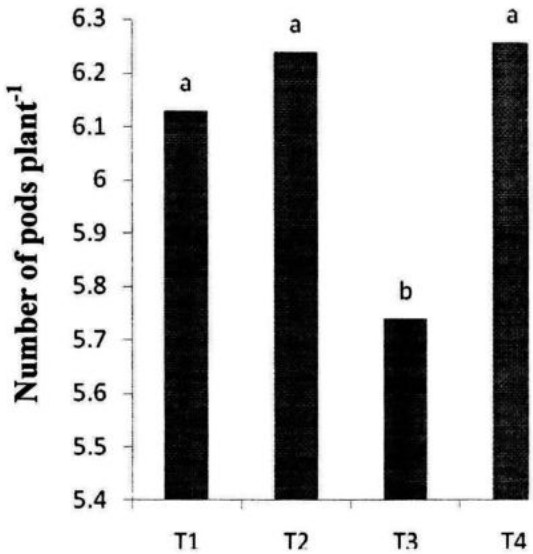


Fig 4.3.6 Effect of trees on number of pods plant^{-1}of mungbean in 2008

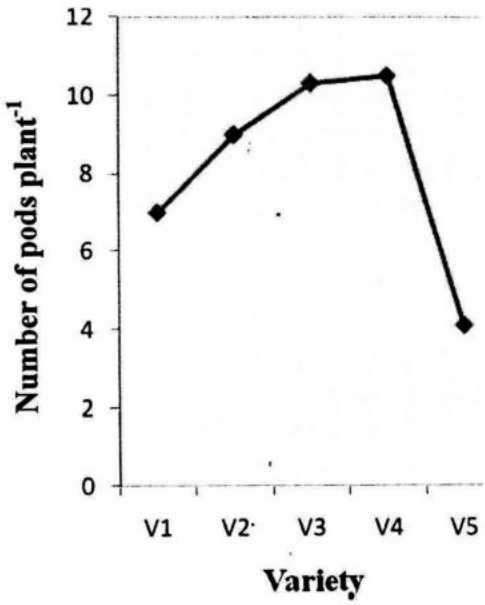


Fig 4.3.7 Effect of variety on number of pods plant^{-1}of mungbean in 2007

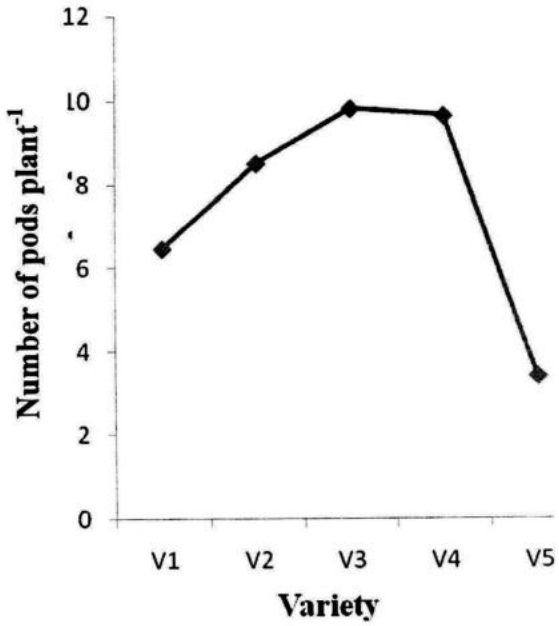
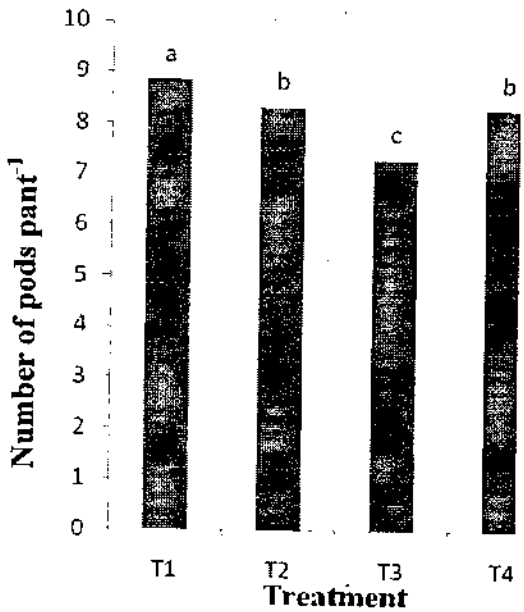


Fig 4.3.8 Effect of variety on number of pods plant^{-1} of mungbean in 2008



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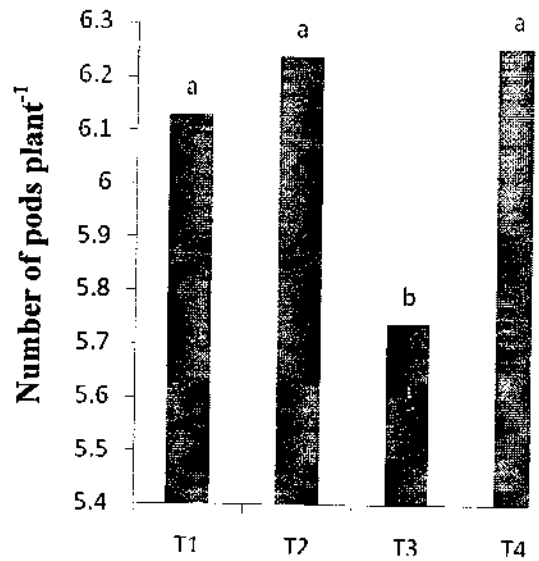

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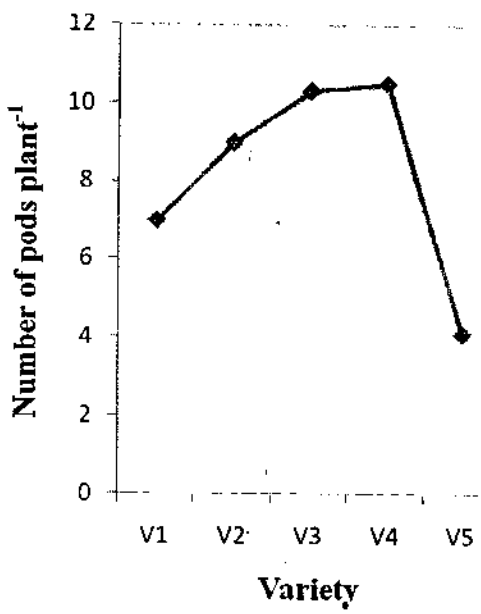

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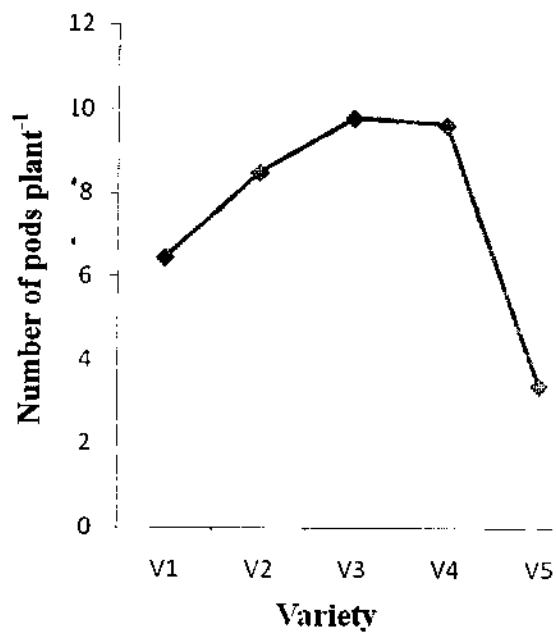

Fig 4.3.8 Effect of variety on number of pods plant^{-1} of mungbean in 2008

4.3.3 Fresh weight of mungbean

Effect of tree species

Fresh weight of mungbean was significantly influenced by the multipurpose tree species. In 2007, significantly the highest fresh weight (6.24 t ha^{-1}) was recorded in T_1 (open field) followed by the T_2 (6.13 t ha^{-1}). The fresh weight found from T_4 (6.0 t ha^{-1}) was statistically similar to that of T_2 and T_3 (5.9 t ha^{-1}). The lowest fresh weight (5.9 t ha^{-1}) was recorded in T_3 (guava). In 2008, T_1 (open field) also produced significantly maximum fresh biomass which was followed by T_2 (6.5 t ha^{-1}). T_4 produced (6.0 t ha^{-1}) statistically identical fresh biomass to that of T_2. Significantly the lowest fresh weight (5.5 t ha^{-1}) was recorded in T_3 (guava).

Response of mungbean varieties

Influencing pattern of fresh biomass of mungbean was almost similar to plant height variation. In 2007, significantly the maximum fresh weight (8.2 t ha^{-1}) was recorded in V_2 followed by V_4 (6.91 t ha^{-1}) and minimum fresh weight (4.2 t ha^{-1}) was found from V_5. In 2008, significantly the maximum fresh weight (8.45 t ha^{-1}) was recorded in V_2 followed by V_1 (7.56 t ha^{-1}), V_1 and V_2 produced the similar fresh weight. But V_3 and V_4 produced moderate amount of biomass which were statistically identical. The minimum fresh weight (4.33 t ha^{-1}) was found in V_5.

Interaction effect of tree species and mungbean variety on fresh biomass production

Interaction effect of tree and varieties of mungbean on fresh biomass production showed that, there was significant variation among the treatment combinations but influencing pattern in both the cropping seasons was almost similar. The highest fresh biomass was produce by V_2 in open field condition seasons (8.5 and 8.6 t ha^{-1}in 2007 and 2008, respectively) which was followed by T_2V_2 combination in both the years (8.47 and 7.02 t ha^{-1}) and then T_4V_2 (8.61 and 7.01 t ha^{-1}in 2007 and 2008, respectively).

Significantly the lowest fresh wt was produced by V_5 (local variety) always showed poor performance in each treatment combinations. The results showed that V_2 (BARI Mug 4) produced higher amount of fresh biomass irrespective of all treatment combinations.

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4.3.4 Pod length of mungbean

Effect of tree species

Pod length of mungbean was significantly influenced by the multipurpose tree species. In 2007, significantly the longest pod (6.48cm) was recorded in T_4 (mango) which was statistically similar to T_2 (6.38 cm). Pod length recorded from T_2 (kalakoroi) was statistically similar to T_1 (6.321cm) and T_3 (6.27cm). Pod length of T_3 was the shortest one among the treatments. In 2007, T_4 (mango), T_2 (kalakoroi), and T_1 (open field) produced maximum and statistically identical number of pods plant^{-1} (6.26 cm, 6.24 cm and 6.13 cm, respectively). Significantly the lowest number of pod/plant (5.74 cm) was recorded in T_3 (guava).

Response of mungbean varieties

Pod length of mungbean was also significantly varied by the varietals characteristics. In 2006, significantly the longest pod (6.913 cm) was recorded in V_4 which was statistically identical to V_3 (6.82cm) followed by V_2 (6.59 cm). Significantly the shortest pod length (5.10cm) was recorded in V_5. In 2007, significantly the longest pod (6.58 cm) was recorded in V_4 followed by V_3 (6.53). V_3 was statistically similar to that of V_4 and V_2 (6.32). The shortest pod length (4.85) was recorded in V_5.

Interaction effect of tree species and mungbean variety on pod length

Pod length was also affected greatly by the interaction effect of trees and varieties. The longest pod was recorded in T_2V_4 combination (BARI Mug 6 under black siris) for both the cropping years (6.97 and 6.77 cm in 2007 and 2008, respectively). Although T_1V_3, T_1V_4, T_2V_3, T_3V_3, T_3V_4, T_4V_1, T_4V_2, T_4V_3 and T_4V_4 combination showed statistically similar length of pod in 2006 but in 2007 T_1V_2, T_1V_3, T_1V_4, T_2V_1, T_2V_2, T_2V_3, T_4V_1, T_4V_2, T_4V_3 and T_4V_4 combination were statistically similar to that of T_2V_4 combination (Table 4.3.1). Significantly the lowest length of pod was found in T_3V_5 combination in both the seasons (5.03 and 4.8 cm in 2006 and 2007, respectively)

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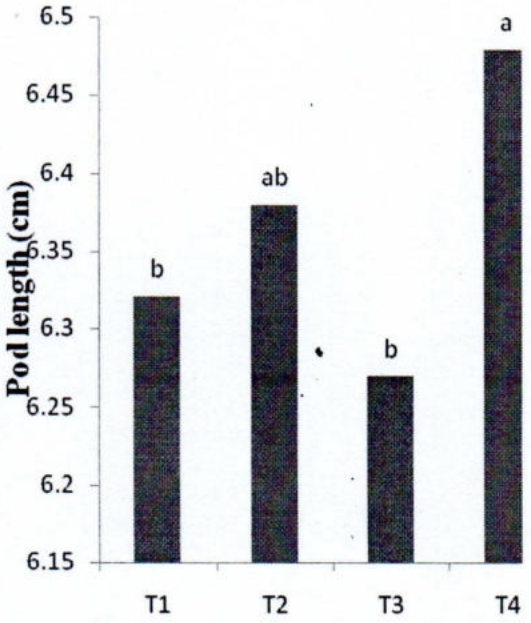


Fig 4.3.9 Effect of trees on pod length of mungbean in 2007

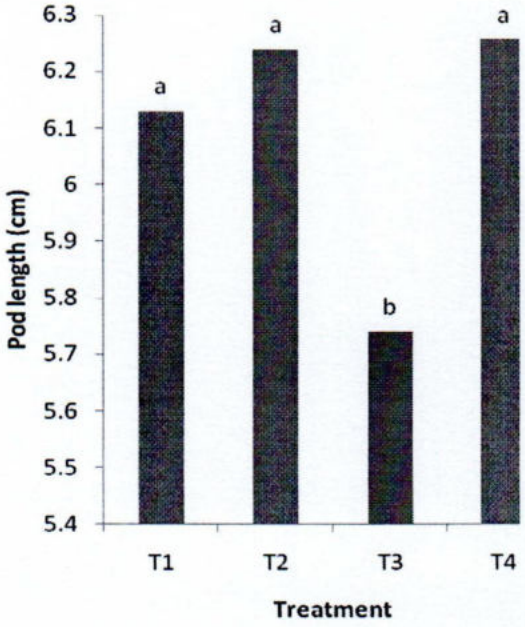


Fig 4.3.10 Effect of trees on pod length of mungbean in 2008

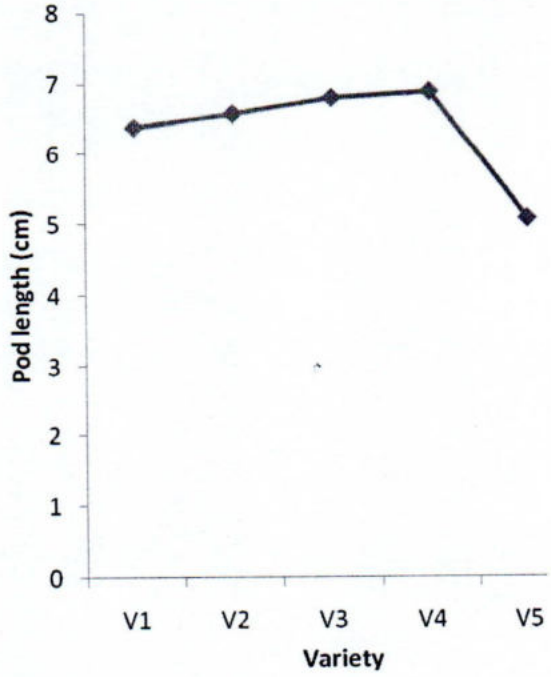


Fig 4.3.11 Effect of variety on pod length of mungbean in 2007

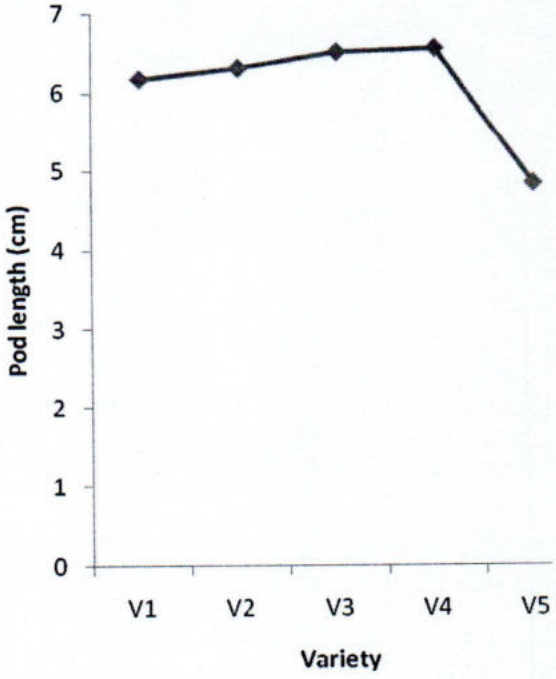
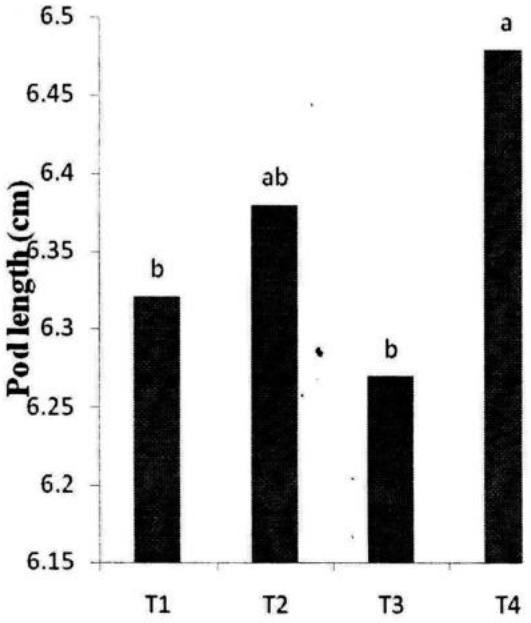


Fig 4.3.12 Effect of variety on pod length of mungbean in 2008



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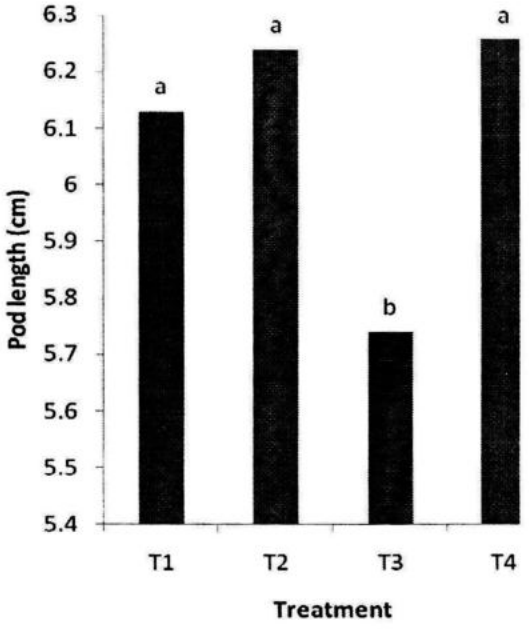

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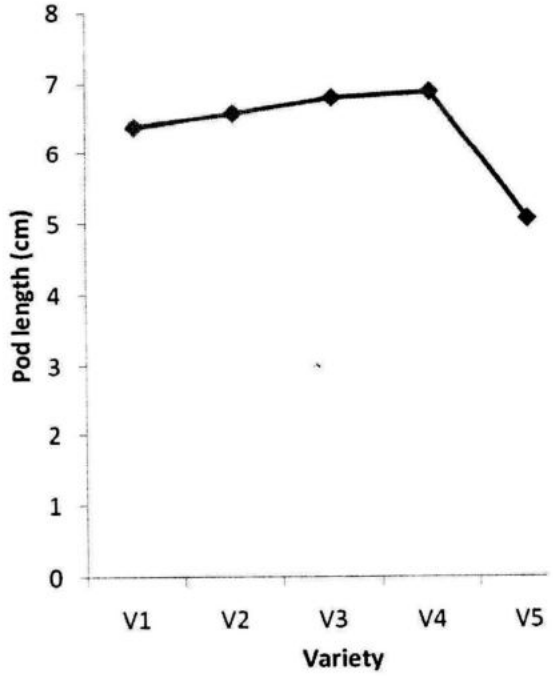

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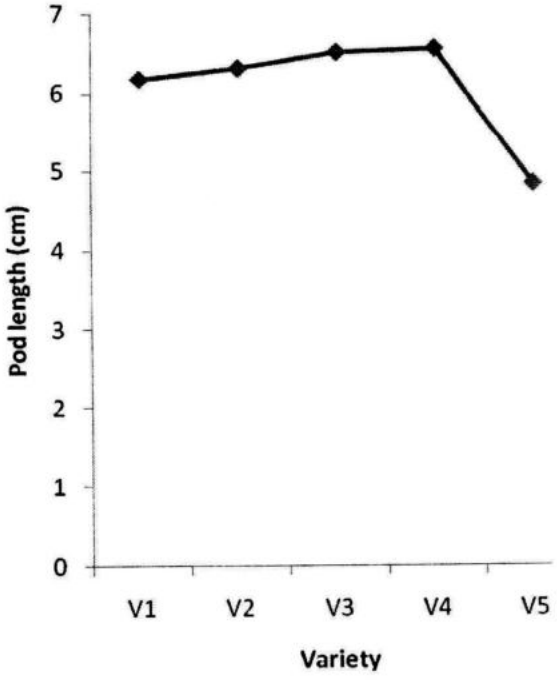

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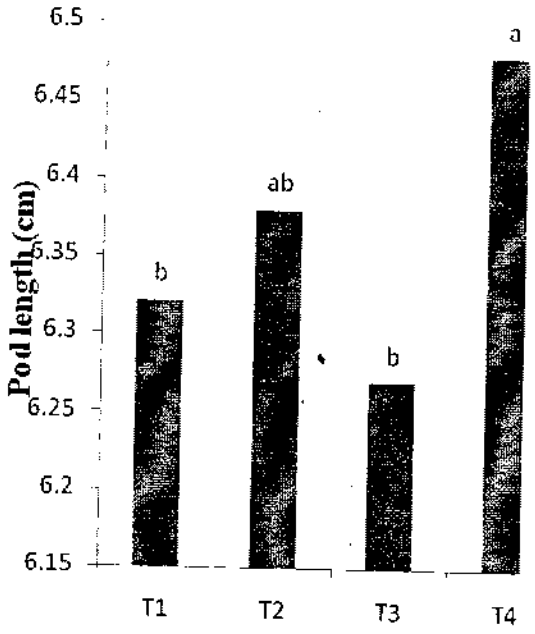

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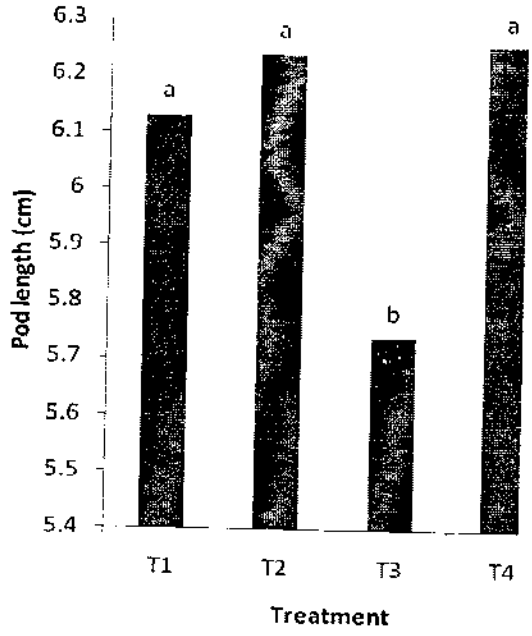

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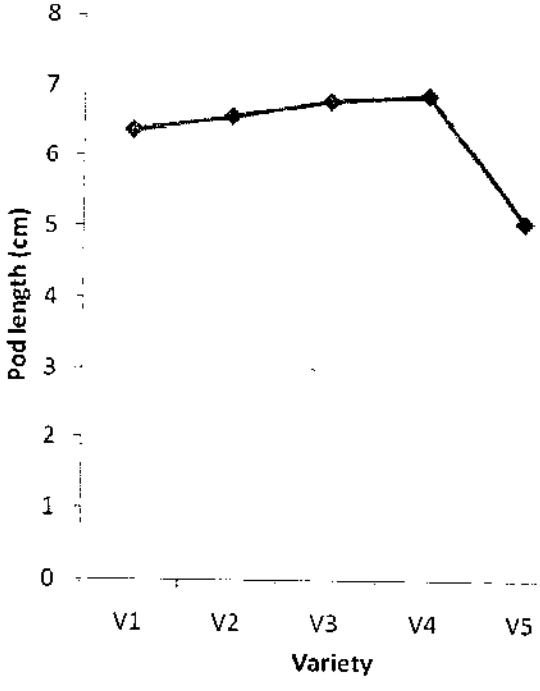

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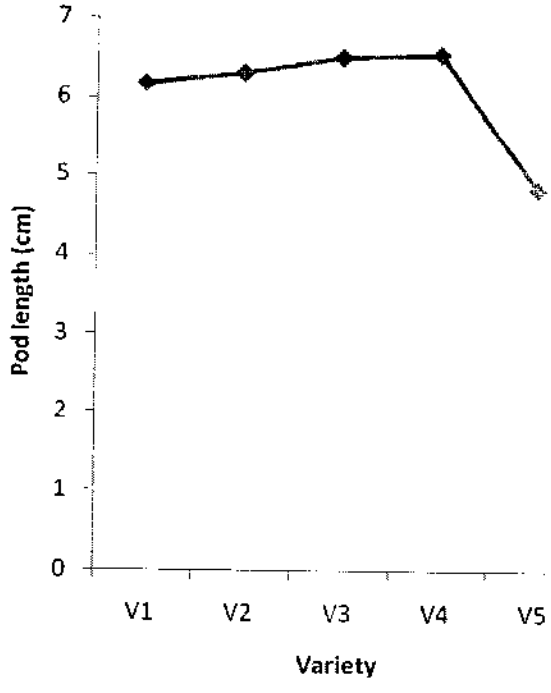

Fig 4.3.12 Effect of variety on pod length of mungbean in 2008

4.3.5 Seeds pod^{-1} of mungbean

Effect of tree species

Seeds pod^{-1} of mungbean was significantly influenced by the multipurpose tree species. In 2007, significantly the highest number of Seeds pod^{-1} (11.43) was recorded in T_1 (open field) followed by T_2 (10.74) and T_4 (10.58). Significantly the lowest number of seeds pod^{-1} (9.33) was recorded in T_3 (guava). In 2007, significantly the highest number of seeds pod^{-1} (10.85) was recorded in T_1 (open field) followed by T_2 (10.10) and T_4 (10.05). Significantly the lowest number of seeds pod^{-1} (8.71) was recorded in T_3 (guava).

Response of mungbean varieties

Seeds pod^{-1} of mungbean was also significantly varied by the varietal characteristics. In 2007, significantly the highest Seeds pod^{-1} (12.18) was recorded in V_4 followed by V_3 (11.52). V_3 was statistically similar to that of V_4 and V_2 (10.77). The lowest seeds pod^{-1} (7.95) was recorded in V_5. In 2008, significantly the highest seeds pod^{-1} (11.46) was recorded in V_4 followed by V_3 (10.79). The lowest seeds pod^{-1} (7.50) was recorded in V_5.

Interaction effect of tree species and mungbean variety on seeds pod^{-1}

Number of seeds pod^{-1} was highly affected by the interaction of tree and varieties. In 2007, significantly the highest number (13.47) of seeds pod^{-1} was counted in T_1V_4 combination followed by T_2V_4 (12.53) and T_1V_3 (12.53) combinations. T_3V_5 produced the least number of seed per pod (7.33). In 2008, highest number of seeds pod^{-1} was recorded in T_1V_4 (12.53) which was statistically similar to that of T_4V_4 (11.93) and T_1V_3 (11.9). T_3V_5 combination produced significantly the lowest number of seeds pod^{-1} (6.97). Other combinations produced the moderate number of seeds pod^{-1}. Pod length and number of seeds per pod were not well correlated indicating that besides pod length some other factors may also contribute to the number of seeds pod^{-1}. Such variability in pod length and number of seeds pod^{-1} of mungbean genotypes were also reported by Chowdhury *et al.* (1988), Ali and Sheikh (1987) and Khanum *et al.* (1982).

4.3.5 Seeds pod^{-1} of mungbean

Effect of tree species

Seeds pod^{-1} of mungbean was significantly influenced by the multipurpose tree species. In 2007, significantly the highest number of Seeds pod^{-1} (11.43) was recorded in T_1 (open field) followed by T_2 (10.74) and T_4 (10.58). Significantly the lowest number of seeds pod^{-1} (9.33) was recorded in T_3 (guava). In 2007, significantly the highest number of seeds pod^{-1} (10.85) was recorded in T_1 (open field) followed by T_2 (10.10) and T_4 (10.05). Significantly the lowest number of seeds pod^{-1} (8.71) was recorded in T_3 (guava).

Response of mungbean varieties

Seeds pod^{-1} of mungbean was also significantly varied by the varietal characteristics. In 2007, significantly the highest Seeds pod^{-1} (12.18) was recorded in V_4 followed by V_3 (11.52). V_3 was statistically similar to that of V_4 and V_2 (10.77). The lowest seeds pod^{-1} (7.95) was recorded in V_5. In 2008, significantly the highest seeds pod^{-1} (11.46) was recorded in V_4 followed by V_3 (10.79). The lowest seeds pod^{-1} (7.50) was recorded in V_5.

Interaction effect of tree species and mungbean variety on seeds pod^{-1}

Number of seeds pod^{-1} was highly affected by the interaction of tree and varieties. In 2007, significantly the highest number (13.47) of seeds pod^{-1} was counted in T_1V_4 combination followed by T_2V_4 (12.53) and T_1V_3 (12.53) combinations. T_3V_5 produced the least number of seed per pod (7.33). In 2008, highest number of seeds pod^{-1} was recorded in T_1V_4 (12.53) which was statistically similar to that of T_4V_4 (11.93) and T_1V_3 (11.9). T_3V_5 combination produced significantly the lowest number of seeds pod^{-1} (6.97). Other combinations produced the moderate number of seeds pod^{-1}. Pod length and number of seeds per pod were not well correlated indicating that besides pod length some other factors may also contribute to the number of seeds pod^{-1}. Such variability in pod length and number of seeds pod^{-1} of mungbean genotypes were also reported by Chowdhury *et al.* (1988), Ali and Sheikh (1987) and Khanum *et al.* (1982).

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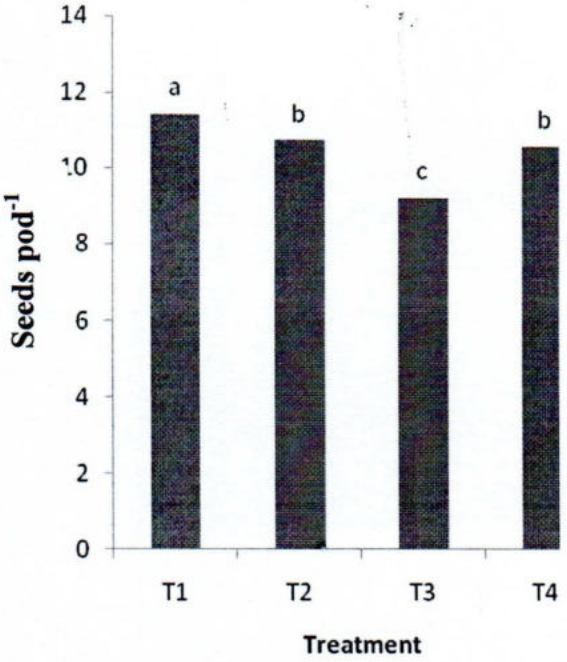


Fig 4.3.13 Effect of trees on seeds pod^{-1} of mungbean in 2007

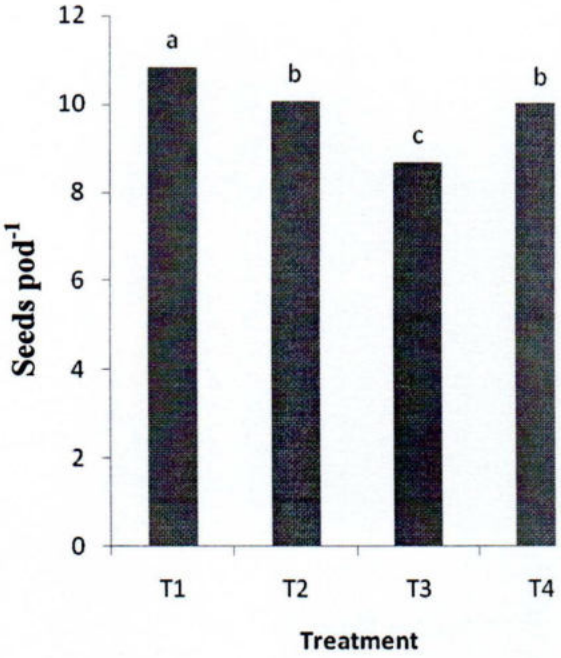


Fig 4.3.14 Effect of trees on seeds pod^{-1} of mungbean in 2008

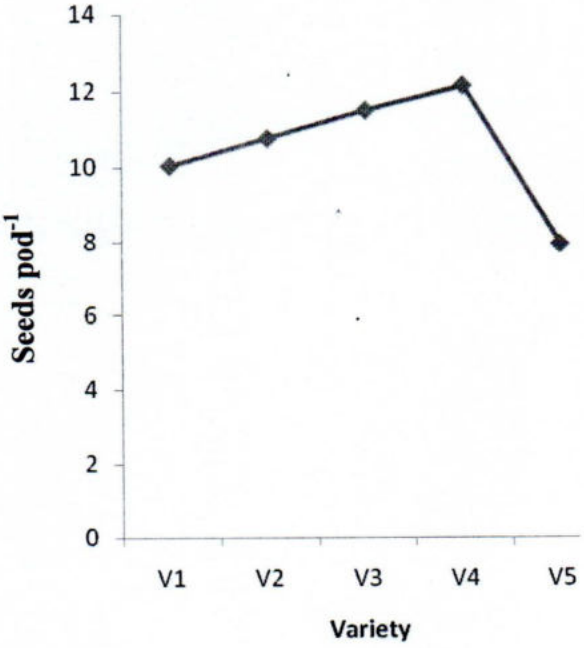


Fig 4.3.15 Effect of variety on seeds pod^{-1} of mungbean in 2007

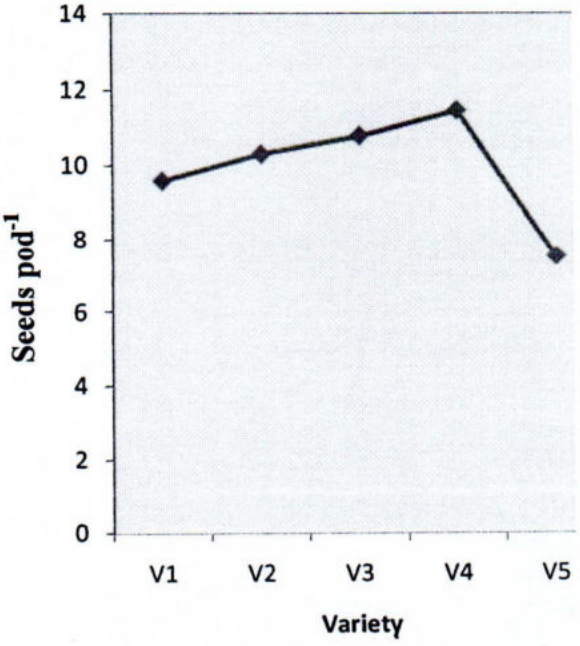
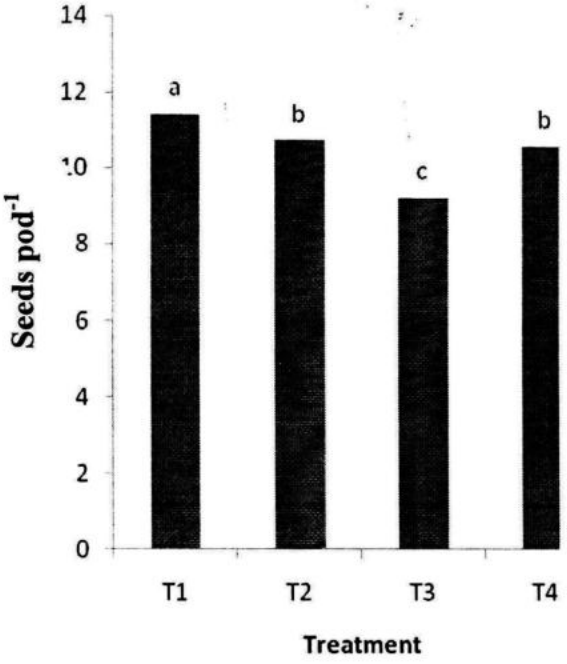


Fig 4.3.16 Effect of variety on seeds pod^{-1} of mungbean in 2008



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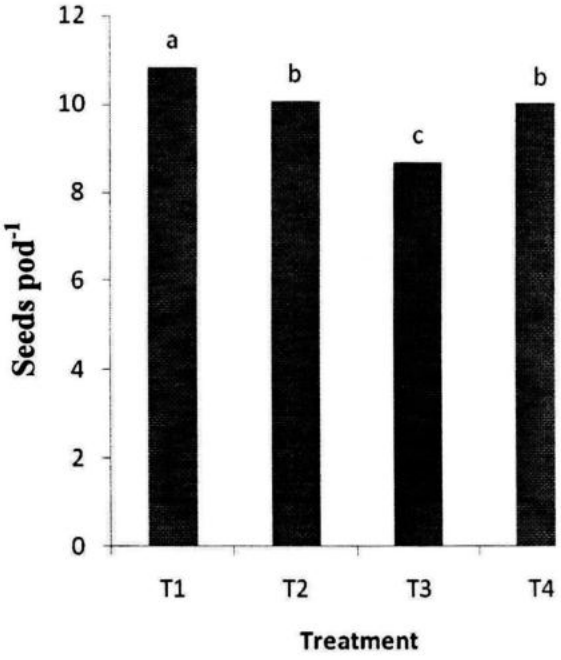

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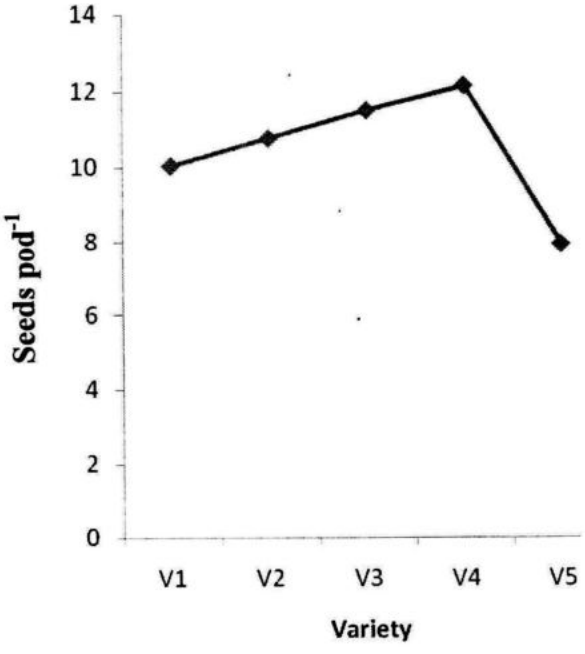

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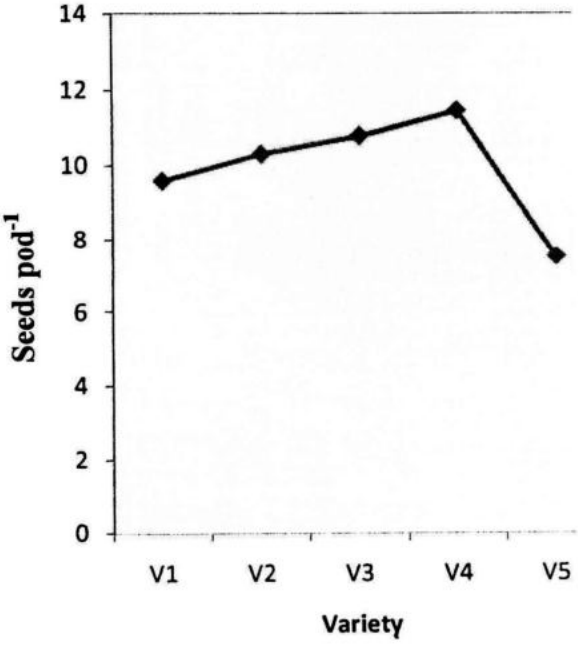


Fig 4.3.16 Effect of variety on seeds pod^{-1} of mungbean in 2008

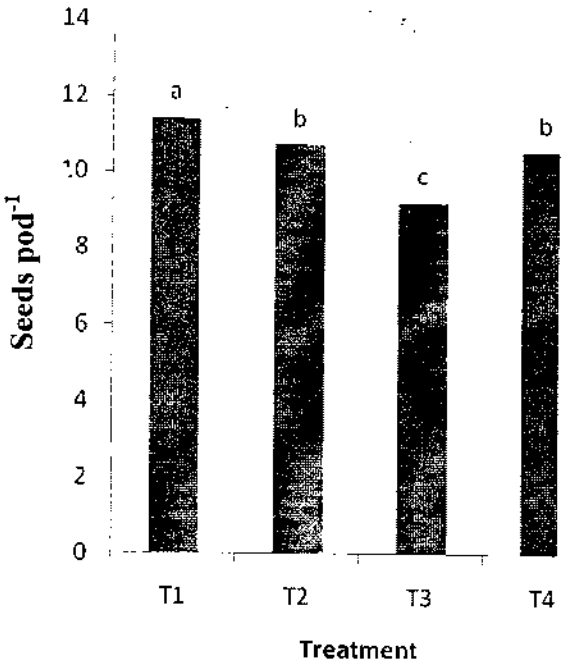
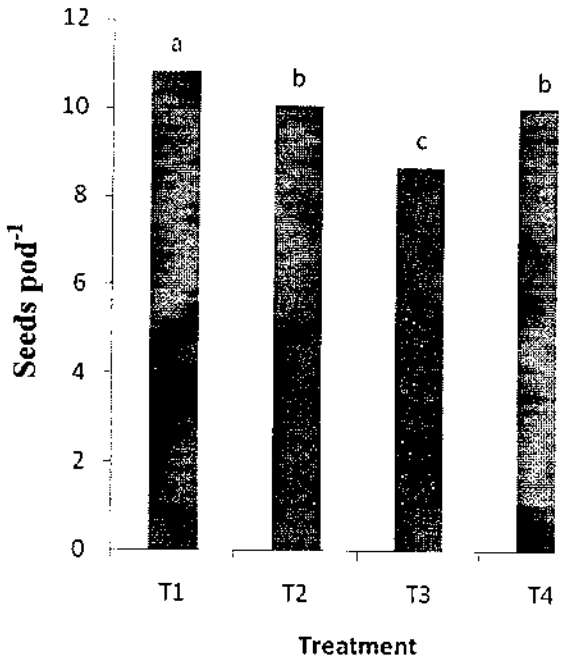


Fig 4.3.13 Effect of trees on seeds pod^{-1} of mungbean in 2007



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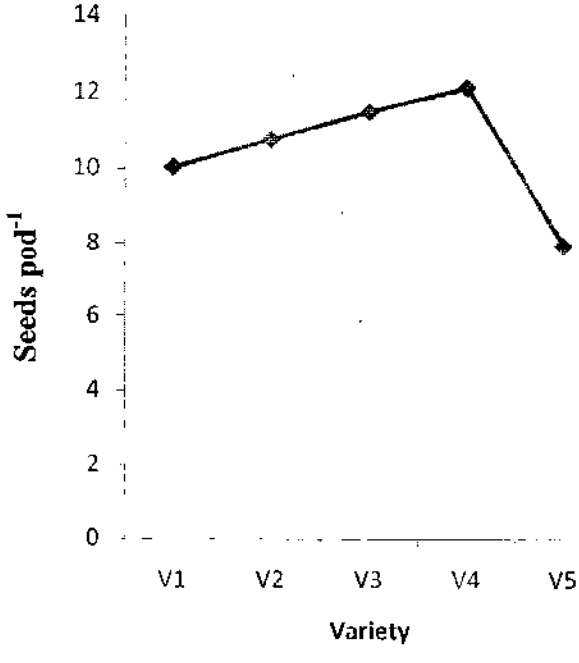

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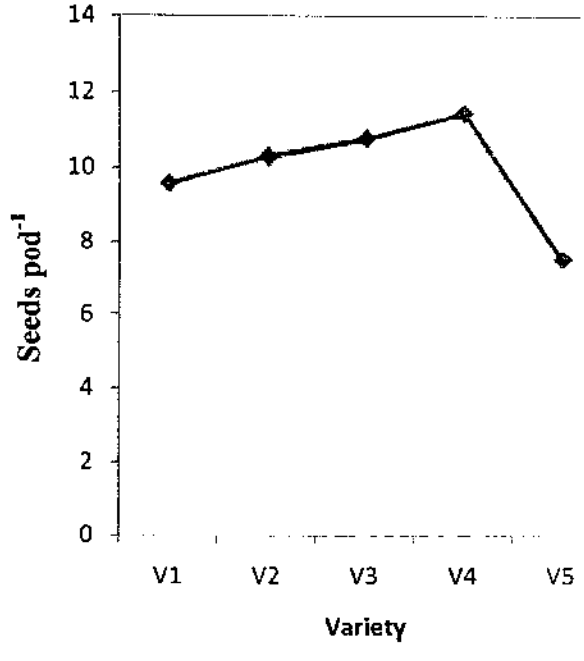

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4.3.6 Thousand seed weight

Effect of tree species

Thousand seed weight of mungbean was significantly influenced by the multipurpose tree species. In 2007, significantly the highest thousand seed weight (32.99 g) was recorded in T_1 (open field) followed by T_2 (31.71 g). T_4 produced (32.01 g) statistically identical weight of thousand seed to T_2. In 2008, significantly the highest thousand seed weight (32.63 g) was recorded in T_1 (open field) followed by T_2 (31.77 g). T_2 was statistically similar to that of T_1. Significantly the lowest thousand seed weight (28.27 g) was recorded in T_3.

Response of mungbean varieties

Thousand seed weight of mungbean was also significantly varied by the varietal characteristics. In 2007, significantly the highest thousand seed weight (48.24 g) was recorded in V_4 followed by V_3 (37.88 g). Significantly the lowest thousand seed weight (19.08 g) was recorded in V_5. In 2008, significantly the highest thousand seed weight (47.49 g) was recorded in V_4 followed by V_3 (37.58 g). Significantly the lowest thousand seed weight (18.58 g) was recorded in V_5.

Interaction effect of tree species and mungbean variety on thousand seed weight

Thousand seed weight of mungbean was affected by the combined effect of different tree species and varieties (Table 4.3.1). Among the five varieties, V_4 (BARI Mug 6) gave significantly higher 1000 seed weight in all treatment conditions in both cropping years. T_1V_4, T_2V_4, T_3V_4 and T_4V_4 produced highest but statistically same 1000 seed weight. Significantly the lowest 1000 seed weight was recorded in T_3V_5 combinations (18.57 and 17.67 g in 2007 and 2008, respectively). The result of 1000 seed weight revealed that BARI Mug 6 produced larger seed in all cases followed by BARI Mug 5 and the smallest seed was produced by local variety.

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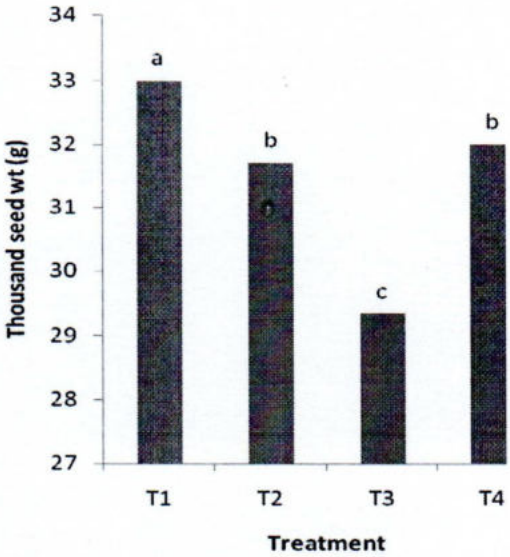


Fig 4.3.17 Effect of trees on thousand seed wt (g) of mungbean in 2007

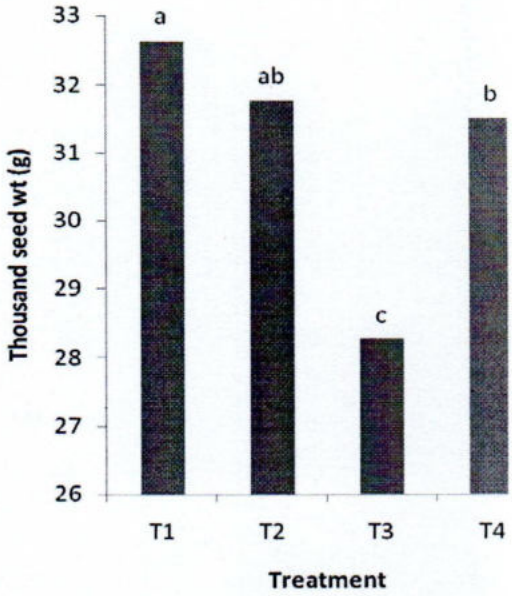


Fig 4.3.18 Effect of trees on thousand seed wt (g) of mungbean in 2008

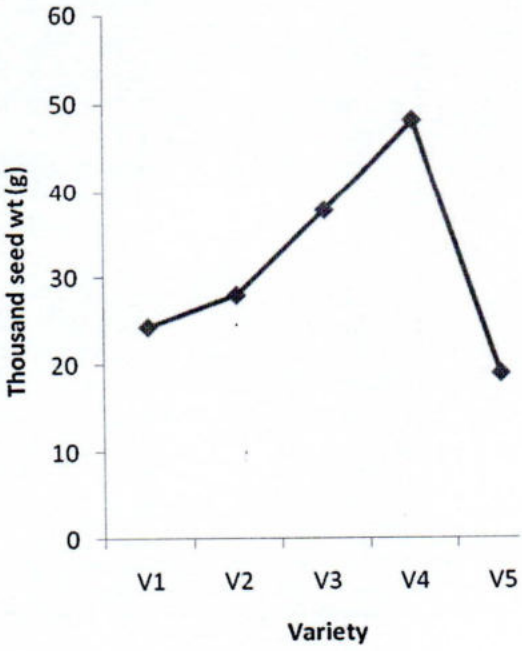


Fig 4.3.19 Effect of variety on thousand seed wt (g) of mungbean in 2007

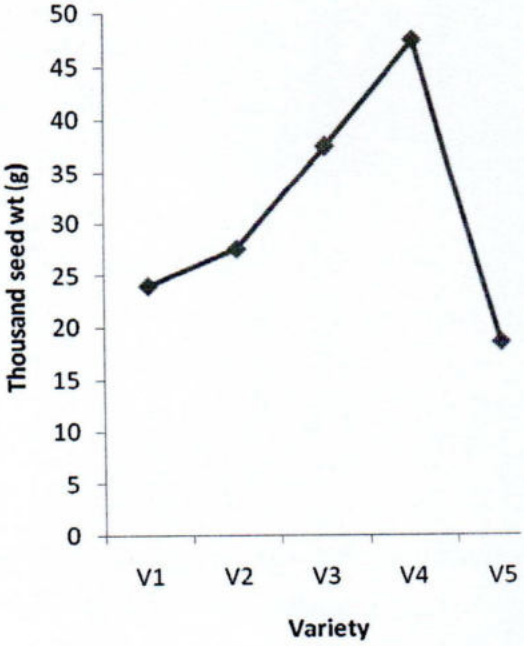
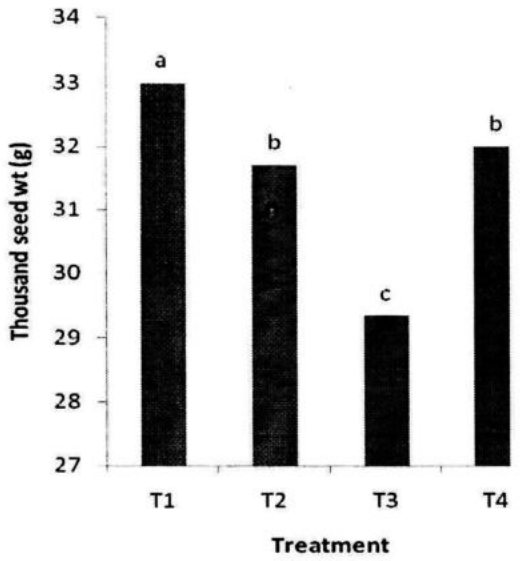


Fig 4.3.20 Effect of variety on thousand seed wt (g) of mungbean in 2008



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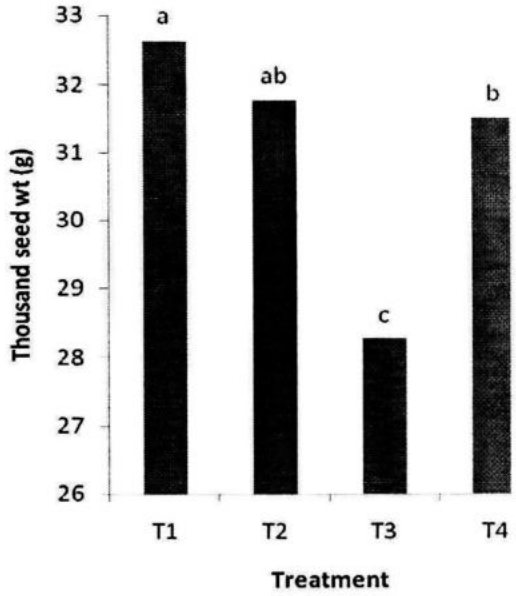


Fig 4.3.18 Effect of trees on thousand seed wt (g) of mungbean in 2008

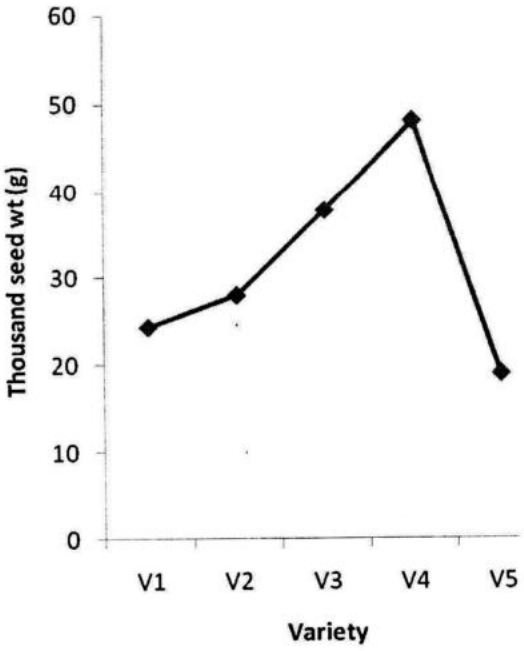


Fig 4.3.19 Effect of variety on thousand seed wt (g) of mungbean in 2007

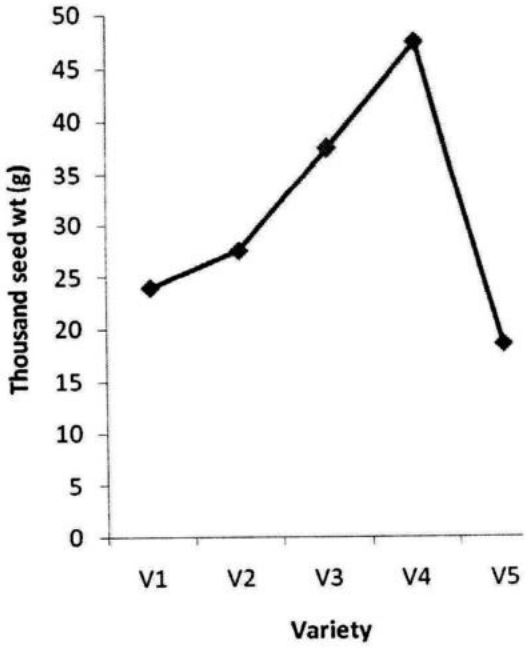
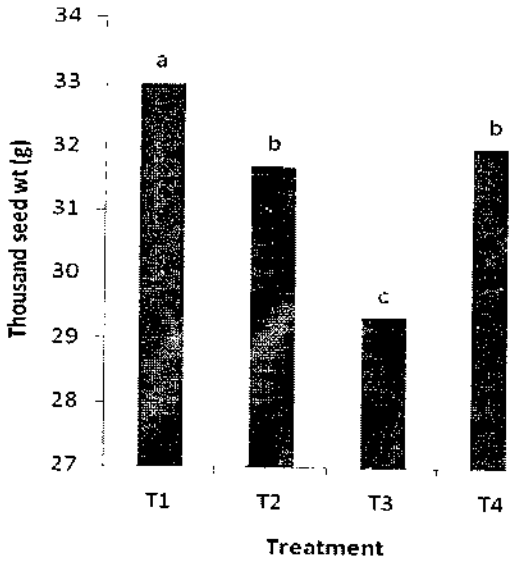


Fig 4.3.20 Effect of variety on thousand seed wt (g) of mungbean in 2008



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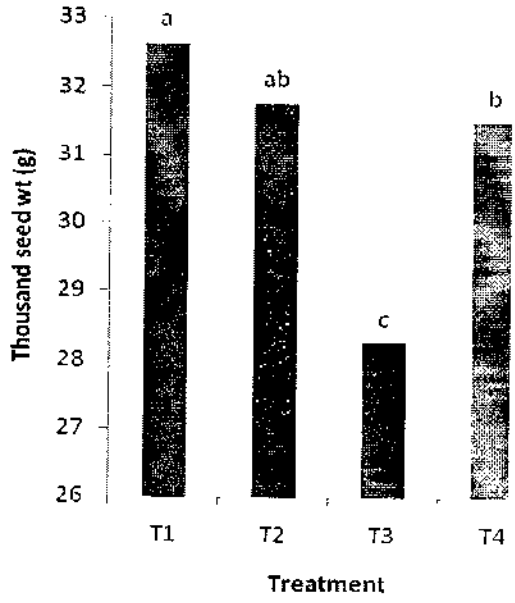

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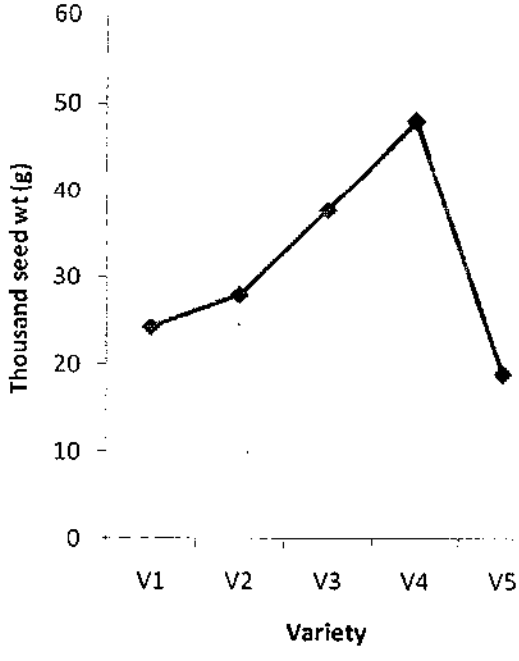

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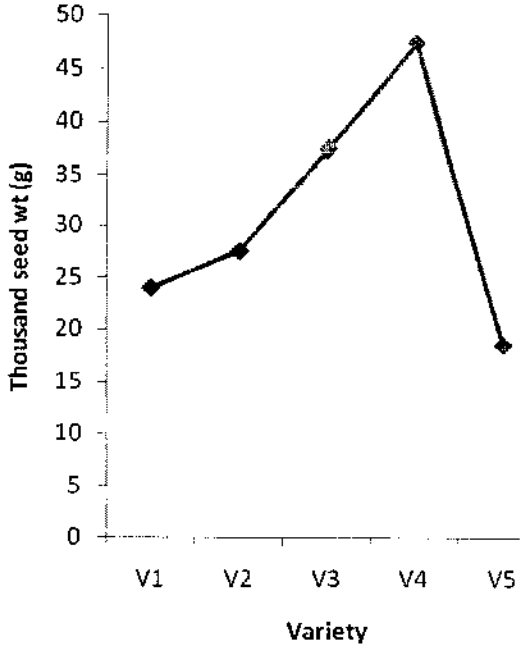

Fig 4.3.20 Effect of variety on thousand seed wt (g) of mungbean in 2008

4.3.7 Grain yield

Effect of tree species

Grain yield of mungbean varieties was greatly affected by the tree shades. The trend of variation of grain yield was almost similar in both the years. The highest grain yield was recorded in open field (1.08 and 1.2 t ha^{-1}in 2007 and 2008, respectively) which was statistically similar to that of T_2 (1.04 and 1.02 t ha^{-1}in 2007 and 2008, respectively). Significantly the lowest grain yield (0.8 and 0.52 t ha^{-1}in 2007 and 2008, respectively)

Response of mungbean varieties

There was significant difference among the varieties in ease of grain yield. V_4 (BARI Mug 6) always produced higher yield over other varieties in both the cropping seasons (1.34 and 1.45 t ha^{-1}in 2007 and 2008, respectively) which was statistically similar and closely followed byV_3 (BARI Mug 5). Significantly lowest grain yield (0.52 and 0.56 t ha^{-1}) was recorded for V_5. The moderate yield was recorded for V_1 and V_2 in both the cropping years.

Interaction effect of tree species and mungbean variety on grain yield

Grain yield of mungbean varieties was affected significantly by the different available light intensities of different MPTs. The obtained grain yield from different combinations showed that seed yield of mungbean varieties increased with the increase of light intensities allowed by different tree species irrespective of varieties (Table 4.3.2). In 2007, the highest grain yield (1.39 t ha^{-1}) was obtained from T_1V_4 (BARI Mug 6 in open field) which was statistically similar to those of T_1V_3 (1.27 t ha^{-1}). T_2V_3 (1.26 t ha^{-1}), T_2V_4 (1.35 t ha^{-1}), T_3V_3 (1.21 t ha^{-1}), T_3V_4 (1.25 t ha^{-1}), T_4V_3 (1.26 t ha^{-1}) and T_4V_4 (1.35 t ha^{-1}). Significantly the lowest yield (0.54 t ha^{-1}) was recorded in T_4V_5 combination (1.4 t/ha). In 2007, the highest yield was recorded for BARI Mug 6 in open field, which was statistically similar to that of T_1V_3 (1. t ha^{-1}), T_2V_4 (1.2 t ha^{-1}), T_2V_3 (1.12 t ha^{-1}) and T_4V_4 (1.01 t ha^{-1}). Significantly the lowest yield (0.25 t ha^{-1}) was recorded in T_3V_5 combination. The yield result indicated that V_4 (BARI Mug 6) was highly capable to produce higher yield over other varieties in each treatment conditions. Only V_4 grown under black siris and mango produced statistically similar yield to that of open field in 2nd year cropping. It proved that V_4 can be grown under different tree species ensuring upto 42.5% available light intensities (Appendix II) without significant yield loss. V_4

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Response of mungbean varieties

There was significant difference among the varieties in ease of grain yield. V_4 (BARI Mug 6) always produced higher yield over other varieties in both the cropping seasons (1.34 and 1.45 t ha^{-1}in 2007 and 2008, respectively) which was statistically similar and closely followed byV_3 (BARI Mug 5). Significantly lowest grain yield (0.52 and 0.56 t ha^{-1}) was recorded for V_5. The moderate yield was recorded for V_1 and V_2 in both the cropping years.

Interaction effect of tree species and mungbean variety on grain yield

Grain yield of mungbean varieties was affected significantly by the different available light intensities of different MPTs. The obtained grain yield from different combinations showed that seed yield of mungbean varieties increased with the increase of light intensities allowed by different tree species irrespective of varieties (Table 4.3.2). In 2007, the highest grain yield (1.39 t ha^{-1}) was obtained from T_1V_4 (BARI Mug 6 in open field) which was statistically similar to those of T_1V_3 (1.27 t ha^{-1}). T_2V_3 (1.26 t ha^{-1}), T_2V_4 (1.35 t ha^{-1}), T_3V_3 (1.21 t ha^{-1}), T_3V_4 (1.25 t ha^{-1}), T_4V_3 (1.26 t ha^{-1}) and T_4V_4 (1.35 t ha^{-1}). Significantly the lowest yield (0.54 t ha^{-1}) was recorded in T_4V_5 combination (1.4 t/ha). In 2007, the highest yield was recorded for BARI Mug 6 in open field, which was statistically similar to that of T_1V_3 (1. t ha^{-1}), T_2V_4 (1.2 t ha^{-1}), T_2V_3 (1.12 t ha^{-1}) and T_4V_4 (1.01 t ha^{-1}). Significantly the lowest yield (0.25 t ha^{-1}) was recorded in T_3V_5 combination. The yield result indicated that V_4 (BARI Mug 6) was highly capable to produce higher yield over other varieties in each treatment conditions. Only V_4 grown under black siris and mango produced statistically similar yield to that of open field in 2nd year cropping. It proved that V_4 can be grown under different tree species ensuring upto 42.5% available light intensities (Appendix II) without significant yield loss. V_4

(BARI Mug 6) closely followed by V_3 (BARI Mug 5). Under guava all varieties showed poor performance due to heaviest shade. The decrease in grain yield due to shading may be attributed to that decreased number of pods per plant. Lower seed yield of mungbean in shaded conditions was reported by Lantican and Catedral (1977) .The study revealed that seed yield obtained in this study was much higher than the national average seed yield (0.65 t ha^{-1}) irrespective of light level and varieties. Use of high yielding varieties and intensive management practices might have contributed such higher yield in this experiment.

Table 4.3.2. Interaction effect of tree species and mungbean variety on grain yield and incorporated fresh weight in 2007 and 2008

Treatment combination	Grain yield (t ha^{-1})		Incorporated fresh weight (t ha^{-1})	
	2007	2008	2007	2008
T_1V_1	0.87 b	0.91 b	6.23c	7.1ab
T_1V_2	0.92 b	0.96 b	8.5a	8.6a
T_1V_3	1.27 a	1.28 a	6.31c	6.9b
T_1V_4	1.39 a	1.4 a	7.02ab	6.7b
T_1V_5	0.56 bc	0.52 c	4.4d	4.5d
T_2V_1	0.86 b	0.84 b	6.42c	6.91b
T_2V_2	0.93 b	0.85 b	8.47a	7.02ab
T_2V_3	1.26 a	1.12 a	6.45c	6.82b
T_2V_4	1.35	1.2 a	7.21ab	6.5b
T_2V_5	0.55 bc	0. c	4.5d	4.3d
T_3V_1	0.84 b	0.51 c	6.0c	6.7b
T_3V_2	0.91 b	0.62 bc	7.5ab	6.9b
T_3V_3	1.21 a	0.81 b	6.01c	5.8bc
T_3V_4	1.25 a	0.82 b	6.0c	5.6c
T_3V_5	0.51 bc	0.25 f	4.1d	3.2e
T_4V_1	1.01 ab	0.81 b	6.3c	6.91d
T_4V_2	1.03 ab	0.825 b	8.01a	7.01ab
T_4V_3	1.26 a	0.96 b	6.4c	6.2b
T_4V_4	1.35 a	1.01 a	6.3c	5.8bc
T_4V_5	0.54 c	.35 d	4.5d	3.9e
CV%	6.56	4.28	8.90	7.26

T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

(BARI Mug 6) closely followed by V_3 (BARI Mug 5). Under guava all varieties showed poor performance due to heaviest shade. The decrease in grain yield due to shading may be attributed to that decreased number of pods per plant. Lower seed yield of mungbean in shaded conditions was reported by Lantican and Catedral (1977) .The study revealed that seed yield obtained in this study was much higher than the national average seed yield (0.65 t ha^{-1}) irrespective of light level and varieties. Use of high yielding varieties and intensive management practices might have contributed such higher yield in this experiment.

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T_1V_5	0.56 bc	0.52 c	4.4d	4.5d
T_2V_1	0.86 b	0.84 b	6.42c	6.91b
T_2V_2	0.93 b	0.85 b	8.47a	7.02ab
T_2V_3	1.26 a	1.12 a	6.45c	6.82b
T_2V_4	1.35	1.2 a	7.21ab	6.5b
T_2V_5	0.55 bc	0. c	4.5d	4.3d
T_3V_1	0.84 b	0.51 c	6.0c	6.7b
T_3V_2	0.91 b	0.62 bc	7.5ab	6.9b
T_3V_3	1.21 a	0.81 b	6.01c	5.8bc
T_3V_4	1.25 a	0.82 b	6.0c	5.6c
T_3V_5	0.51 bc	0.25 f	4.1d	3.2e
T_4V_1	1.01 ab	0.81 b	6.3c	6.91d
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T_4V_3	1.26 a	0.96 b	6.4c	6.2b
T_4V_4	1.35 a	1.01 a	6.3c	5.8bc
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T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

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4.3.8 Productivity Evaluation

Harvest index

In 2007, highest harvest index (17.65 %) was calculated for T_4V_4 combination followed by T_3V_4 (17.24%). The third highest HI was 16.75% found in both T_3V_3 and T_1V_3 combinations. On the other hand T_1V_4 produced the highest HI (17.28 %) in the following years (2008). In this year 2nd highest HI (15.64 %) was found in T_1V_3 and third highest HI (15.58%) was recorded in T_2V_4 followed by T_4V_4 (14.83 %). The HI study revealed that V_4 under mango can produced higher HI than that of three other (V_1, V_2 and V_5) varieties when grown in open field.

LER

Land equivalent ratio for different agroforestry systems varied differently by the varieties as well as cropping years. In 2006, highest LER was recorded for guava based agroforestry system (2.1-2.17%) except T_3V_4 combination (2.08) followed by black siris based agroforestry system (1.09-2.13%). Mango based system produced lowest LER and the range was 1.83-2.03%. In 2007, maximum LER was recorded in mango based system (5.22-5.44%) which was followed by black siris based system (2.29-2.39%) in this year guava based system produced lowest LER and the range was 1.75-1.91%.

The following year (2008) highest LER from mango based system due to higher increment of mango tree in agroforestry system than sole tree production and this ratio (Ti/Ts) although grain yield ratio of mung bean varieties between agroforestry and sole cropping was 0.87. The result proved that effect of under storey crops on the increment of trees was found higher in mango followed by black siris and then guava.

Economic evaluation

The highest BCR was recorded for T_1V_4 combination (BARI Mug 6 in open field) in both the cropping years (1.84 and 1.85 in 2007 and 2008 respectively) followed by T_4V_4 (BARI Mug 6 in mango). BARI Mug 6 always found profitable over other varieties in each treatment combination, followed by BARI Mug 5. Local variety (V_5) always gave negative net return as well as poor BCR (<1) in both the cropping years irrespective of treatment combinations. The study revealed that BARI Mug 6 was more profitable grown under mango (BCR was 1.33) than the variety BARI Mug 3 and BARI Mug 4 grown in open field (BCR values 1.2 and 1.27, respectively)

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Table 4.3.3. Productivity evaluation through harvest index and land equivalent ratio of mungbean in agroforestry practice in 2007 and 2008

Treatment Combination	Grain yield (t/ha)		Fresh yield ($t\ ha^{-1}$)		Biological yield ($t\ ha^{-1}$)		Harvest index (%)		Ci/Cs		Ti/Ts		LER	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1V_1	0.87	0.91	6.23	7.1	7.1	8.01	12.25	11.36	-	-	-	-	-	-
T_1V_2	0.92	0.96	8.5	8.6	9.42	9.56	9.76	10.04	-	-	-	-	-	-
T_1V_3	1.27	1.28	6.31	6.9	7.58	8.18	16.75	15.64	-	-	-	-	-	-
T_1V_4	1.39	1.4	7.02	6.7	8.41	8.1	16.52	17.28	-	-	-	-	-	-
T_1V_5	0.56	0.52	4.4	4.5	4.96	5.02	11.29	10.35	-	-	-	-	-	-
T_2V_1	0.86	0.84	6.42	6.91	7.28	7.75	11.81	10.83	0.98	0.92	1.12	1.43	2.1	2.35
T_2V_2	0.93	0.85	8.67	7.02	9.6	7.87	9.68	10.80	1.01	0.88	1.12	1.43	2.13	2.31
T_2V_3	1.26	1.12	6.45	6.82	7.71	7.94	16.34	14.11	0.99	0.88	1.12	1.43	2.11	2.31
T_2V_4	1.35	1.2	7.21	6.5	8.56	7.7	15.77	15.58	0.97	0.86	1.12	1.43	2.09	2.29
T_2V_5	0.55	0.5	4.5	4.3	5.05	4.8	10.89	10.42	0.98	0.96	1.12	1.43	2.1	2.39
T_3V_1	0.84	0.51	6.0	6.7	6.84	7.21	12.28	7.07	0.96	0.56	1.19	1.27	2.15	1.83
T_3V_2	0.91	0.62	7.5	6.9	8.41	7.52	10.82	8.24	0.98	0.64	1.19	1.27	2.17	1.91
T_3V_3	1.21	0.81	6.01	5.8	7.22	6.61	16.75	12.25	0.95	0.63	1.19	1.27	2.14	1.9
T_3V_4	1.25	0.82	6.0	5.6	7.25	6.42	17.24	12.77	0.89	0.58	1.19	1.27	2.08	1.85
T_3V_5	0.51	0.25	4.1	3.2	4.61	3.45	11.07	7.24	0.91	0.48	1.19	1.27	2.1	1.75
T_4V_1	1.01	0.81	6.3	6.91	7.31	7.72	13.82	10.49	1.16	0.89	0.87	4.55	2.03	5.44
T_4V_2	1.03	0.825	8.01	7.1	9.04	7.925	11.39	10.41	1.11	0.85	0.87	4.55	1.98	5.4
T_4V_3	1.26	0.96	6.4	6.2	7.66	7.16	16.45	13.40	0.99	0.75	0.87	4.55	1.86	5.3
T_4V_4	1.35	1.01	6.3	5.8	7.65	6.81	17.65	14.83	0.97	0.72	0.87	4.55	1.84	5.27
T_4V_5	0.54	0.35	4.5	3.9	5.04	4.25	10.71	8.24	0.96	0.67	0.87	4.55	1.83	5.22

T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

Table 4.3.3. Productivity evaluation through harvest index and land equivalent ratio of mungbean in agroforestry practice in 2007 and 2008

Treatment Combination	Grain yield (t/ha)		Fresh yield ($t\ ha^{-1}$)		Biological yield ($t\ ha^{-1}$)		Harvest index (%)		Ci/Cs		Ti/Ts		LER	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1V_1	0.87	0.91	6.23	7.1	7.1	8.01	12.25	11.36	-	-	-	-	-	-
T_1V_2	0.92	0.96	8.5	8.6	9.42	9.56	9.76	10.04	-	-	-	-	-	-
T_1V_3	1.27	1.28	6.31	6.9	7.58	8.18	16.75	15.64	-	-	-	-	-	-
T_1V_4	1.39	1.4	7.02	6.7	8.41	8.1	16.52	17.28	-	-	-	-	-	-
T_1V_5	0.56	0.52	4.4	4.5	4.96	5.02	11.29	10.35	-	-	-	-	-	-
T_2V_1	0.86	0.84	6.42	6.91	7.28	7.75	11.81	10.83	0.98	0.92	1.12	1.43	2.1	2.35
T_2V_2	0.93	0.85	8.67	7.02	9.6	7.87	9.68	10.80	1.01	0.88	1.12	1.43	2.13	2.31
T_2V_3	1.26	1.12	6.45	6.82	7.71	7.94	16.34	14.11	0.99	0.88	1.12	1.43	2.11	2.31
T_2V_4	1.35	1.2	7.21	6.5	8.56	7.7	15.77	15.58	0.97	0.86	1.12	1.43	2.09	2.29
T_2V_5	0.55	0.5	4.5	4.3	5.05	4.8	10.89	10.42	0.98	0.96	1.12	1.43	2.1	2.39
T_3V_1	0.84	0.51	6.0	6.7	6.84	7.21	12.28	7.07	0.96	0.56	1.19	1.27	2.15	1.83
T_3V_2	0.91	0.62	7.5	6.9	8.41	7.52	10.82	8.24	0.98	0.64	1.19	1.27	2.17	1.91
T_3V_3	1.21	0.81	6.01	5.8	7.22	6.61	16.75	12.25	0.95	0.63	1.19	1.27	2.14	1.9
T_3V_4	1.25	0.82	6.0	5.6	7.25	6.42	17.24	12.77	0.89	0.58	1.19	1.27	2.08	1.85
T_3V_5	0.51	0.25	4.1	3.2	4.61	3.45	11.07	7.24	0.91	0.48	1.19	1.27	2.1	1.75
T_4V_1	1.01	0.81	6.3	6.91	7.31	7.72	13.82	10.49	1.16	0.89	0.87	4.55	2.03	5.44
T_4V_2	1.03	0.825	8.01	7.1	9.04	7.925	11.39	10.41	1.11	0.85	0.87	4.55	1.98	5.4
T_4V_3	1.26	0.96	6.4	6.2	7.66	7.16	16.45	13.40	0.99	0.75	0.87	4.55	1.86	5.3
T_4V_4	1.35	1.01	6.3	5.8	7.65	6.81	17.65	14.83	0.97	0.72	0.87	4.55	1.84	5.27
T_4V_5	0.54	0.35	4.5	3.9	5.04	4.25	10.71	8.24	0.96	0.67	0.87	4.55	1.83	5.22

T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

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	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1V_1	0.87	0.91	6.23	7.1	7.1	8.01	12.25	11.36	-	-	-	-	-	-
T_1V_2	0.92	0.96	8.5	8.6	9.42	9.56	9.76	10.04	-	-	-	-	-	-
T_1V_3	1.27	1.28	6.31	6.9	7.58	8.18	16.75	15.64	-	-	-	-	-	-
T_1V_4	1.39	1.4	7.02	6.7	8.41	8.1	16.52	17.28	-	-	-	-	-	-
T_1V_5	0.56	0.52	4.4	4.5	4.96	5.02	11.29	10.35	-	-	-	-	-	-
T_2V_1	0.86	0.84	6.42	6.91	7.28	7.75	11.81	10.83	0.98	0.92	1.12	1.43	2.1	2.35
T_2V_2	0.93	0.85	8.67	7.02	9.6	7.87	9.68	10.80	1.01	0.88	1.12	1.43	2.13	2.31
T_2V_3	1.26	1.12	6.45	6.82	7.71	7.94	16.34	14.11	0.99	0.88	1.12	1.43	2.11	2.31
T_2V_4	1.35	1.2	7.21	6.5	8.56	7.7	15.77	15.58	0.97	0.86	1.12	1.43	2.09	2.29
T_2V_5	0.55	0.5	4.5	4.3	5.05	4.8	10.89	10.42	0.98	0.96	1.12	1.43	2.1	2.39
T_3V_1	0.84	0.51	6.0	6.7	6.84	7.21	12.28	7.07	0.96	0.56	1.19	1.27	2.15	1.83
T_3V_2	0.91	0.62	7.5	6.9	8.41	7.52	10.82	8.24	0.98	0.64	1.19	1.27	2.17	1.91
T_3V_3	1.21	0.81	6.01	5.8	7.22	6.61	16.75	12.25	0.95	0.63	1.19	1.27	2.14	1.9
T_3V_4	1.25	0.82	6.0	5.6	7.25	6.42	17.24	12.77	0.89	0.58	1.19	1.27	2.08	1.85
T_3V_5	0.51	0.25	4.1	3.2	4.61	3.45	11.07	7.24	0.91	0.48	1.19	1.27	2.1	1.75
T_4V_1	1.01	0.81	6.3	6.91	7.31	7.72	13.82	10.49	1.16	0.89	0.87	4.55	2.03	5.44
T_4V_2	1.03	0.825	8.01	7.1	9.04	7.925	11.39	10.41	1.11	0.85	0.87	4.55	1.98	5.4
T_4V_3	1.26	0.96	6.4	6.2	7.66	7.16	16.45	13.40	0.99	0.75	0.87	4.55	1.86	5.3
T_4V_4	1.35	1.01	6.3	5.8	7.65	6.81	17.65	14.83	0.97	0.72	0.87	4.55	1.84	5.27
T_4V_5	0.54	0.35	4.5	3.9	5.04	4.25	10.71	8.24	0.96	0.67	0.87	4.55	1.83	5.22

T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

Table 4.3.4. Economic evaluation through BCR of mungbean in agroforestry practice in 2007 and 2008

Treatment Combination	Total cost of production (Tk ha^{-1})		Gross return (Tk ha^{-1})		Net return (Tk ha^{-1})		BCR	
	2007	2008	2007	2008	2007	2008	2007	2008
T_1V_1	22703	22703	26100	27300	3397	4597	1.15	1.20
T_1V_2	22703	22703	27600	28800	4897	6097	1.22	1.27
T_1V_3	22703	22703	38100	38400	15397	15697	1.68	1.69
T_1V_4	22703	22703	41700	42000	18997	19297	1.84	1.85
T_1V_5	22703	22703	16800	15600	-5903	-7103	0.74	0.69
T_2V_1	22703	22703	25800	25200	3097	2497	1.14	1.11
T_2V_2	22703	22703	27900	25500	5197	2797	1.23	1.12
T_2V_3	22703	22703	37800	33600	15097	10897	1.66	1.48
T_2V_4	22703	22703	40500	36000	17797	13297	1.78	1.59
T_2V_5	22703	22703	16500	15000	-6203	-7703	0.73	0.66
T_3V_1	22703	22703	25200	15300	2497	-7403	1.11	0.67
T_3V_2	22703	22703	27300	18600	4597	-4103	1.20	0.82
T_3V_3	22703	22703	36300	24300	13597	1597	1.60	1.07
T_3V_4	22703	22703	37500	24600	14797	1897	1.65	1.08
T_3V_5	22703	22703	15300	7500	-7403	-15203	0.67	0.33
T_4V_1	22703	22703	30300	24300	7597	1597	1.33	1.07
T_4V_2	22703	22703	30900	24750	8197	2047	1.36	1.09
T_4V_3	22703	22703	37800	28800	15097	6097	1.66	1.27
T_4V_4	22703	22703	40500	30300	17797	7597	1.78	1.33
T_4V_5	22703	22703	16200	10500	-6503	-12203	0.71	0.46

T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

Table 4.3.4. Economic evaluation through BCR of mungbean in agroforestry practice in 2007 and 2008

Treatment Combination	Total cost of production (Tk ha^{-1})		Gross return (Tk ha^{-1})		Net return (Tk ha^{-1})		BCR	
	2007	2008	2007	2008	2007	2008	2007	2008
T_1V_1	22703	22703	26100	27300	3397	4597	1.15	1.20
T_1V_2	22703	22703	27600	28800	4897	6097	1.22	1.27
T_1V_3	22703	22703	38100	38400	15397	15697	1.68	1.69
T_1V_4	22703	22703	41700	42000	18997	19297	1.84	1.85
T_1V_5	22703	22703	16800	15600	-5903	-7103	0.74	0.69
T_2V_1	22703	22703	25800	25200	3097	2497	1.14	1.11
T_2V_2	22703	22703	27900	25500	5197	2797	1.23	1.12
T_2V_3	22703	22703	37800	33600	15097	10897	1.66	1.48
T_2V_4	22703	22703	40500	36000	17797	13297	1.78	1.59
T_2V_5	22703	22703	16500	15000	-6203	-7703	0.73	0.66
T_3V_1	22703	22703	25200	15300	2497	-7403	1.11	0.67
T_3V_2	22703	22703	27300	18600	4597	-4103	1.20	0.82
T_3V_3	22703	22703	36300	24300	13597	1597	1.60	1.07
T_3V_4	22703	22703	37500	24600	14797	1897	1.65	1.08
T_3V_5	22703	22703	15300	7500	-7403	-15203	0.67	0.33
T_4V_1	22703	22703	30300	24300	7597	1597	1.33	1.07
T_4V_2	22703	22703	30900	24750	8197	2047	1.36	1.09
T_4V_3	22703	22703	37800	28800	15097	6097	1.66	1.27
T_4V_4	22703	22703	40500	30300	17797	7597	1.78	1.33
T_4V_5	22703	22703	16200	10500	-6503	-12203	0.71	0.46

T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

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Treatment Combination	Total cost of production (Tk ha^{-1})		Gross return (Tk ha^{-1})		Net return (Tk ha^{-1})		BCR	
	2007	2008	2007	2008	2007	2008	2007	2008
T_1V_1	22703	22703	26100	27300	3397	4597	1.15	1.20
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T_1V_5	22703	22703	16800	15600	-5903	-7103	0.74	0.69
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T_2V_2	22703	22703	27900	25500	5197	2797	1.23	1.12
T_2V_3	22703	22703	37800	33600	15097	10897	1.66	1.48
T_2V_4	22703	22703	40500	36000	17797	13297	1.78	1.59
T_2V_5	22703	22703	16500	15000	-6203	-7703	0.73	0.66
T_3V_1	22703	22703	25200	15300	2497	-7403	1.11	0.67
T_3V_2	22703	22703	27300	18600	4597	-4103	1.20	0.82
T_3V_3	22703	22703	36300	24300	13597	1597	1.60	1.07
T_3V_4	22703	22703	37500	24600	14797	1897	1.65	1.08
T_3V_5	22703	22703	15300	7500	-7403	-15203	0.67	0.33
T_4V_1	22703	22703	30300	24300	7597	1597	1.33	1.07
T_4V_2	22703	22703	30900	24750	8197	2047	1.36	1.09
T_4V_3	22703	22703	37800	28800	15097	6097	1.66	1.27
T_4V_4	22703	22703	40500	30300	17797	7597	1.78	1.33
T_4V_5	22703	22703	16200	10500	-6503	-12203	0.71	0.46

T_1 = Open field (control), T_2 = Black siris, T_3 = Guava, T_4 = Mango, V_1 = BARI Mug 3 (Progati), V_2 = BARI Mug 4 (Rupsa), V_3 = BARI Mug 5(Taiwan), V_4= BARI Mug 6 and V_5= Local variety

T_1

T_2

T_3

T_4

Plate 4.3.1. Different mungbean varieties were shown in different treatment at 30 DAS (T_1= open field, T_2= Under black siris, T_3= Under guava and T_4= Under mango)

T_1

T_2

T_3

T_4

Plate 4.3.1. Different mungbean varieties were shown in different treatment at 30 DAS (T_1= open field, T_2= Under black siris, T_3= Under guava and T_4= Under mango)

T_1

T_2

T_3

T_4

Plate 4.3.1. Different mungbean varieties were shown in different treatment at 30 DAS (T_1= open field, T_2= Under black siris, T_3= Under guava and T_4= Under mango)

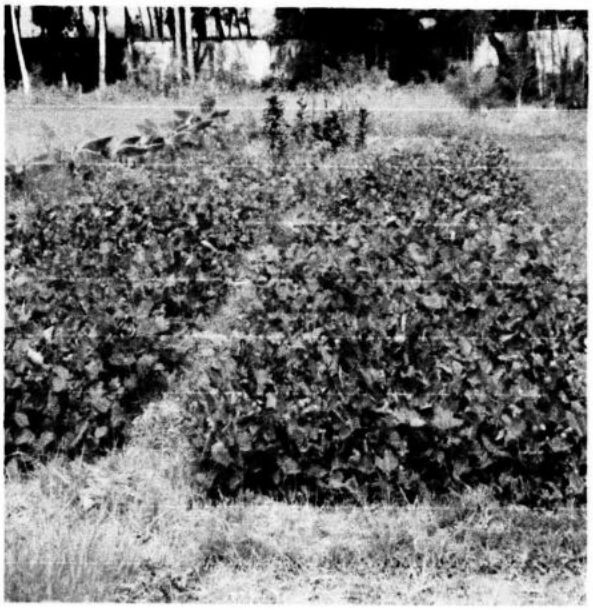
T_1

T_2

T_3

T_4

Plate 4.3.2. Different mungbean varieties were shown in different treatment at 45 DAS (T_1 = open field, T_2 = Under black siris, T_3 = Under guava and T_4 = Under mango)



T_1

T_2

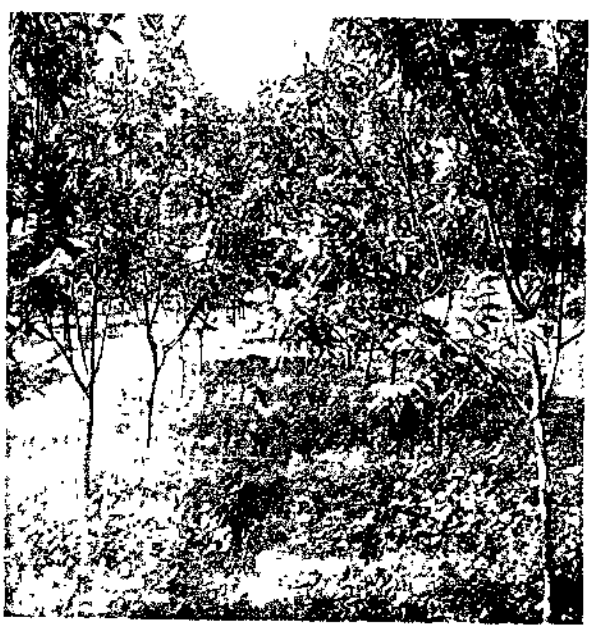
T_3

T_4

Plate 4.3.2. Different mungbean varieties were shown in different treatment at 45 DAS (T_1 = open field, T_2 = Under black siris, T_3 = Under guava and T_4 = Under mango)

T_1

T_2



T_3

T_4

Plate 4.3.2. Different mungbean varieties were shown in different treatment at 45 DAS

(T_1 = open field, T_2 = Under black siris, T_3 = Under guava and T_4 = Under mango)

T_4

T_2

T_3

T_4

Plate 4.3.3. Different mungbean varieties were shown in different treatment at 65 DAS (T_2= Under black siris, T_3= Under guava and T_4= Under mango)

T_4

T_2

T_3

T_4

Plate 4.3.3. Different mungbean varieties were shown in different treatment at 65 DAS (T_2= Under black siris, T_3= Under guava and T_4= Under mango)

T_4

T_2

T_3

T_4

Plate 4.3.3. Different mungbean varieties were shown in different treatment at 65 DAS (T_2= Under black siris, T_3= Under guava and T_4= Under mango)

Experiment # 4: Performance of Banana in Different Agroforestry Systems

Performance of banana was studied as middle storied crop of multistoried agroforestry systems. Various responses of different parameter of banana are due to combined effect of partial shade provided by different MPTs and bellow ground interactions among the components which are discussed below-

4.4.1 Plant height

The plant height of banana was significantly influenced by different tree crop combinations in both the cropping seasons (Table 4.4.1). In 2006, significantly the highest plant height was (2.76 m) recorded in T_1 (Sole banana) followed by T_2 (Banana with Potato – Onion) which ware statistically similar to that of all other treatments except T_5 (Banana with Ipil-ipil + Potato - Onion). T_5 produced significantly lowest plant height (2.47 m). In 2007, the highest plant height (2.5m) was also recorded in T_1 which was identical to T_2 (2.47m). Significantly the lowest plant height (2.15m) was recorded in T_6 (Banana with Goraneem + Potato – onion). The plant height found in T_4 (Banana with Gora neem), T_3 (Banana with Ipil-ipil) and T_5 were statistically similar to that of T_6. From the above result it is clear that partial shades and bellow ground interactions have significant effect on plant height of banana. In T_2 and T_1 there ware no tree species, that's why they produce the tallest plant. It may be due to use of Raton sucker. Hossain *et al.* (2007) found similar plant height of Banana (1.92 – 2.45m) in coconut based agroforestry system.

4.4.2 Base girth

Base girth of Banana plant was also significantly influenced by the different agroforestry systems (Table 4.4.1) in both the cropping seasons. In 2006, significantly highest base girth (57.92cm) was found in T_1 (sole banana) which was statistically similar to that of T_2 (55.83cm). Significantly lowest value of base girth (50.67cm) was found in T_4 which was quite identical to T_3 (51.50 cm), moderate base girth were found in T_6 and T_5 ,the values were 53.17 cm and 53.33 cm respectively which were also statistically identical. In 2007 the highest value of base girth was recorded in T_1 (54.50 cm) which was statistically similar to that of T_2 (52.83cm). Significantly the lowest base girth was recorded in T_6 (46.83). T_4, T_3 and T_5 produced the plant possessing base girth of 48.67, 49.83 and 49.00 cm, respectively which ware statistically similar.

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Table 4.4.1 Growth performance of banana in different agroforestry systems.

Treatments	Plant height(m)		Base girth(cm)		No. of leaf		Leaf length(cm)		Leaf breath(cm)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1	2.76a	2.50a	57.92a	54.50a	11.33a	9.50a	161.0a	147.80a	62.33a	59.17a
T_2	2.63ab	2.47a	55.83ab	52.83ab	11.17ab	8.67ab	160.0a	141.30ab	61.00a	55.67ab
T_3	2.57ab	2.40ab	51.50c	49.83bc	9.50abc	8.00bc	141.3c	135.0bc	50.33bc	55.33ab
T_4	2.57ab	2.32ab	50.67c	48.67bc	9.17bc	7.50c	141.3c	128.30c	49.33c	50.83bc
T_5	2.47b	2.30ab	53.33bc	49.00bc	9.00c	7.33c	156.0ab	125.20c	53.00b	49.83bc
T_6	2.52ab	2.15b	52.17bc	46.83c	9.67abc	7.00c	153.7b	125.30c	53.00b	48.33c
CV%	0.287	3.77	2.77	2.96	7.19	4.97	1.42	3.15	2.21	4.13

T_1 = Sole banana, T_2 = Banana with Potato - Onion, T_3 = Banana with Ipil-ipil, T_4 = Banana with Goraneem,

T_5 = Banana with Ipil-ipil + Potato - Onion, T_6 =. Banana with Goraneem + Potato - onion

Table 4.4.1 Growth performance of banana in different agroforestry systems.

Treatments	Plant height(m)		Base girth(cm)		No. of leaf		Leaf length(cm)		Leaf breath(cm)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1	2.76a	2.50a	57.92a	54.50a	11.33a	9.50a	161.0a	147.80a	62.33a	59.17a
T_2	2.63ab	2.47a	55.83ab	52.83ab	11.17ab	8.67ab	160.0a	141.30ab	61.00a	55.67ab
T_3	2.57ab	2.40ab	51.50c	49.83bc	9.50abc	8.00bc	141.3c	135.0bc	50.33bc	55.33ab
T_4	2.57ab	2.32ab	50.67c	48.67bc	9.17bc	7.50c	141.3c	128.30c	49.33c	50.83bc
T_5	2.47b	2.30ab	53.33bc	49.00bc	9.00c	7.33c	156.0ab	125.20c	53.00b	49.83bc
T_6	2.52ab	2.15b	52.17bc	46.83c	9.67abc	7.00c	153.7b	125.30c	53.00b	48.33c
CV%	0.287	3.77	2.77	2.96	7.19	4.97	1.42	3.15	2.21	4.13

T_1 = Sole banana, T_2 = Banana with Potato - Onion, T_3 = Banana with Ipil-ipil, T_4 = Banana with Goraneem,

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	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1	2.76a	2.50a	57.92a	54.50a	11.33a	9.50a	161.0a	147.80a	62.33a	59.17a
T_2	2.63ab	2.47a	55.83ab	52.83ab	11.17ab	8.67ab	160.0a	141.30ab	61.00a	55.67ab
T_3	2.57ab	2.40ab	51.50c	49.83bc	9.50abc	8.00bc	141.3c	135.0bc	50.33bc	55.33ab
T_4	2.57ab	2.32ab	50.67c	48.67bc	9.17bc	7.50c	141.3c	128.30c	49.33c	50.83bc
T_5	2.47b	2.30ab	53.33bc	49.00bc	9.00c	7.33c	156.0ab	125.20c	53.00b	49.83bc
T_6	2.52ab	2.15b	52.17bc	46.83c	9.67abc	7.00c	153.7b	125.30c	53.00b	48.33c
CV%	0.287	3.77	2.77	2.96	7.19	4.97	1.42	3.15	2.21	4.13

T_1 = Sole banana, T_2 = Banana with Potato - Onion, T_3 = Banana with Ipil-ipil, T_4 = Banana with Goraneem, T_5 = Banana with Ipil-ipil + Potato - Onion, T_6 =. Banana with Goraneem + Potato - onion

4.4.3 Number of leaves

The ANOVA indicated that significant response was observed incase of number of leaves due to different treatments. In 2006, the highest number of leaf (11.33) was observed from T_1 (open field) which was statistically similar with T_2 (11.17), T_3 (9.50) and T_6 (9.67). Significantly the lowest number of leaf (9.00) was produced by T_5 (Table 4.4.1).

In 2007, the highest number of leaf (9.5) was recorded from T_1 which was statistically similar with T_2 (8.67). Again the lowest leaf number (7.0) was recorded from T_6 and it was statistically alike with T_4 (7.5), and T_5 (7.33).

4.4.4 Leaf length

Leaf length was statistically significant at 1% level of probability for different treatments (Table 4.4.1). In 2006, the biggest leaf (161.0 cm) was found from T_1 which was statistically similar with T_2 (160.0) and T_5 (156.0). The smallest leaf recorded from T_4 (141.3cm) and T_3 (141.3cm). In 2007, the highest leaf length (147.8cm) was produced by T_1 which was statistically similar with T_2 (141.3cm). Again the lowest leaf length was produced by T_5 (125.2 cm) and it was statistically similar with T_4 (128.3 cm), T_3 (135.0 cm) & T_6 (125.3 cm)

4.4.5 Leaf breadth

The influencing pattern of leaf breath almost similar to leaf length and maximum leaf breadth was recorded from T_1 which was statistically similar with T_2 in both the cropping years (Table 4.4.1) But the lowest leaf breadth was recorded from T_4 (49.33 cm) in 2006 which was statistically similar with T_3 (50.33 cm) on the other hand in 2007 the lowest leaf breadth was recorded from T_6 (48.33 cm) which was statistically indifference with T_5 (49.83cm) & T_4 (50.83cm).

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4.4.6 Number of hands bunch^{-1}

Number of hands bunch^{-1} was significantly influenced by different treatments (Table 4.4.2). In 2006, the maximum number of hands bunch^{-1} (5.83) was produced from T_1 (sole banana) which was statistically similar to that of T_2 (5.50) and T_5 (5.17). and the minimum number of hand (5.0) was recorded from T_4 that was statistically identical to T_3 (5.08) and T_6 (5.08). In 2007, significantly the highest number of hands bunch^{-1} was found in T_1 (5.50) which were statistically similar to that of all other treatments except T_6. Although T_6 produced the significantly lowest number (4.50) of hands bunch^{-1}.

4.4.7 Number of fingers hand^{-1}

Number of fingers hand^{-1} was not significantly influenced by different tree crop combination in both cropping seasons ((Table 4.4.2). But numerically highest number of fingers hand^{-1} was observed from T_1 in both the year (11.83 and 14.23 in the year 2006 and 2007, respectively).

4.4.8 Length of finger

Length of finger of banana was significantly influenced by different treatments ((Table 4.4.2). In 2006, significantly the longest finger was recorded in T_1 (18.67cm) which was quite identical to T_2 (18.17cm) and statistically similar to T_3 (17.50cm). All other treatments produced the shortest finger and their numerical value of length of finger was 16.83cm. In 2007, the highest value of finger length was recorded in T_5 (17.53) which was statistically similar to that of T_3 (17.43cm), T_1 (17.1cm) and T_2 (16.97cm), Significantly lowest value of finger length was recorded in T_6 (15.13cm) which statistically identical to that of T_4 (15.23cm).

Table 4.4.2: Yield contributing characters of banana in different agroforestry systems

Treatments	No.of fingers hand^{-1}		No.of fingers hand^{-1}		Length of finger(cm)		Girth of finger(cm)	
	2006	2007	2006	2007	2006	2007	2006	2007
T_1	5.83a	5.50a	11.83a	14.23a	18.67a	17.10ab	14.66a	13.83a
T_2	5.50ab	5.00ab	11.00a	11.07a	18.17a	16.97ab	14.53a	13.80a
T_3	5.08b	5.17ab	10.33a	10.73a	17.50ab	17.43a	14.43a	13.77a
T_4	5.00b	4.83ab	10.67a	10.43a	16.83b	15.23b	14.90a	13.10a
T_5	5.17ab	4.83ab	10.40a	10.47a	16.83b	17.53a	14.40a	12.07b
T_6	5.08b	4.50b	10.07a	9.82a	16.83b	15.13b	14.33a	13.20a
CV%	4.71	6.79	6.37	15.15	2.54	4.57	1.44	2.50

T_1 = Sole banana, T_2 = Banana with Potato - Onion, T_3 = Banana with Ipil-ipil, T_4 = Banana with Goraneem, T_5 = Banana with Ipil-ipil + Potato - Onion, T_6 =. Banana with Goraneem + Potato - onion

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Number of fingers hand^{-1} was not significantly influenced by different tree crop combination in both cropping seasons ((Table 4.4.2). But numerically highest number of fingers hand^{-1} was observed from T_1 in both the year (11.83 and 14.23 in the year 2006 and 2007, respectively).

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Treatments	No.of fingers hand^{-1}		No.of fingers hand^{-1}		Length of finger(cm)		Girth of finger(cm)	
	2006	2007	2006	2007	2006	2007	2006	2007
T_1	5.83a	5.50a	11.83a	14.23a	18.67a	17.10ab	14.66a	13.83a
T_2	5.50ab	5.00ab	11.00a	11.07a	18.17a	16.97ab	14.53a	13.80a
T_3	5.08b	5.17ab	10.33a	10.73a	17.50ab	17.43a	14.43a	13.77a
T_4	5.00b	4.83ab	10.67a	10.43a	16.83b	15.23b	14.90a	13.10a
T_5	5.17ab	4.83ab	10.40a	10.47a	16.83b	17.53a	14.40a	12.07b
T_6	5.08b	4.50b	10.07a	9.82a	16.83b	15.13b	14.33a	13.20a
CV%	4.71	6.79	6.37	15.15	2.54	4.57	1.44	2.50

T_1 = Sole banana, T_2 = Banana with Potato - Onion, T_3 = Banana with Ipil-ipil, T_4 = Banana with Goraneem, T_5 = Banana with Ipil-ipil + Potato - Onion, T_6 =. Banana with Goraneem + Potato - onion

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	2006	2007	2006	2007	2006	2007	2006	2007
T_1	5.83a	5.50a	11.83a	14.23a	18.67a	17.10ab	14.66a	13.83a
T_2	5.50ab	5.00ab	11.00a	11.07a	18.17a	16.97ab	14.53a	13.80a
T_3	5.08b	5.17ab	10.33a	10.73a	17.50ab	17.43a	14.43a	13.77a
T_4	5.00b	4.83ab	10.67a	10.43a	16.83b	15.23b	14.90a	13.10a
T_5	5.17ab	4.83ab	10.40a	10.47a	16.83b	17.53a	14.40a	12.07b
T_6	5.08b	4.50b	10.07a	9.82a	16.83b	15.13b	14.33a	13.20a
CV%	4.71	6.79	6.37	15.15	2.54	4.57	1.44	2.50

T_1 = Sole banana, T_2 = Banana with Potato - Onion, T_3 = Banana with Ipil-ipil, T_4 = Banana with Goraneem, T_5 = Banana with Ipil-ipil + Potato - Onion, T_6 =. Banana with Goraneem + Potato - onion

4.4.9 Girth of finger

Girth of finger was not significantly influenced by the different treatments in 2006 but in 2007, it was highly significant. Significantly the highest finger girth was recorded in T_1 (13.83) which was statistically identical to T_4 T_3, T_6 and T_2 and significantly the lowest Girth of finger was obtained in T_5 (12.07cm).

Table 4.4. 3 Yield and yield contributing characters of banana in different agroforestry systems

Treatements	Weight (g finger^{-1})		Yield plant $^{-1}$ (kg)		Fresh yield (t ha^{-1})	
	2006	2007	2006	2007	2006	2007
T_1	113.8a	98.90a	7.85a	5.79a	8.72a	6.4 b
T_2	112.0a	98.37a	6.78b	6.13a	7.53b	6.64a
T_3	106.4a	98.53a	5.67c	5.64a	6.30c	6.03bc
T_4	106.4a	95.77a	5.67c	4.93b	6.29c	5.37bc
T_5	102.5a	94.63a	5.43c	4.95b	5.93c	5.33bc
T_6	102.4a	94.13a	5.34c	4.01c	6.03c	4.63c
CV%	3.86	2.63	4.54	4.62	4.53	8.16

T_1 = Sole banana, T_2 = Banana with Potato - Onion, T_3 = Banana with Ipil-ipil, T_4 = Banana with Goraneem, T_5 = Banana with Ipil-ipil + Potato - Onion, T_6 =. Banana with Goraneem + Potato – onion

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T_4	106.4a	95.77a	5.67c	4.93b	6.29c	5.37bc
T_5	102.5a	94.63a	5.43c	4.95b	5.93c	5.33bc
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T_1 = Sole banana, T_2 = Banana with Potato - Onion, T_3 = Banana with Ipil-ipil, T_4 = Banana with Goraneem, T_5 = Banana with Ipil-ipil + Potato - Onion, T_6 =. Banana with Goraneem + Potato – onion

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T_3	106.4a	98.53a	5.67c	5.64a	6.30c	6.03bc
T_4	106.4a	95.77a	5.67c	4.93b	6.29c	5.37bc
T_5	102.5a	94.63a	5.43c	4.95b	5.93c	5.33bc
T_6	102.4a	94.13a	5.34c	4.01c	6.03c	4.63c
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4.4.10 Finger weight

Weight per finger was not significantly influenced by different treatments in both cropping season (Table 4.4.3)but numerically highest finger weight was found in T_1 in both the production years(113.8 and 98.9 gm in 2006 and 2007, respectively).

4.4.11Yield per plant

Yield per plant of banana was significantly influenced by different treatments in both cropping season (Table 4.4.3). In 2006, significantly the highest yield per plant was recorded in T_1 (7.85kg.) followed by T_2 (6.78 kg.). The lowest yield was found in T_5 (5.3 kg) which was statistically similar to that of T_4 (5.67 kg), T_3 (5.67 kg) and T_6 (5.43 kg). In 2007, significantly highest yield was recorded in T_2 (6.13 kg) which was statically identical to that of T_1 (5.79 kg) and T_3 (5.64 kg). Significantly lowest yield was found in T_6 (4.01 kg). T_4 and T_5 produced 4.93 and 4.95 kg respectively which were statically identical.

4.12 Fresh yield

Fresh yield (t ha^{-1}) is the ultimate object of banana cultivation. The fresh yield of banana is mainly depended on the yield contributing characters like number of hand $bunch^{-1}$, number of finger $hand^{-1}$ and finger weight. Degree of light intensity provided by different MPTs in addition to below ground competitions for growth resources had significant impact on fresh yield of banana (Table 4.4.3). The influencing pattern was similar to that of yield per plant. In 2006 the highest fresh yield was recorded in T_1 (8.72 t ha^{-1}) followed by T_2 (7.53 t ha^{-1}). Significantly lowest yield was recorded in T_5 (5.93 t ha^{-1}) which was similar to that of all other treatments except T_2. In 2007, the highest fresh yield (6.64 t ha^{-1}) was obtained from T_2 followed by T_1 (6.4 t ha^{-1}). Again the lowest yield (4.63 t ha^{-1}) was observed from T_6 which was statistically similar with T_4 (5.37), T_3 (6.03) and T_5 (5.33 t ha^{-1}).This result shows that banana fresh yield was directly correlated with the light intensity.

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Experiment # 5: Performance of Potato as a Lower Storied Crop of Multistoried Agroforestry Systems

4.5.1 Days of first emergence

In 2006, there was significant variation in the required period of first emergence. The range was about 10-11 days (Table 4.5.1). But in 2007, duration of first emergence was required from 9-11 days. In both the years maximum time was required (10.92 and 10.5 days in the year of 2006 and 2007, respectively) for T_1 (Sole potato i.e. control) and minimum time (10.17 and 9.5 days in 2006 and 2007, respectively) was required for T_6 (Potato with banana + goraneem).Comparatively longer period in sole potato might be due to low moisture content in the soil than that under tree canopies.

4.5.2 Days of 80% emergence

Days of 80% emergence was significantly influenced by the treatments. In 2006, for 80% emergence significantly the longest period (20.08 days) was required in T_1 (Sole potato i.e. control), which was identical to T_2 (Potato with banana) and the duration was 19.83 days. Significantly the lowest duration (19.08 days) was required for T_6 (Potato with banana + goraneem)

In 2007, the highest duration for 80% emergence was required in T_1 (20.67 days) which was statistically similar to that of T_2 (20.33 days). The lowest duration was recorded for T_6 (18.5 days). T_6 (18.5 days) was identical to T_5 (19.00 days). Other treatments needed moderate time (Table 4.5.1) for 80% emergence.

Table 4.5.1: Days of emergence and height performance of potato grown as a lower storied crop of multistoried Agroforestry systems

Treatment	Days of first emergence		Days of 80% emergence		Plant height (cm)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_1	10.92a	10.50a	20.08a	20.67a	43.42 c	45.33 c
T_2	10.83a	10.5 a	19.83a	20.33ab	44.70 bc	48.25c
T_3	10.42 c	10.00a	19.42 b	19.50 bc	47.63 a	53.37 b
T_4	10.58b	10.17a	19.17 bc	19.33 bc	45.28 b	51.47 b
T_5	10.42 c	10.00 a	19.17 bc	19.00 c	49.23a	57.67a
T_6	10.17 d	9.50 a	19.08 c	18.50 c	49.00a	54.03b
CV%	1.48	4.57	1.57	2.07	4.05	2.26

T_1 = Sole potato (control), T_2 = Potato with banana, T_3 = Potato with ipil-ipil, T_4 = Potato with goraneem, T_5 = Potato with banana + ipil-ipil, T_6 = Potato with banana + goraneem

Experiment # 5: Performance of Potato as a Lower Storied Crop of Multistoried Agroforestry Systems

4.5.1 Days of first emergence

In 2006, there was significant variation in the required period of first emergence. The range was about 10-11 days (Table 4.5.1). But in 2007, duration of first emergence was required from 9-11 days. In both the years maximum time was required (10.92 and 10.5 days in the year of 2006 and 2007, respectively) for T_1 (Sole potato i.e. control) and minimum time (10.17 and 9.5 days in 2006 and 2007, respectively) was required for T_6 (Potato with banana + goraneem).Comparatively longer period in sole potato might be due to low moisture content in the soil than that under tree canopies.

4.5.2 Days of 80% emergence

Days of 80% emergence was significantly influenced by the treatments. In 2006, for 80% emergence significantly the longest period (20.08 days) was required in T_1 (Sole potato i.e. control), which was identical to T_2 (Potato with banana) and the duration was 19.83 days. Significantly the lowest duration (19.08 days) was required for T_6 (Potato with banana + goraneem)

In 2007, the highest duration for 80% emergence was required in T_1 (20.67 days) which was statistically similar to that of T_2 (20.33 days). The lowest duration was recorded for T_6 (18.5 days). T_6 (18.5 days) was identical to T_5 (19.00 days). Other treatments needed moderate time (Table 4.5.1) for 80% emergence.

Table 4.5.1: Days of emergence and height performance of potato grown as a lower storied crop of multistoried Agroforestry systems

Treatment	Days of first emergence		Days of 80% emergence		Plant height (cm)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_1	10.92a	10.50a	20.08a	20.67a	43.42 c	45.33 c
T_2	10.83a	10.5 a	19.83a	20.33ab	44.70 bc	48.25c
T_3	10.42 c	10.00a	19.42 b	19.50 bc	47.63 a	53.37 b
T_4	10.58b	10.17a	19.17 bc	19.33 bc	45.28 b	51.47 b
T_5	10.42 c	10.00 a	19.17 bc	19.00 c	49.23a	57.67a
T_6	10.17 d	9.50 a	19.08 c	18.50 c	49.00a	54.03b
CV%	1.48	4.57	1.57	2.07	4.05	2.26

T_1 = Sole potato (control), T_2 = Potato with banana, T_3 = Potato with ipil-ipil, T_4 = Potato with goraneem, T_5 = Potato with banana + ipil-ipil, T_6 = Potato with banana + goraneem

Experiment # 5: Performance of Potato as a Lower Storied Crop of Multistoried Agroforestry Systems

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Days of 80% emergence was significantly influenced by the treatments. In 2006, for 80% emergence significantly the longest period (20.08 days) was required in T_1 (Sole potato i.e. control), which was identical to T_2 (Potato with banana) and the duration was 19.83 days. Significantly the lowest duration (19.08 days) was required for T_6 (Potato with banana + goraneem)

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	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_1	10.92a	10.50a	20.08a	20.67a	43.42 c	45.33 c
T_2	10.83a	10.5 a	19.83a	20.33ab	44.70 bc	48.25c
T_3	10.42 c	10.00a	19.42 b	19.50 bc	47.63 a	53.37 b
T_4	10.58b	10.17a	19.17 bc	19.33 bc	45.28 b	51.47 b
T_5	10.42 c	10.00 a	19.17 bc	19.00 c	49.23a	57.67a
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4.5.3 Plant height

Plant height of potato was significantly influenced by different upper storied tree species. In 2006, the highest plant height (49.23cm) was observed from T_5 followed by T_6(49.00cm) and T_3 (47.63cm). T_6, T_5 and T_3 were statistically identical. The lowest plant height was obtained from T_1 (43.42cm) which was statistically similar to T_2 (44.7cm). T_4 produced moderate plant height (45.28cm) which was similar to T_2. In 2007, significantly the longest plant (57.67cm) was produced by T_5 followed by T_6 (54.03cm). The plant height recorded from T_4(51.47cm) and T_3 (53.37cm) were statistically identical to T_6. The lowest plant height was observed from T_1(45.33cm) which was statistically identical to T_2(48.25cm). The response of plant height revealed that increase of light intensity might be caused of shorter plant. In order to highest to lowest light intensity received by the treatment were T_1,T_2, T_4, T_3, T_6 and T_5 (Appendix table 4.5.4)

4.5.4 Number of tillers hill^{-1}

Tiller production per hill was differing significantly at 1% level of probability in 2007 but in 2006 number of tillers hill^{-1} was not varied statistically. Although highest number of tiller was recorded from T_1 (4.6) followed by T_2 (4.5), T_4 (4.0) and T_6 (3.75). The minimum number was counted in T_3 (3.5). In 2007, significantly the highest number of tillers (5.0) was produced by T_1 (sole potato) which was statistically similar to T_2 & T_4 treatments. The minimum tiller per hill (3.60) was produced by T_3 (potato with ipil ipil) which was statistically similar to T_5 (3.73) & T_6 (3.73).

4.5.5 Tuber yield hill^{-1}

Tuber production is the ultimate object of potato cultivation. Partial shade conditions provided by banana and/ or different MPTs had a positively impact on tuber yield (Table 4.5.2). The influencing pattern in 2007 was almost similar to that of 2006. In 2006, significantly the highest tuber yield per hill (185.12g) was recorded in T_1 (sole potato) followed by T_2 (potato with banana). Significantly the poorest yield (90g) was obtained from T_3 (potato with ipil ipil), that was statistically similar to T_5 (potato with banana +ipil ipil) and T_4 (potato with goraneem). T_6 (potato with banana + goraneem) produced moderate amount (130.3g) of tuber per hill. In 2007, the maximum tuber yield per hill (203.4g) was produced by T_1 (sole potato), whereas T_3 i.e. potato produced with ipil ipil showed the lowest tuber yield per hill (94.77g) which was statistically similar to T_5 (potato with banana+ ipil ipil).

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4.5.6 Weight of tuber

Weight of individual tuber was not significantly affected by partial shade of different treatments. In 2006, the maximum weight of tuber (g/tuber) was recorded from T_1 (37.5 g) which was followed by T_2 (36 g), T_6 (35.3 g) and T_5 (35.1 g). The minimum tuber yield per hill was found in T_3 (31.0 g). But tuber weight in 2007, was found significantly different by the treatments. In that year the maximum tuber weight (42.37g) was found from T_2 (potato with banana) which was statistically similar to T_1. Again, the significantly lowest tuber weight (26.30g) was produced by T_3 (potato with ipil ipil) which was statistically similar to T_4 (27.83g) & T_5 (30.72g).

4.5.7 Yield

The tuber yield (t/ha) was greatly affected by the different configuration of the component in both cropping seasons. The variation was identical to that of tuber yield per hill. In both the year significantly the highest yield was recorded in T_1 i.e. open field (18.51 and 20.3 t/ha in 2006 and 2007 irrespectively followed by T_2 (Table 4.5.2). Significantly the lowest yield (9.0 and 9.5 t/ha 1st and 2nd year respectively) was obtained by T_3 (potato with ipil ipil) which was similar to T_5 (12.11 and 11.5 in 2006 and 2007 respectively). T_6 produced the moderate yield in both the cropping season (13.03 and 12.8 t/ha in 2006 and 2007 respectively. Performance of potato under different treatment combinations proved that low light intensity created by multistoried system hampered its yield. For higher yield of potato banana + gora neem association is better than banana + ipil ipil.

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Table 4.5.2: Yield and yield contributing characteristics of potato grown as lower storied crop of multistoried agroforestry systems

Treatment	Number of tiller hill^{-1}		Tuber yield hill^{-1} 2007		Weight of tuber (g tuber^{-1})		Yield (t ha^{-1})	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_1	4.6	5.00 a	185.12a	203.40 a	37.5	40.78 ab	18.51a	20.3a
T_2	4.5	4.50 ab	170.5b	177.10 b	36.0	42.37 a	17.05b	17.7b
T_3	3.5	3.60 c	90.0d	94.77 d	31.0	26.30 d	9.00d	9.5d
T_4	4.0	4.30 ab	111.5cd	119.3 c	32.5	27.83 cd	11.15ad	11.9c
T_5	3.53	3.73 bc	121.1cd	114.6 cd	35.1	30.72 cd	12.11cd	11.5cd
T_6	3.75	3.73 bc	130.3c	128.20 c	35.3	34.37 bc	13.03c	12.8c
CV%		7.42		5.27		8.26		

T_1 = Sole potato (control), T_2 = Potato with banana, T_3 = Potato with ipil-ipil, T_4 = Potato with goraneem, T_5 = Potato with banana + ipil-ipil, T_6 = Potato with banana + goraneem

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	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_1	4.6	5.00 a	185.12a	203.40 a	37.5	40.78 ab	18.51a	20.3a
T_2	4.5	4.50 ab	170.5b	177.10 b	36.0	42.37 a	17.05b	17.7b
T_3	3.5	3.60 c	90.0d	94.77 d	31.0	26.30 d	9.00d	9.5d
T_4	4.0	4.30 ab	111.5cd	119.3 c	32.5	27.83 cd	11.15ad	11.9c
T_5	3.53	3.73 bc	121.1cd	114.6 cd	35.1	30.72 cd	12.11cd	11.5cd
T_6	3.75	3.73 bc	130.3c	128.20 c	35.3	34.37 bc	13.03c	12.8c
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T_1 = Sole potato (control), T_2 = Potato with banana, T_3 = Potato with ipil-ipil, T_4 = Potato with goraneem, T_5 = Potato with banana + ipil-ipil, T_6 = Potato with banana + goraneem

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Treatment	Number of tiller hill^{-1}		Tuber yield hill^{-1} 2007		Weight of tuber (g tuber^{-1})		Yield (t ha^{-1})	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
T_1	4.6	5.00 a	185.12a	203.40 a	37.5	40.78 ab	18.51a	20.3a
T_2	4.5	4.50 ab	170.5b	177.10 b	36.0	42.37 a	17.05b	17.7b
T_3	3.5	3.60 c	90.0d	94.77 d	31.0	26.30 d	9.00d	9.5d
T_4	4.0	4.30 ab	111.5cd	119.3 c	32.5	27.83 cd	11.15ad	11.9c
T_5	3.53	3.73 bc	121.1cd	114.6 cd	35.1	30.72 cd	12.11cd	11.5cd
T_6	3.75	3.73 bc	130.3c	128.20 c	35.3	34.37 bc	13.03c	12.8c
CV%		7.42		5.27		8.26		

T_1 = Sole potato (control), T_2 = Potato with banana, T_3 = Potato with ipil-ipil, T_4 = Potato with goraneem, T_5 = Potato with banana + ipil-ipil, T_6 = Potato with banana + goraneem

Experiment # 6: Performance of Onion as a Lower Storied Crop of Multistoried Agroforestry Systems

4.6.1 Plant height

Plant height is an important morphological characteristic of onion that was significantly influenced in both the cropping seasons. In 2006, the highest plant height (41.10 cm) was recorded in T_6 (onion with banana + gora neem) that was statistically similar to that (38.37 cm) of T_5 (onion with banana + ipil ipil). The lowest plant height (35.67 cm) was found in T_1 (open field) which was identical to T_2 (35.8 cm), T_3 (36.43 cm) and T_4 (37.37 cm).

In 2007, significantly the longest plant of onion was recorded in T_6 (44.83 cm) followed by T_5 (42.60 cm). Significantly the shortest plant was found in T_1 (39.43 cm) which was identical to T_2 (40.27 cm). T_3 and T_4 produced the moderate length of plants (Table 4.6.1).

Plant height depends on a number of factors such as intensity and duration of light, moisture content of soil, mineral nutrients, temperature, area of growing space (aerial and edaphic) and genetic set up of plants. Plant grown in low light levels was found to be exhibited apical dominance than those grown in high light environment resulting in taller plants under shade (Hillman, 1984). The present study revealed the above phenomena i.e. plant height increased with the decrease of light levels, as the average light intensity received by T_1, T_2, T_3, T_4, T_5 and T_6 were 100, 97, 88.33, 87.66, 85.00 and 4.66% respectively (Appendix Table 4.5.6)

4.6.2 Number of leaves per plant^{-1}

Number of leaves per plant^{-1} of onion was severely affected by the multistoried treatments (Table 4.6.1). The influencing pattern in both the cropping season was almost similar.

Maximum number of leaves plant^{-1} (6.28 and 6.8 in 2006 and 2007, respectively) was produced by T_1 (sole onion) which was identical to that of T_2 (potato with banana) in both the year. Highest number leaves produced by T_5 (5.58) and T_6 (5.55) were statistically similar to T_1 in 2006 but in 2007 only T_5 (6.47) was similar to that of T_1. In both the experimental year significantly the lowest leaf number was produced by T_4 (4.7 and 5.3 in 2006 and 2007, respectively) which was similar to that of T_3 (4.8 and 5.6 in 2006 and 2007, respectively).

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Number of leaves per plant^{-1} of onion was severely affected by the multistoried treatments (Table 4.6.1). The influencing pattern in both the cropping season was almost similar.

Maximum number of leaves plant^{-1} (6.28 and 6.8 in 2006 and 2007, respectively) was produced by T_1 (sole onion) which was identical to that of T_2 (potato with banana) in both the year. Highest number leaves produced by T_5 (5.58) and T_6 (5.55) were statistically similar to T_1 in 2006 but in 2007 only T_5 (6.47) was similar to that of T_1. In both the experimental year significantly the lowest leaf number was produced by T_4 (4.7 and 5.3 in 2006 and 2007, respectively) which was similar to that of T_3 (4.8 and 5.6 in 2006 and 2007, respectively).

Experiment # 6: Performance of Onion as a Lower Storied Crop of Multistoried Agroforestry Systems

4.6.1 Plant height

Plant height is an important morphological characteristic of onion that was significantly influenced in both the cropping seasons. In 2006, the highest plant height (41.10 cm) was recorded in T_6 (onion with banana + gora neem) that was statistically similar to that (38.37 cm) of T_5 (onion with banana + ipil ipil). The lowest plant height (35.67 cm) was found in T_1 (open field) which was identical to T_2 (35.8 cm), T_3 (36.43 cm) and T_4 (37.37 cm).

In 2007, significantly the longest plant of onion was recorded in T_6 (44.83 cm) followed by T_5 (42.60 cm). Significantly the shortest plant was found in T_1 (39.43 cm) which was identical to T_2 (40.27 cm). T_3 and T_4 produced the moderate length of plants (Table 4.6.1).

Plant height depends on a number of factors such as intensity and duration of light, moisture content of soil, mineral nutrients, temperature, area of growing space (aerial and edaphic) and genetic set up of plants. Plant grown in low light levels was found to be exhibited apical dominance than those grown in high light environment resulting in taller plants under shade (Hillman, 1984). The present study revealed the above phenomena i.e. plant height increased with the decrease of light levels, as the average light intensity received by T_1, T_2, T_3, T_4, T_5 and T_6 were 100, 97, 88.33, 87.66, 85.00 and 4.66% respectively (Appendix Table 4.5.6)

4.6.2 Number of leaves per plant^{-1}

Number of leaves per plant^{-1} of onion was severely affected by the multistoried treatments (Table 4.6.1). The influencing pattern in both the cropping season was almost similar.

Maximum number of leaves plant^{-1} (6.28 and 6.8 in 2006 and 2007, respectively) was produced by T_1 (sole onion) which was identical to that of T_2 (potato with banana) in both the year. Highest number leaves produced by T_5 (5.58) and T_6 (5.55) were statistically similar to T_1 in 2006 but in 2007 only T_5 (6.47) was similar to that of T_1. In both the experimental year significantly the lowest leaf number was produced by T_4 (4.7 and 5.3 in 2006 and 2007, respectively) which was similar to that of T_3 (4.8 and 5.6 in 2006 and 2007, respectively).

4.6.3 Leaf dry weight per plant

Leaf dry weight per plant was significantly affected by the different multistoried treatments. Affecting pattern of leaf dry weight due to various treatments was quite similar in both the cropping seasons (Table 4.6.1). The highest leaf dry weight/plant was recorded in T_1 (sole onion) and the values were 1.65 and 1.60 gm in 2006 and 2007 respectively. T_2, T_3, T_5 and T_6 produced statistically similar leaf dry weight open field that of T_1 in both the cropping seasons. The lowest amount of leaf dry weight was obtained from T_4 (1.48g) which was identical to T_3 (1.49 g) in 2006 but T_4 (1.24 g) and T_3 (1.49 g) produced significantly different leaf dry weight in 2007.

Table 4.6.1: Performance of growth characteristics of onion grown as lower storied crop of multistoried agroforestry systems

Treatments	Plant height (cm)		No. of leaves per plant^{-1}		Leaf dry weight plant^{-1} (g)	
	2006	2007	2006	2007	2006	2007
T_1	35.67b	39.43d	6.28a	6.80a	1.65a	1.60a
T_2	35.80b	40.27d	6.00a	6.63a	1.61a	1.60a
T_3	36.43b	41.47c	4.83b	5.60c	1.49b	1.49b
T_4	37.37b	41.73bc	4.75b	5.30c	1.48b	1.24c
T_5	38.37ab	42.60b	5.58ab	6.47ab	1.58a	1.59a
T_6	41.10a	44.83a	5.55ab	6.27b	1.57ab	1.50ab
CV%	3.23	0.93	7.38	1.95	2.07	2.38

T_1 = Sole onion (control), T_2 = Onion with banana, T_3 = Onion with ipil- ipil, T_4 = Onion with goraneem, T_5= (Onion with banana + ipil- ipil), T_6 = Onion with banan +goraneem

4.6.4 Bulb diameter

Bulb diameter is one of the important yield contributing characteristic of onion which was significantly affected by the partial shade conditions provided by banana and/or different MPTs. (Table 4.6.2). In 2006, highest bulb diameter (4.54 cm) was measured in T_1 and T_2. Although T_5 (4.49 cm) and T_6 (4.32 cm) produced identical bulb diameter. Smallest bulb diameter was produced from T_4 (3.94 cm) which was similar to that of T_3 (3.93 cm).In 2007, the biggest bulb diameter was found in T_2 (4.23 cm) which was statistically similar to that of T_1 (4.12 cm) and T_5 (4.0 cm). The lowest bulb diameter was recorded from T_3 (3.43 cm) which was statistically similar to that of T_4 (3.6 cm)

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Treatments	Plant height (cm)		No. of leaves per plant^{-1}		Leaf dry weight plant^{-1} (g)	
	2006	2007	2006	2007	2006	2007
T_1	35.67b	39.43d	6.28a	6.80a	1.65a	1.60a
T_2	35.80b	40.27d	6.00a	6.63a	1.61a	1.60a
T_3	36.43b	41.47c	4.83b	5.60c	1.49b	1.49b
T_4	37.37b	41.73bc	4.75b	5.30c	1.48b	1.24c
T_5	38.37ab	42.60b	5.58ab	6.47ab	1.58a	1.59a
T_6	41.10a	44.83a	5.55ab	6.27b	1.57ab	1.50ab
CV%	3.23	0.93	7.38	1.95	2.07	2.38

T_1 = Sole onion (control), T_2 = Onion with banana, T_3 = Onion with ipil- ipil, T_4 = Onion with goraneem, T_5= (Onion with banana + ipil- ipil), T_6 = Onion with banan +goraneem

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Table 4.6.1: Performance of growth characteristics of onion grown as lower storied crop of multistoried agroforestry systems

Treatments	Plant height (cm)		No. of leaves per plant^{-1}		Leaf dry weight plant^{-1} (g)	
	2006	2007	2006	2007	2006	2007
T_1	35.67b	39.43d	6.28a	6.80a	1.65a	1.60a
T_2	35.80b	40.27d	6.00a	6.63a	1.61a	1.60a
T_3	36.43b	41.47c	4.83b	5.60c	1.49b	1.49b
T_4	37.37b	41.73bc	4.75b	5.30c	1.48b	1.24c
T_5	38.37ab	42.60b	5.58ab	6.47ab	1.58a	1.59a
T_6	41.10a	44.83a	5.55ab	6.27b	1.57ab	1.50ab
CV%	3.23	0.93	7.38	1.95	2.07	2.38

T_1 = Sole onion (control), T_2 = Onion with banana, T_3 = Onion with ipil- ipil, T_4 = Onion with goraneem, T_5= (Onion with banana + ipil- ipil), T_6 = Onion with banan +goraneem

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4.6.5 Bulb fresh weight

Bulb fresh weight (g bulb^{-1}) was also significantly influenced by the treatments in 2007 but the values of bulb fresh weight recorded in 2006 was not varied statistically (Table 4.6.2).

In 2006, the highest bulb fresh weight (33.42g) was recorded in T_1 (open field) followed by T_5 (30.37 g). The lowest fresh weight (g bulb^{-1}) was calculated in T_4 (27.87 g).

In 2007, significantly the highest fresh weight was recorded from T_2 (27.03 g), followed by T_5 (20.68 g) and T_6 (20.09 g). The lowest amount of fresh weight per bulb was obtained from T_3. T_1 (19.53 g) and T_4 (19.18 g) produced the moderate amount of fresh weight which were statistically similar to that of both T_3 and T_5.

Table 4.6.2. Performance of yield contributing characteristics of onion grown as lower storied crop of multistoried Agroforestry systems.

Treatments	Bulb diameter (cm bulb^{-1})		Bulb fresh weight (g bulb^{-1})		Bulb dry weight (g bulb^{-1})	
	2006	2007	2006	2007	2006	2007
T_1	4.54a	4.12ab	33.42a	19.53bc	5.62a	3.07bc
T_2	4.54a	4.23a	31.77a	27.03a	5.61a	4.56a
T_3	3.93b	3.43c	29.17a	18.27c	4.79c	2.87c
T_4	3.94b	3.60c	27.87a	19.18bc	4.11d	2.97bc
T_5	4.49a	4.00ab	30.37a	20.68b	5.07b	3.25b
T_6	4.32a	3.90b	29.73a	20.09b	4.94bc	3.07bc
CV%	2.41	2.49	9.42	2.97	1.96	6.31

T_1 = Sole onion (control), T2 = Onion with banana, T_3 = Onion with ipil- ipil, T_4 = Onion with goraneem, T_5 = (Onion with banana + ipil- ipil), T_6 = Onion with banan +goraneem

4.6.6 Bulb dry weight

Bulb dry weight was significantly influenced by the treatments. In 2006, bulb dry weight (g/bulb) varied as it was in the fresh weight, but the variation of fresh weight was insignificant. The height dry weight per bulb (5.6 g) was measured in T_1 (open field) which was identical to T_2 (5.61 g). Significantly the lowest amount of dry weight (4.11 g) was produced by T_4 (onion with gora neem). T_5, T_6 and T_3 produced moderate amount of dry matter and the values were 5.07, 4.94 and 4.79 g bulb^{-1}, respectively.

4.6.5 Bulb fresh weight

Bulb fresh weight (g bulb^{-1}) was also significantly influenced by the treatments in 2007 but the values of bulb fresh weight recorded in 2006 was not varied statistically (Table 4.6.2).

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Treatments	Bulb diameter (cm bulb^{-1})		Bulb fresh weight (g bulb^{-1})		Bulb dry weight (g bulb^{-1})	
	2006	2007	2006	2007	2006	2007
T_1	4.54a	4.12ab	33.42a	19.53bc	5.62a	3.07bc
T_2	4.54a	4.23a	31.77a	27.03a	5.61a	4.56a
T_3	3.93b	3.43c	29.17a	18.27c	4.79c	2.87c
T_4	3.94b	3.60c	27.87a	19.18bc	4.11d	2.97bc
T_5	4.49a	4.00ab	30.37a	20.68b	5.07b	3.25b
T_6	4.32a	3.90b	29.73a	20.09b	4.94bc	3.07bc
CV%	2.41	2.49	9.42	2.97	1.96	6.31

T_1 = Sole onion (control), T2 = Onion with banana, T_3 = Onion with ipil- ipil, T_4 = Onion with goraneem, T_5 = (Onion with banana + ipil- ipil), T_6 = Onion with banan +goraneem

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Treatments	Bulb diameter (cm bulb^{-1})		Bulb fresh weight (g bulb^{-1})		Bulb dry weight (g bulb^{-1})	
	2006	2007	2006	2007	2006	2007
T_1	4.54a	4.12ab	33.42a	19.53bc	5.62a	3.07bc
T_2	4.54a	4.23a	31.77a	27.03a	5.61a	4.56a
T_3	3.93b	3.43c	29.17a	18.27c	4.79c	2.87c
T_4	3.94b	3.60c	27.87a	19.18bc	4.11d	2.97bc
T_5	4.49a	4.00ab	30.37a	20.68b	5.07b	3.25b
T_6	4.32a	3.90b	29.73a	20.09b	4.94bc	3.07bc
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In 2007, significantly the highest dry weight/ bulb (4.56 g) was recorded in T_2 followed by T_5 (3.25 g). Significantly the lowest dry matter (2.87 g) was produced by T_3. The dry weight obtained from T_1 (3.07 g), T_4 (2.97 g) and T_6 (3.07 g) were statistically similar to those of T_5 and T_3. These variations might be due to available light intensities and moisture content which influenced the production of photosynthates and their translocation to the bulb.

4.6.7 Bulb fresh yield

Bulb fresh yield (t ha^{-1}) was affected significantly by multistoried treatments in 2006 but in 2007 it was varied insignificantly. In 2006, significantly the highest fresh yield (10.18 t/ha) was recorded in T_1 (onion control). T_2 (9.92 t ha^{-1}) and T_5 (9.58 t ha^{-1}) produced statistically similar fresh yield to that of T_1. Significantly the lowest yield (8.44 t ha^{-1}) of onion was found in T_4 which was statistically similar to that of T_3 and T_6 (Table 4.6.3). In 2007, numerically highest yield (7.04 t ha^{-1}) was obtained from T_1 which was followed by T_2 (5.46 t ha^{-1}), T_5 (5.4 t ha^{-1}), T_6 (5.28), T_3 (5.25 t ha^{-1}) and than T_4 (5.21 t ha^{-1}). Significant variation of fresh yield of onion in 2006 by different treatment might be significant mortality rate of onion seedlings.

4.6.8 Total dry matter

Total dry matter production of onion (kg ha^{-1}) was influenced significantly in both cropping seasons. In 2006, significantly highest but identical yields 2222 and 2205 kg ha^{-1} were produced by T_1 and T_2 and significantly the lowest dry yield (1831 kg ha^{-1}) was obtained by T_4. The moderate amount of dry matter was produced by T_3, T_5 and T_6 the values were 2009, 2053 and 2034 kg/ha respectively. Total dry matter production revealed that lower light intensity represents the lower yield, but less importance of moisture content on the variation of yield. In 2007, significantly the maximum yield was recorded in T_1 (1611 kg ha^{-1}), followed by T_2 (1270 kg ha^{-1}) and T_5 (1268 kg ha^{-1}), T_4 always produced the minimum dry matter (1122 kg ha^{-1}). The total dry matter produced by T_3 and T_6 were 1231 and 1232 kg ha^{-1}, respectively which was statistically similar to both T_2 and T_4.

In 2007, significantly the highest dry weight/ bulb (4.56 g) was recorded in T_2 followed by T_5 (3.25 g). Significantly the lowest dry matter (2.87 g) was produced by T_3. The dry weight obtained from T_1 (3.07 g), T_4 (2.97 g) and T_6 (3.07 g) were statistically similar to those of T_5 and T_3. These variations might be due to available light intensities and moisture content which influenced the production of photosynthates and their translocation to the bulb.

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Table 4.6.3: Yield performance of onion and their mortality (%) under multistoried agroforestry system.

Treatments	Bulb fresh yield ($t\ ha^{-1}$)		Total dry matter ($kg\ ha^{-1}$)		Mortality %	
	2006	2007	2006	2007	2006	2007
T_1	10.18a	7.04a	2222a	1611a	13.72a	24.00a
T_2	9.92ab	5.46a	2205a	1270b	13.60a	29.00a
T_3	8.91bc	5.25a	2009b	1231bc	10.70b	26.33a
T_4	8.44c	5.21a	1831c	1122c	12.37a	23.67a
T_5	9.58ab	5.40a	2053b	1268b	7.69c	23.67a
T_6	9.08bc	5.28a	2034b	1232bc	9.65b	26.30a
CV%	3.57	13.75	1.83	3.92	13.92	16.07

T_1 = Sole onion (control), T_2 = Onion with banana, T_3 = Onion with ipil- ipil, T_4 = Onion with goraneem, T_5 = Onion with banana + ipil- ipil, T_6 = Onion with banan +goraneem

4.6.9 Mortality rate

Seedling mortality rate (%) was significant in 2006. The highest mortality (13.72 %) was recorded in T_1, followed by T_2 (13.60) and T_4 (12.37%). This was occurred might be due to high temperature and low moisture content. Significantly the lowest mortality (7.69 %) was found in T_5 which treatment prevailed high moisture content in the soil and low temperature as well as light intensity. In 2007, the mortality rate of seedling was not significant but the numerical variation was as it was in 2006 (Table 4.6.3). In 2006, the range of mortality rate of different treatments was 7.69-13.72 % which was varied significantly treatment to treatment. But in 2007 mortality rate was higher and the range was 23.67-29.00% although there was no significant difference among the treatments. High mortality rate was the causes of lower yield in 2007 irrespective of treatments.

Table 4.6.3: Yield performance of onion and their mortality (%) under multistoried agroforestry system.

Treatments	Bulb fresh yield ($t\ ha^{-1}$)		Total dry matter ($kg\ ha^{-1}$)		Mortality %	
	2006	2007	2006	2007	2006	2007
T_1	10.18a	7.04a	2222a	1611a	13.72a	24.00a
T_2	9.92ab	5.46a	2205a	1270b	13.60a	29.00a
T_3	8.91bc	5.25a	2009b	1231bc	10.70b	26.33a
T_4	8.44c	5.21a	1831c	1122c	12.37a	23.67a
T_5	9.58ab	5.40a	2053b	1268b	7.69c	23.67a
T_6	9.08bc	5.28a	2034b	1232bc	9.65b	26.30a
CV%	3.57	13.75	1.83	3.92	13.92	16.07

T_1 = Sole onion (control), T_2 = Onion with banana, T_3 = Onion with ipil- ipil, T_4 = Onion with goraneem, T_5 = Onion with banana + ipil- ipil, T_6 = Onion with banan +goraneem

4.6.9 Mortality rate

Seedling mortality rate (%) was significant in 2006. The highest mortality (13.72 %) was recorded in T_1, followed by T_2 (13.60) and T_4 (12.37%). This was occurred might be due to high temperature and low moisture content. Significantly the lowest mortality (7.69 %) was found in T_5 which treatment prevailed high moisture content in the soil and low temperature as well as light intensity. In 2007, the mortality rate of seedling was not significant but the numerical variation was as it was in 2006 (Table 4.6.3). In 2006, the range of mortality rate of different treatments was 7.69-13.72 % which was varied significantly treatment to treatment. But in 2007 mortality rate was higher and the range was 23.67-29.00% although there was no significant difference among the treatments. High mortality rate was the causes of lower yield in 2007 irrespective of treatments.

Table 4.6.3: Yield performance of onion and their mortality (%) under multistoried agroforestry system.

Treatments	Bulb fresh yield ($t\ ha^{-1}$)		Total dry matter ($kg\ ha^{-1}$)		Mortality %	
	2006	2007	2006	2007	2006	2007
T_1	10.18a	7.04a	2222a	1611a	13.72a	24.00a
T_2	9.92ab	5.46a	2205a	1270b	13.60a	29.00a
T_3	8.91bc	5.25a	2009b	1231bc	10.70b	26.33a
T_4	8.44c	5.21a	1831c	1122c	12.37a	23.67a
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Plate 4.4.1 Performance of banana as middle storey component in multistoried agroforestry system

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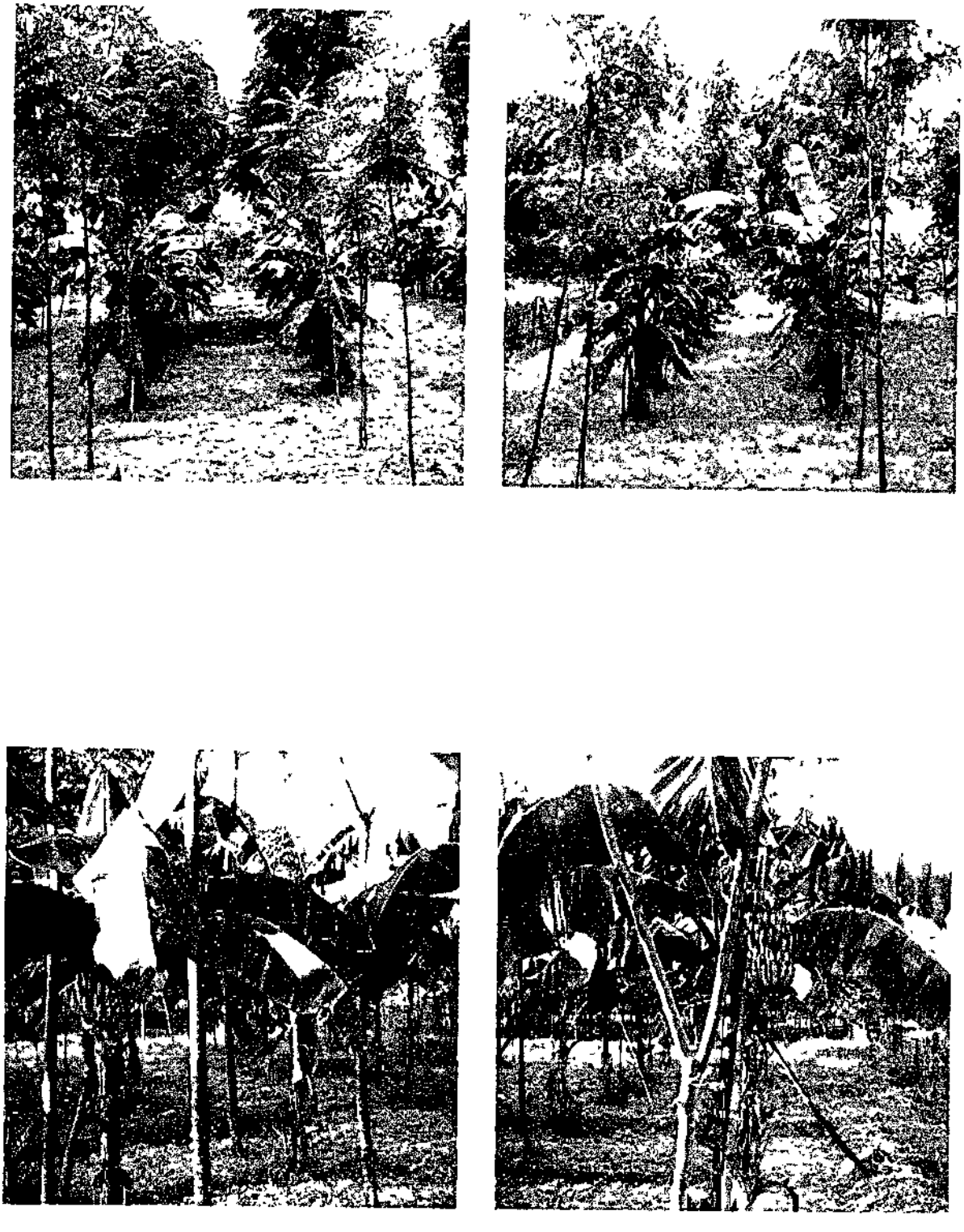

Plate 4.4.1 Performance of banana as middle storey component in multistoried agroforestry system

Plate 4.5.1 Performance of potato as lower storey component in multistoried agroforestry system

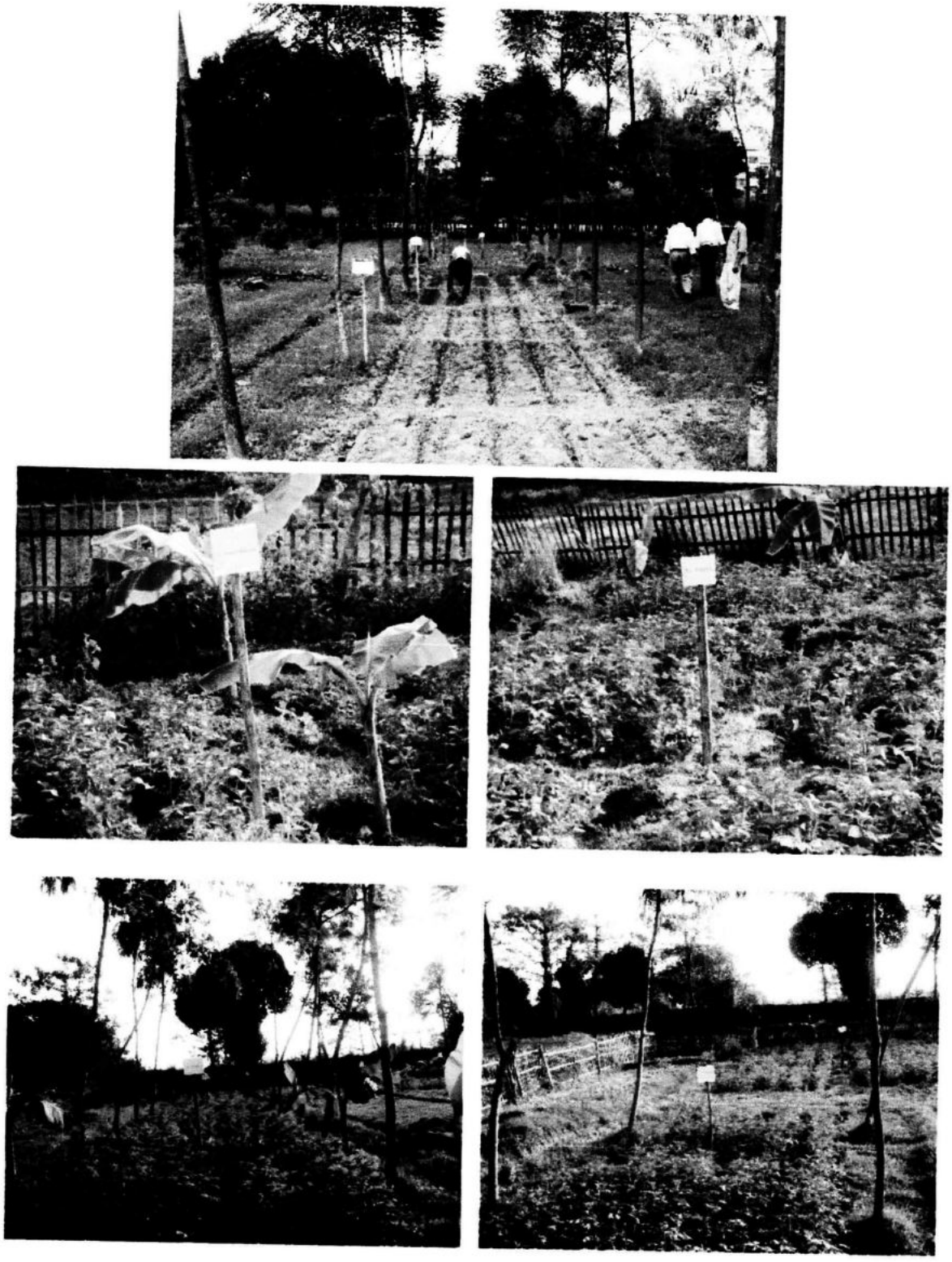

Plate 4.5.1 Performance of potato as lower storey component in multistoried agroforestry system

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Plate 4.5.2 Harvesting phase of potato as lower storey component in multistoried agroforestry system

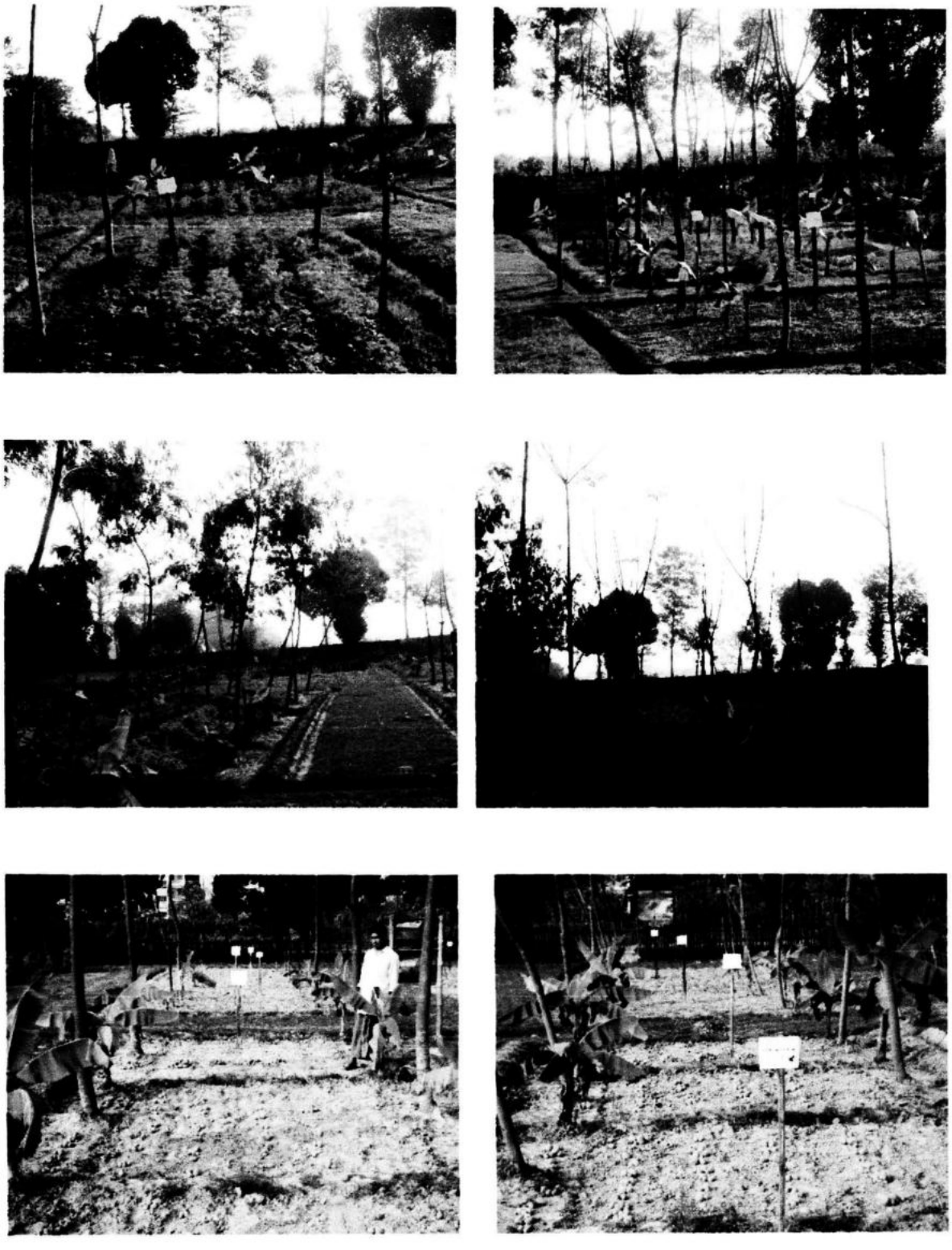

Plate 4.5.2 Harvesting phase of potato as lower storey component in multistoried agroforestry system

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Plate 4.6.1 Performance of onion as lower storey component in multistoried agroforestry system

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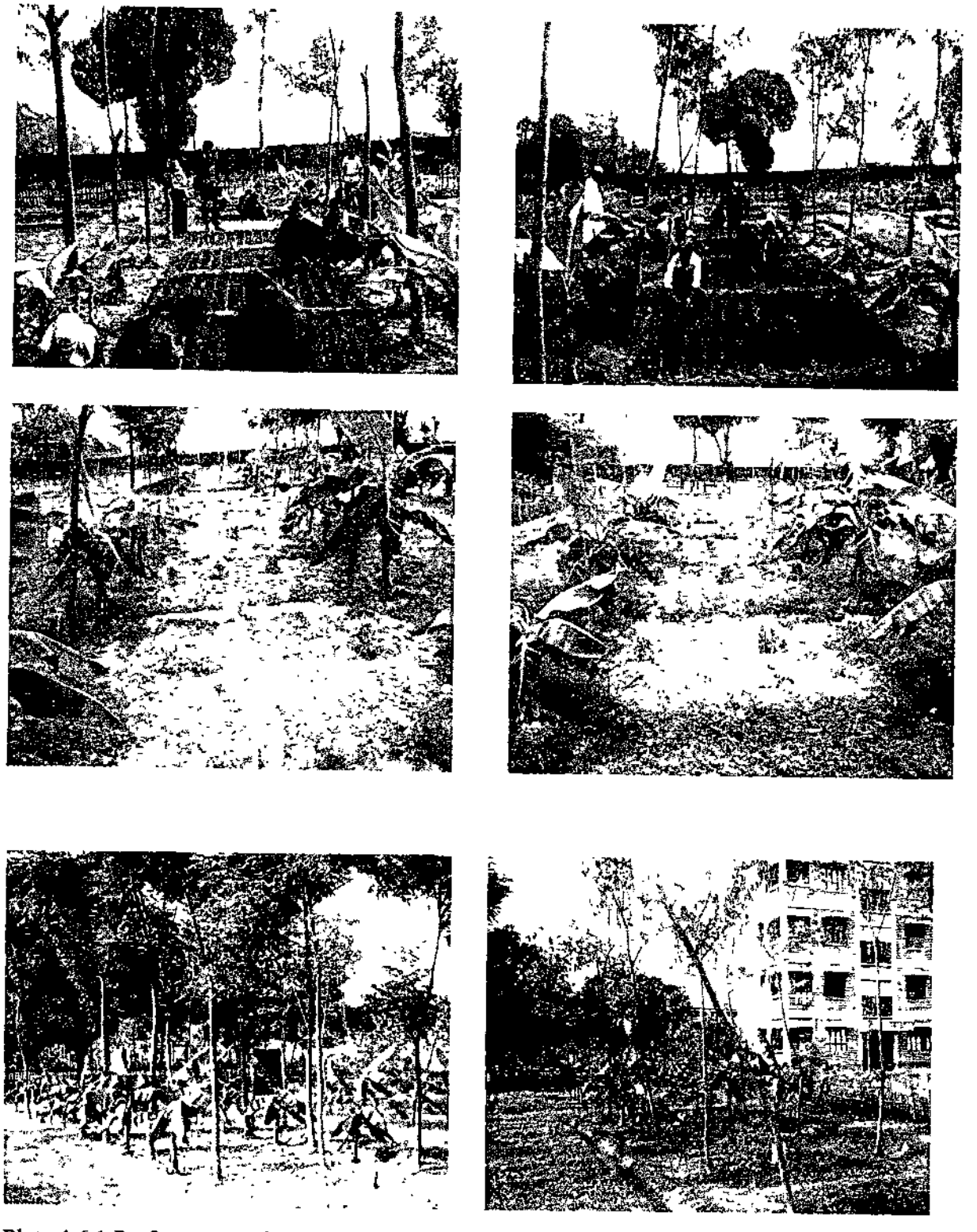

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Experiment # 7 Effect of Lower Storied Crops on the Performance of MPTs

7.1 Mean Annual Increment: Mean annual increment (MAI) is one of the most important growth parameter for tree species. It is usually used for height, girth, canopy and volume which are described bellow-

7.1.1Tree height: Mean annual increment of height of MPTs were influenced positively by the lower storied crop cultivation irrespective of tree species. Among the three tree species black siris responded highly in agroforestry practice followed by mango. Least influence was found in guava. Difference of MAI value between agroforestry species and sole species were 0.4,.03 and 0.1m in black siris, guava and mango respectively.

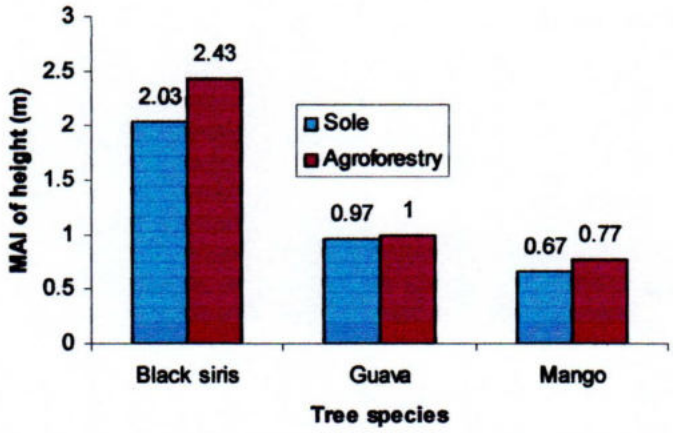

Fig 4.8.1: Mean annual increment of height of black siris, guava and mango in agroforestry and sole cultivation

7.1.2 Base girth: Mean annual increment of base girths was also influenced positively by the lower storied crop cultivation irrespective of tree species. Incase of base girth increment order was black siris >guava>mango. Difference of MAI value between agroforestry species and sole species were1.0, 0.47 and 0 .4 cm in black siris, guava and mango, respectively

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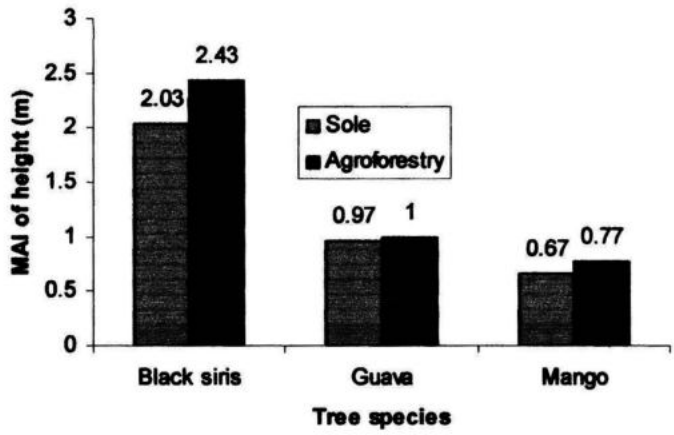

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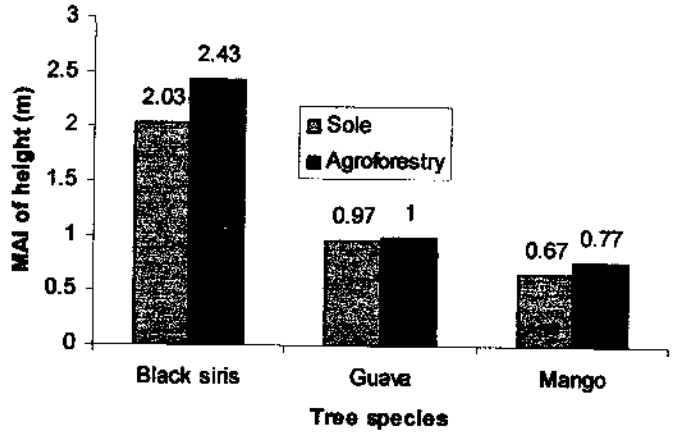

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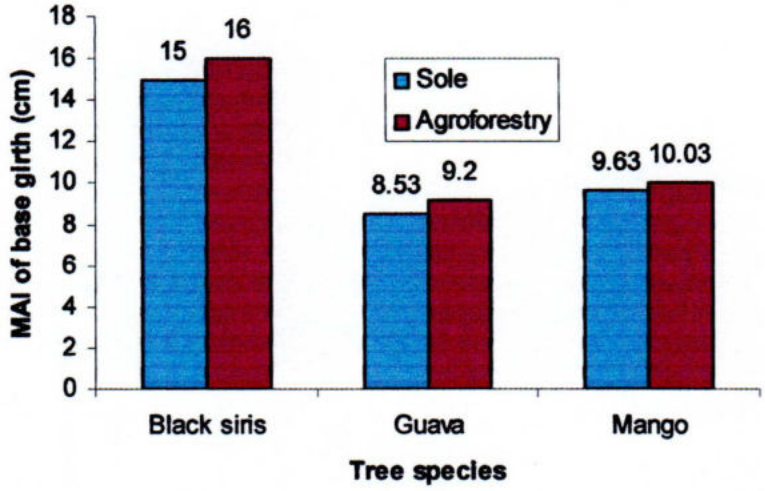
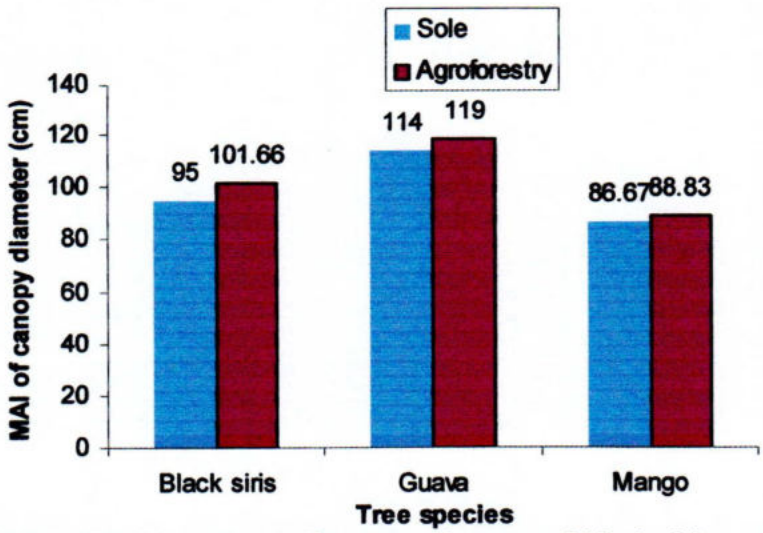


Fig 4.8.2: Mean annual increment of base girth of black siris, guava and mango in agroforestry and sole cultivation

7.1.3 Canopy Diameter: Mean annual increment of canopy diameters were influenced positively but the ranking order was different to previous parameters. Increment order of canopy diameter was guava >black siris >mango . Difference of MAI value between agroforestry species and sole species were 5.0, 6.66 and 2.16 cm in black siris, guava and mango respectively



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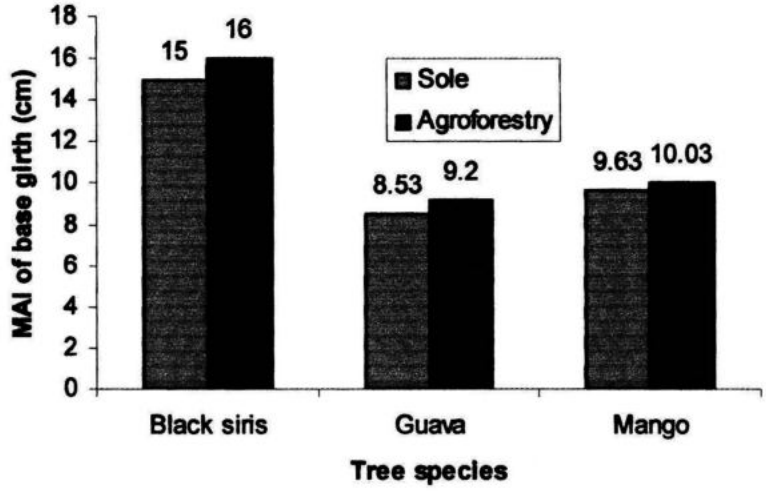

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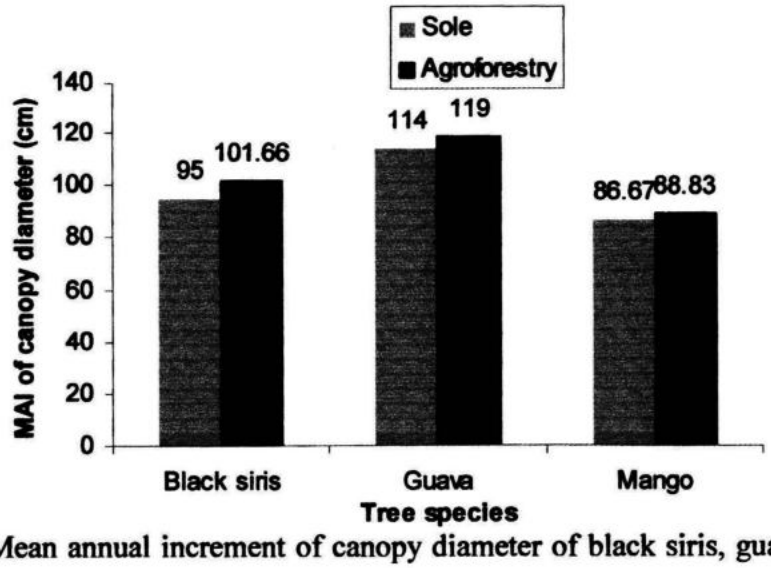

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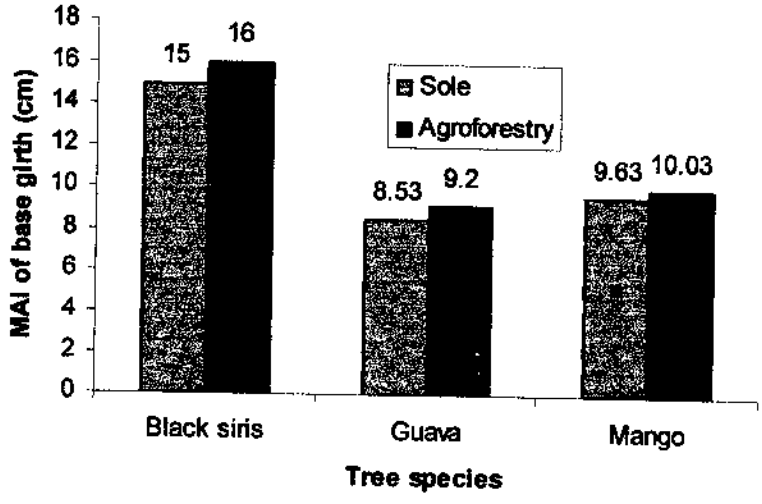

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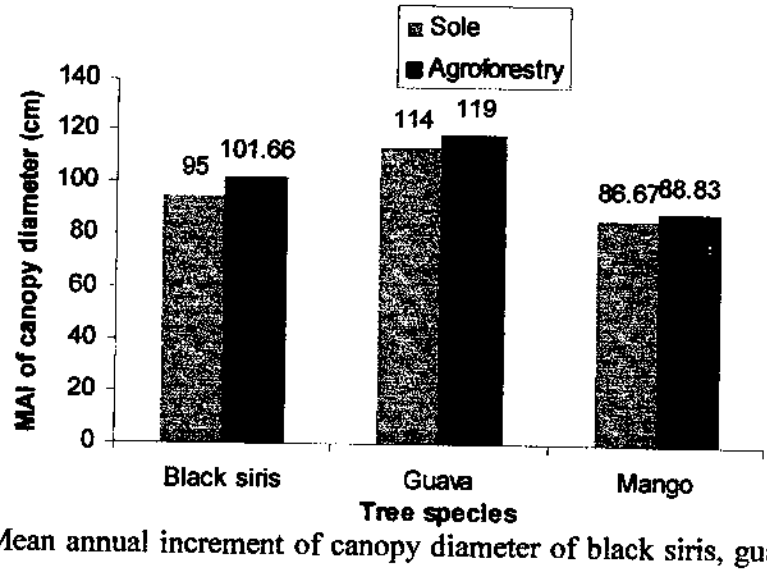
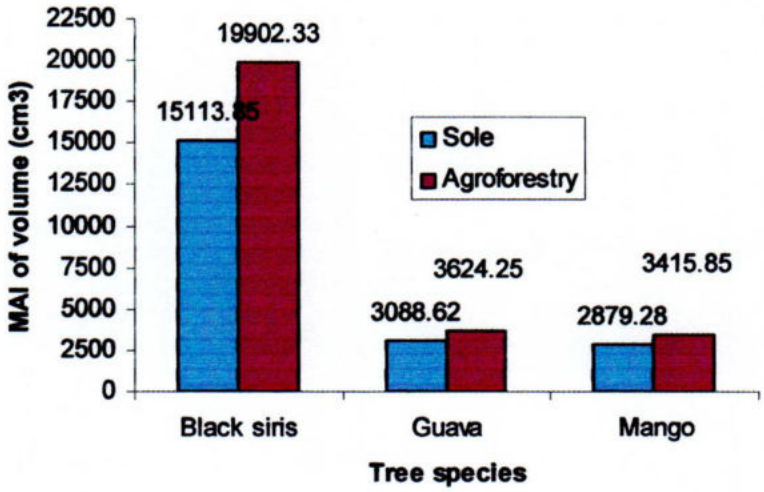


Fig 4.8.3: Mean annual increment of canopy diameter of black siris, guava and mango in agroforestry and sole cultivation

7.1.4 Volume: Mean annual increment of volumes were influenced positively and increment orded was similar to that of base girth ie, black siris > mango > guava but the difference of MAI value between agroforestry species and sole species were 4788.48, 535.63 and 536.57 cm3 in black siris, guava and mango, respectively.



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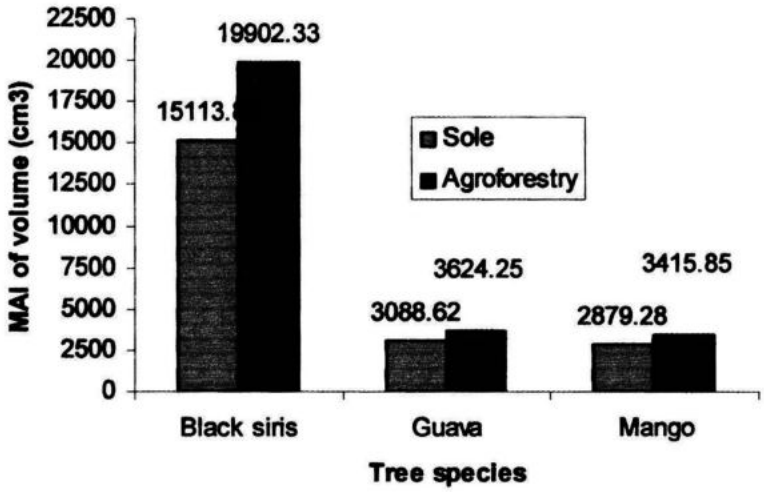

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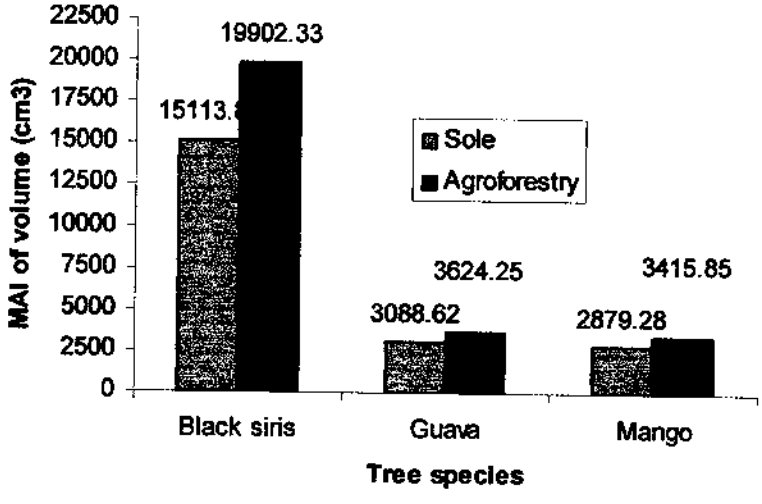

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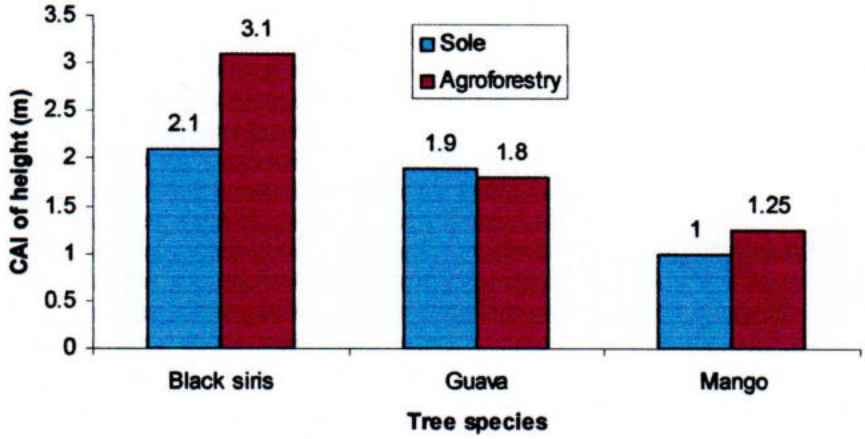

Fig 4.8.5: Current annual increment of height of black siris, guava and mango in agroforestry and sole cultivation

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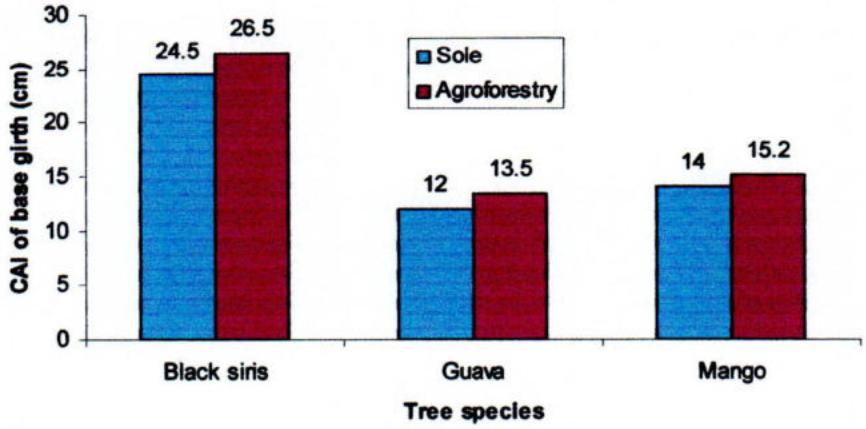

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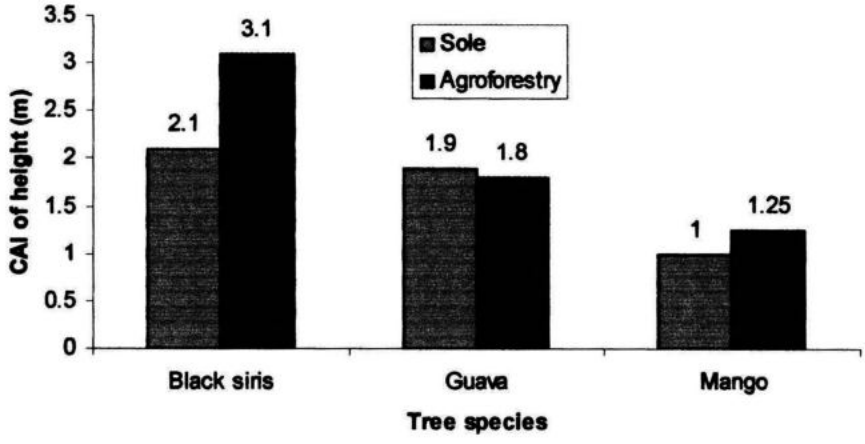

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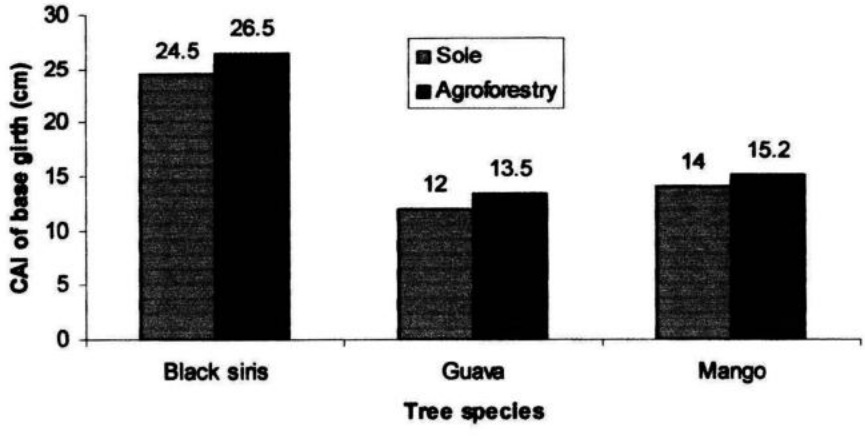

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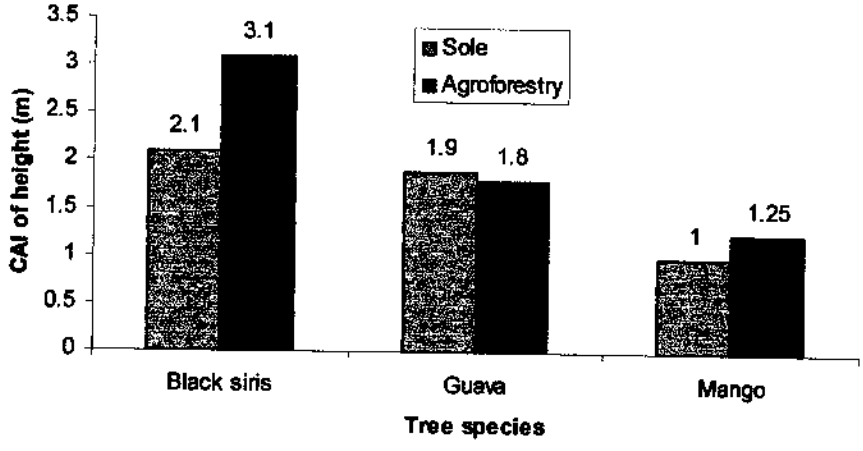

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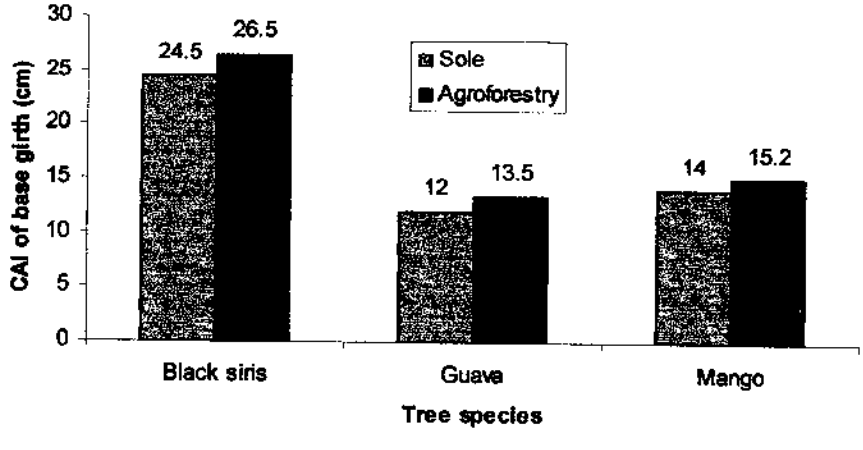

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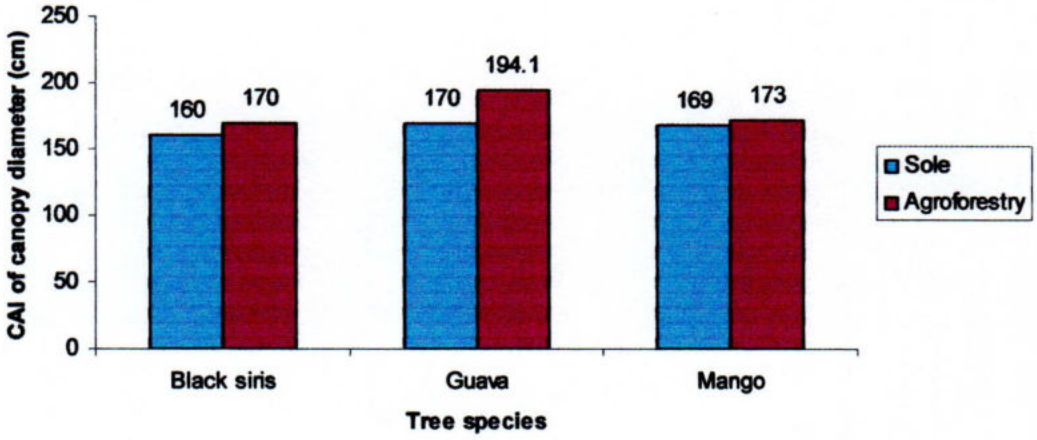

Fig 4.8.7: Current annual increment of canopy diameter of black siris, guava and mango in agroforestry and sole cultivation

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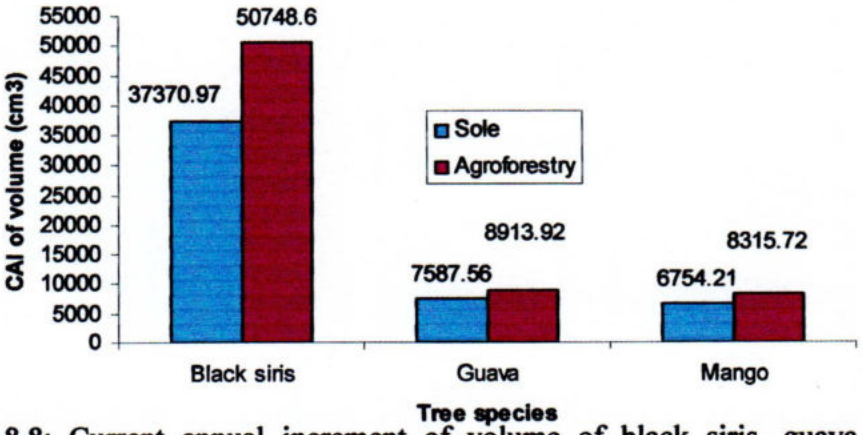

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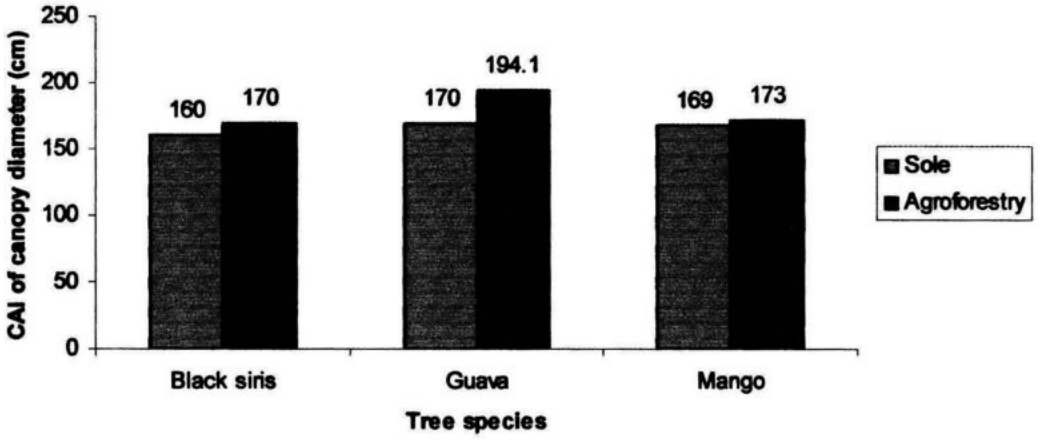

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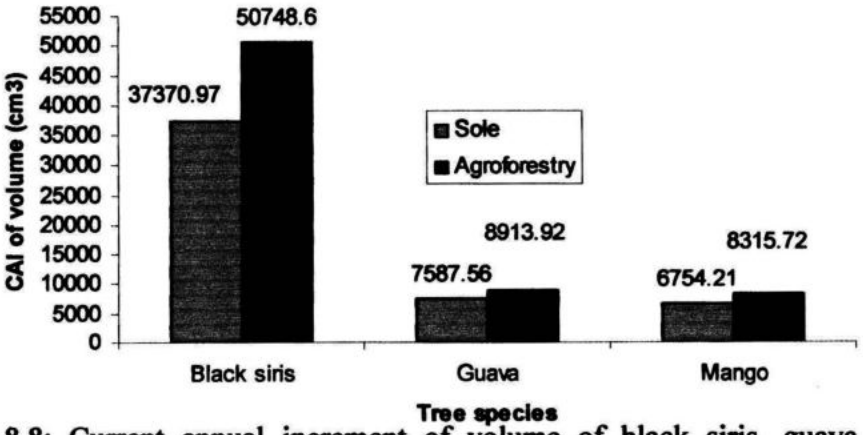

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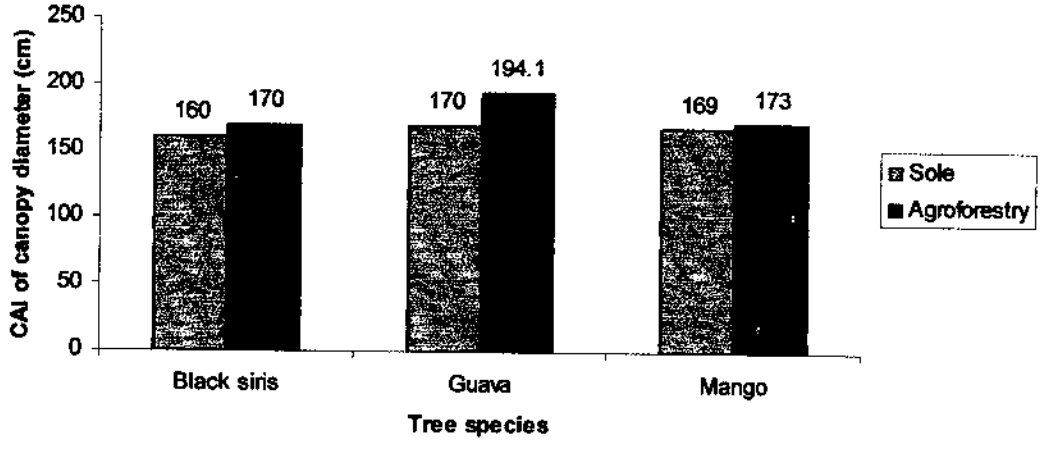

Fig 4.8.7: Current annual increment of canopy diameter of black siris, guava and mango in agroforestry and sole cultivation

7.2.4 Volume: Current annual increment of volumes were influenced positively and increment order was similar to that of base girth ie, black siris > mango > guava but the difference of MAI value between agroforestry species and sole species were 13377.63, 1326.36 and 1561.51 cm3 in black siris, guava and mango respectively

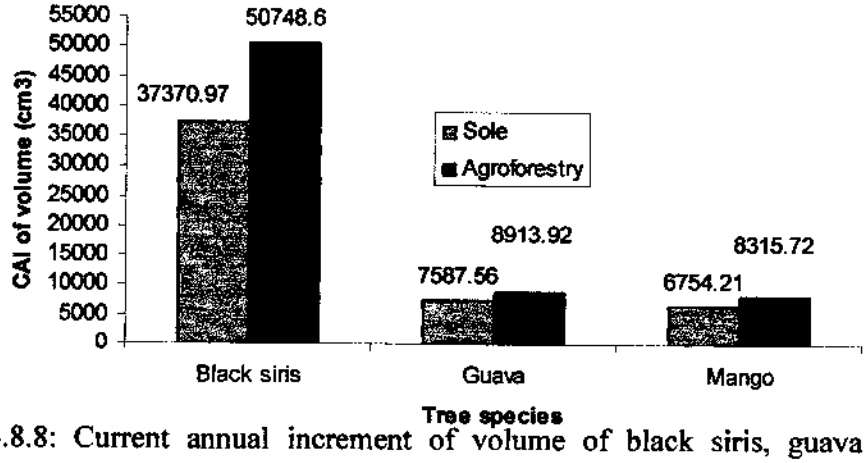

Fig 4.8.8: Current annual increment of volume of black siris, guava and mango in agroforestry and sole cultivation

7.3 Mean Annual Increment: Mean annual increment (MAI) is one of the most important growth parameter for tree species. It is usually used for height, girth, girth at breast height and volume which are described bellow-

7.3.1 Tree height: Mean annual increment of height of MPTs were influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest height (2.57m) has been observed in goraneem+ banana+ potato+ onion followed by goraneem+ banana. On the other hand lowest height (2.23 m) have been observed in goraneem (sole).

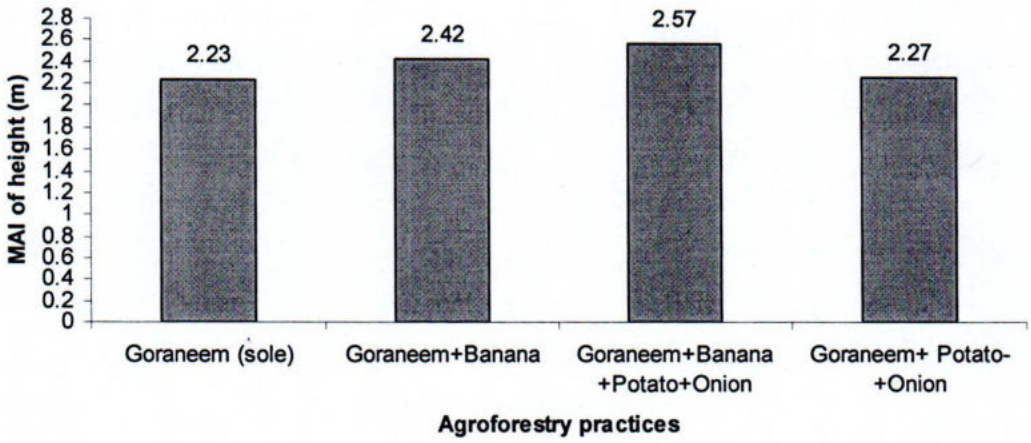

Fig 4.8.9: Mean annual increment of height for goraneem in different multistory agroforestry practices

7.3.2 Base girth: Mean annual increment of base girths were also influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest base girth (17.93cm) has been observed in goraneem+ banana+ potato+ onion followed by goraneem+ potato+ onion. On the other hand lowest base girth (2.23 cm) has been observed in goraneem (sole).

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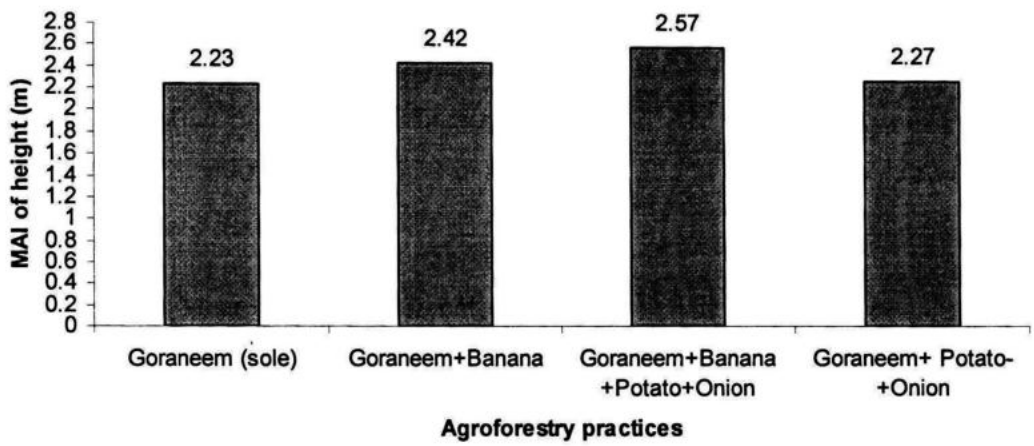

Fig 4.8.9: Mean annual increment of height for goraneem in different multistory agroforestry practices

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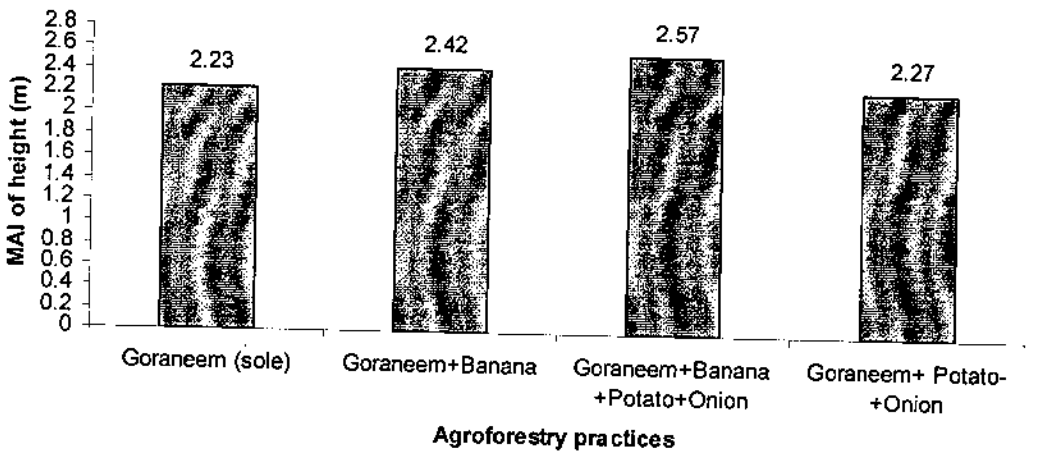

Fig 4.8.9: Mean annual increment of height for goraneem in different multistory agroforestry practices

7.3.2 Base girth: Mean annual increment of base girths were also influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest base girth (17.93cm) has been observed in goraneem+ banana+ potato+ onion followed by goraneem+ potato+ onion. On the other hand lowest base girth (2.23 cm) has been observed in goraneem (sole).

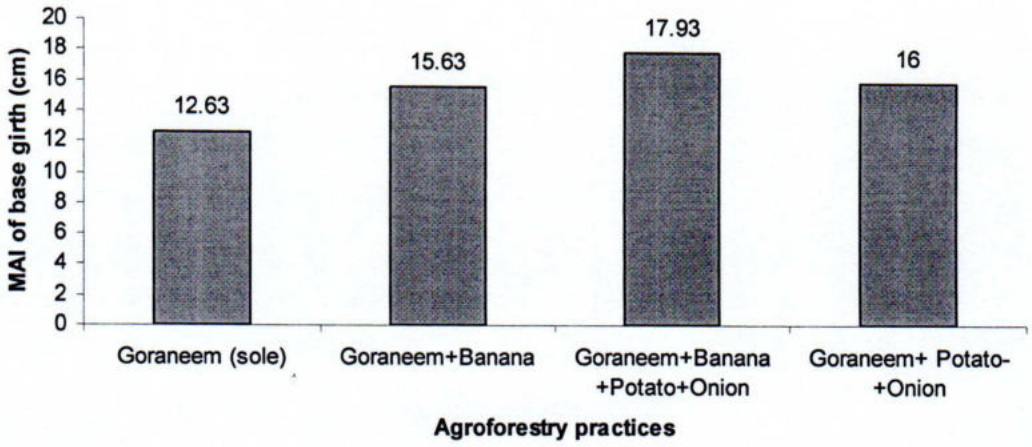

Fig 4.8.10: Mean annual increment of base girth for goraneem in different multistory agroforestry practices

7.3.3 Girth at breast height: Mean annual increment of girth at breast height was influenced positively but the ranking order was different. Among the different multistoried practice, highest girth (17cm) has been observed in goraneem+ banana+ potato+ onion followed by goraneem+ banana. On the other hand lowest girth (12 cm) has been observed in goraneem (sole).

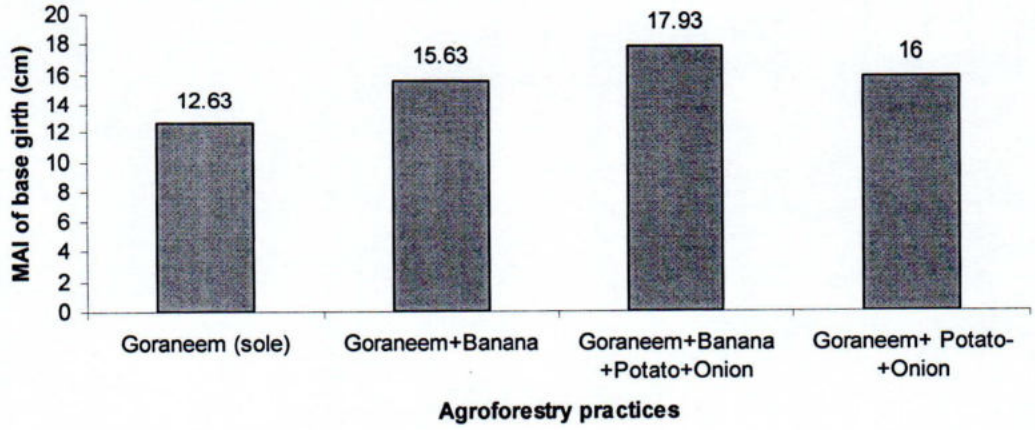

Fig 4.8.11: Mean annual increment of girth at breast height for goraneem in different multistory agroforestry practices

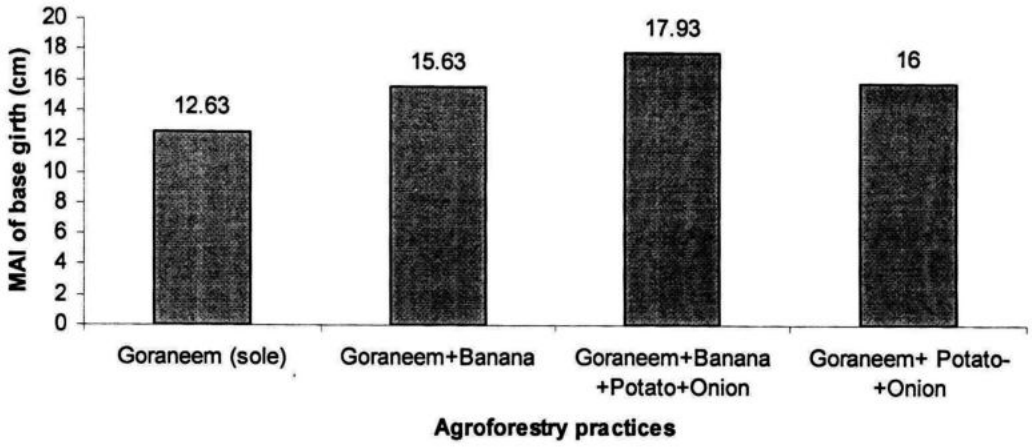

Fig 4.8.10: Mean annual increment of base girth for goraneem in different multistory agroforestry practices

7.3.3 Girth at breast height: Mean annual increment of girth at breast height was influenced positively but the ranking order was different. Among the different multistoried practice, highest girth (17cm) has been observed in goraneem+ banana+ potato+ onion followed by goraneem+ banana. On the other hand lowest girth (12 cm) has been observed in goraneem (sole).

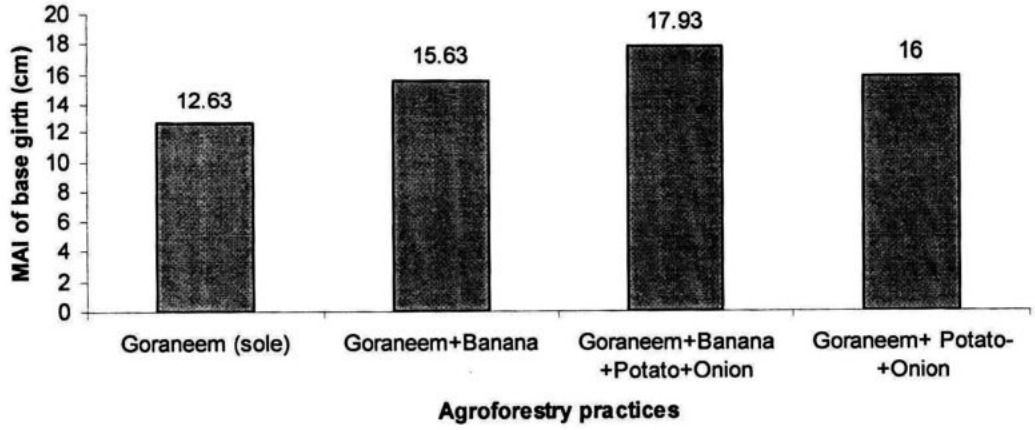

Fig 4.8.11: Mean annual increment of girth at breast height for goraneem in different multistory agroforestry practices

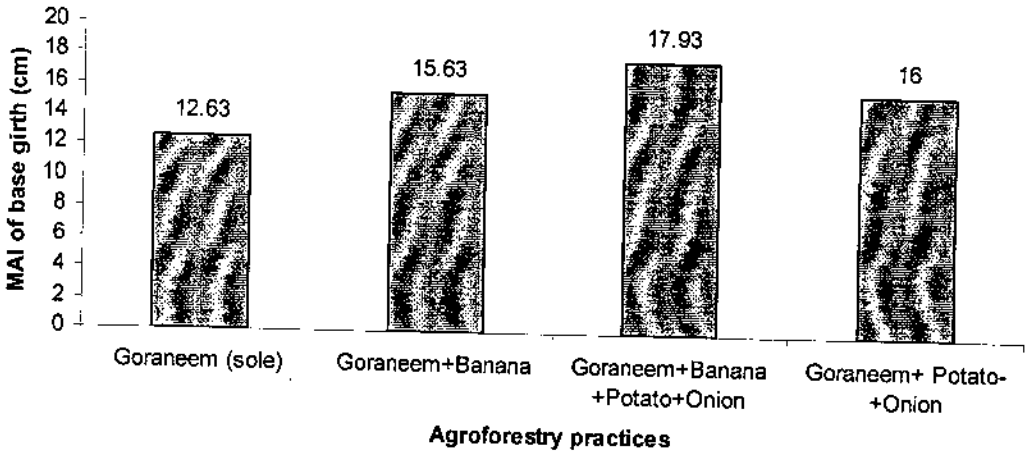

Fig 4.8.10: Mean annual increment of base girth for goraneem in different multistory agroforestry practices

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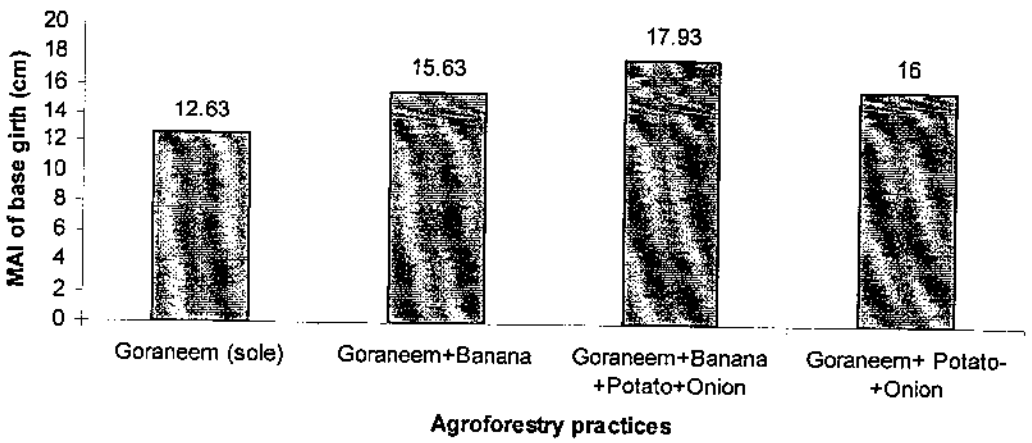

Fig 4.8.11: Mean annual increment of girth at breast height for goraneem in different multistory agroforestry practices

7.3.4 Volume: Mean annual increment of volumes were influenced positively and the ranking order was different ie, goraneem+ banana+ potato+ onion > goraneem+ banana > goraneem+ potato+ onion> goraneem but the different MAI value of agroforestry species and sole species were 27735.4, 20486.25 and 20165.61, 13108.45 cm3 in goraneem+ banana+ potato+ onion, goraneem+ banana, goraneem+ potato+ onion and goraneem

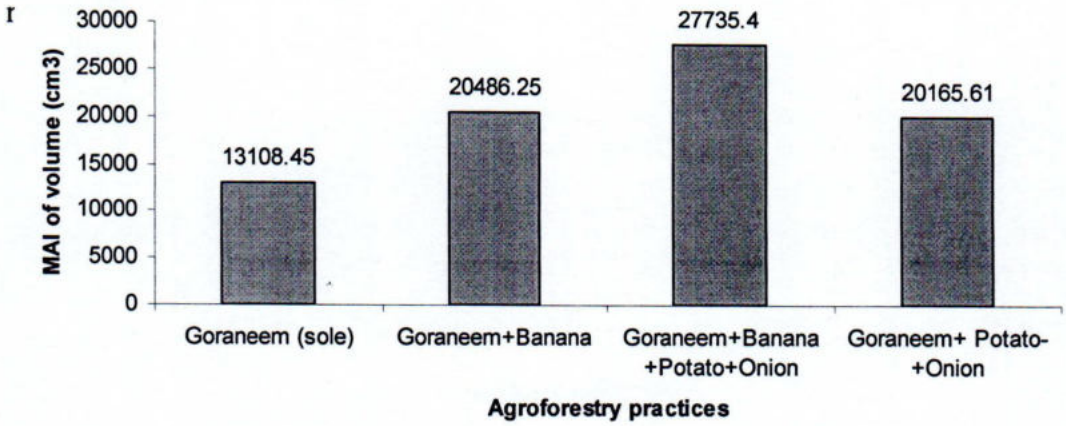

Fig 4.8.12: Mean annual increment of volume for goraneem in different multistory agroforestry practices

7.4 Current Annual Increment: Current annual increment (CAI) is one of the most important growth parameter for tree species. It is usually used for height, girth, girth at breast height and volume which are described bellow-

7.4.1 Tree height: Current annual increment of height of MPTs were influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest height (1.95m) has been observed in goraneem+ banana+ potato+ onion followed by goraneem+ banana (1.9m). On the other hand lowest height (1.55 m) have been observed in goraneem + potato+ onion.

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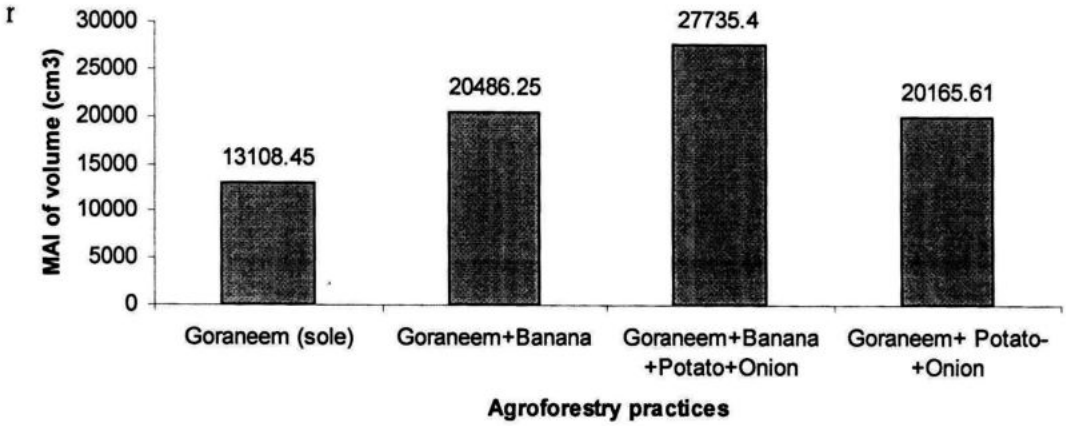

Fig 4.8.12: Mean annual increment of volume for goraneem in different multistory agroforestry practices

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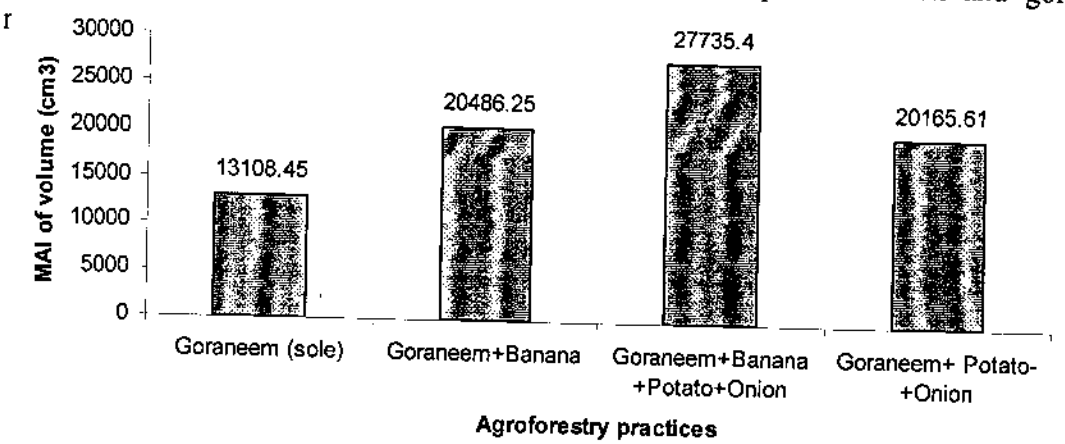

Fig 4.8.12: Mean annual increment of volume for goraneem in different multistory agroforestry practices

7.4 Current Annual Increment: Current annual increment (CAI) is one of the most important growth parameter for tree species. It is usually used for height, girth, girth at breast height and volume which are described bellow-

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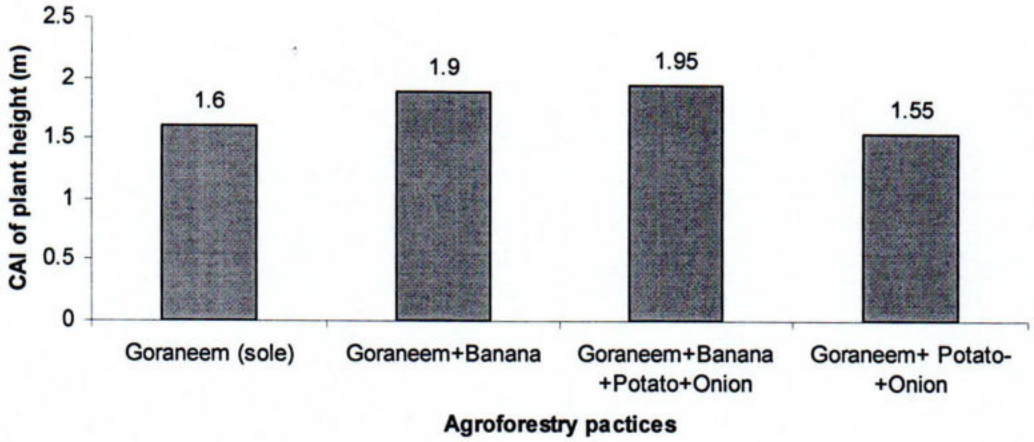

Fig 4.8.13: Current annual increment of plant height for goraneem in different multistory agroforestry practices

7.4.2 Base girth: Current annual increment of base girths were also influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest base girth (20cm) has been observed in goraneem + potato+ onion followed by goraneem+ banana+ potato+ onion(15cm). On the other hand lowest base girth (13 cm) has been observed in goraneem (sole).

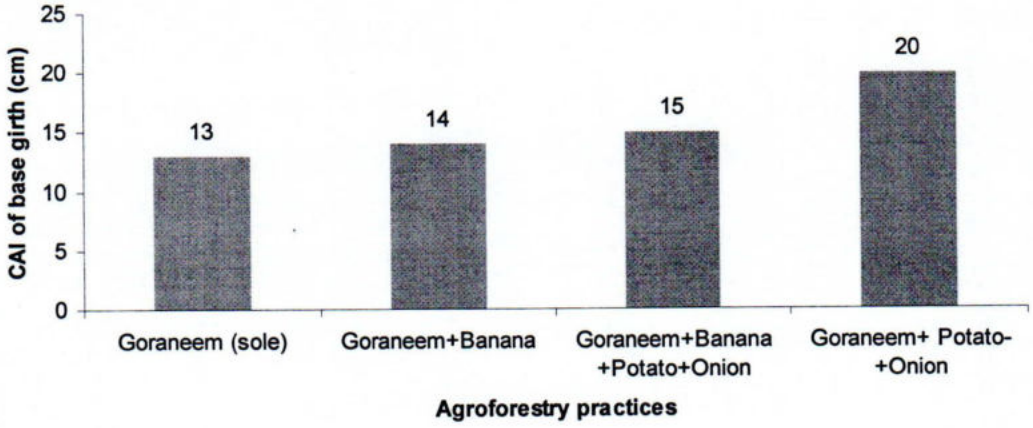

Fig 4.8.14: Current annual increment of base girth for goraneem in different multistory agroforestry practices

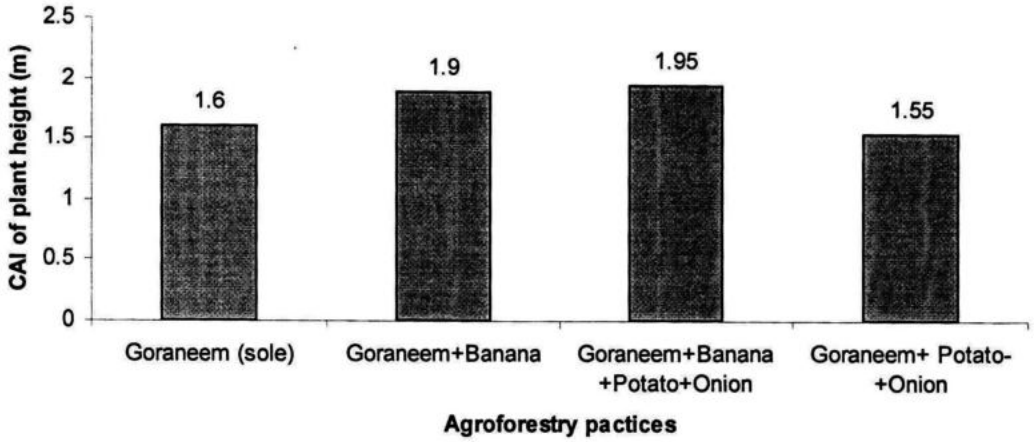

Fig 4.8.13: Current annual increment of plant height for goraneem in different multistory agroforestry practices

7.4.2 Base girth: Current annual increment of base girths were also influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest base girth (20cm) has been observed in goraneem + potato+ onion followed by goraneem+ banana+ potato+ onion(15cm). On the other hand lowest base girth (13 cm) has been observed in goraneem (sole).

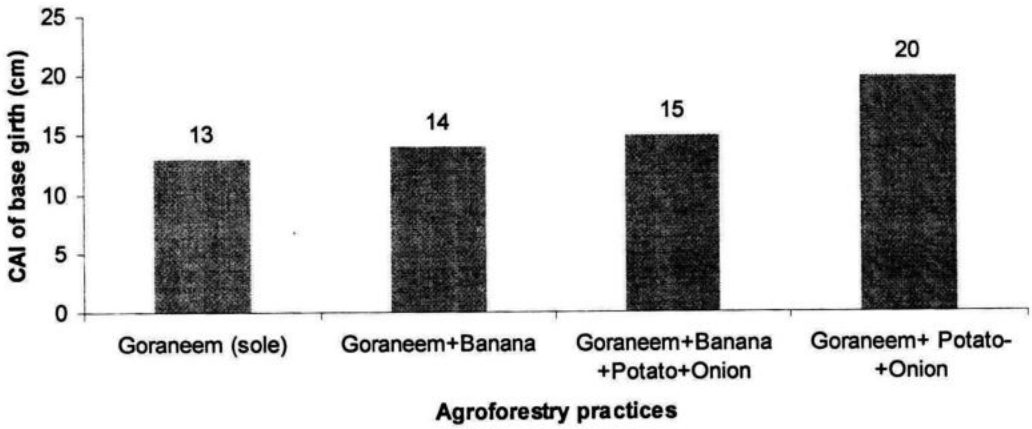

Fig 4.8.14: Current annual increment of base girth for goraneem in different multistory agroforestry practices

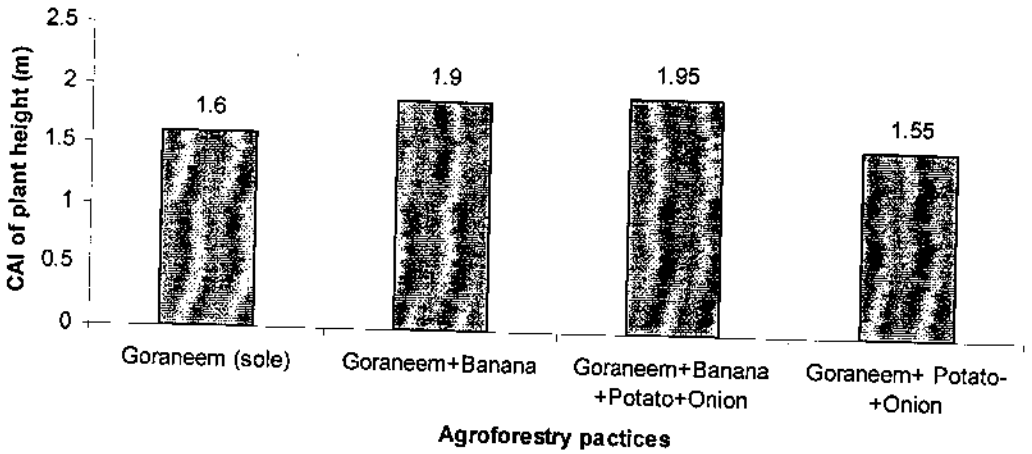

Fig 4.8.13: Current annual increment of plant height for goraneem in different multistory agroforestry practices

7.4.2 Base girth: Current annual increment of base girths were also influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest base girth (20cm) has been observed in goraneem + potato+ onion followed by goraneem+ banana+ potato+ onion(15cm). On the other hand lowest base girth (13 cm) has been observed in goraneem (sole).

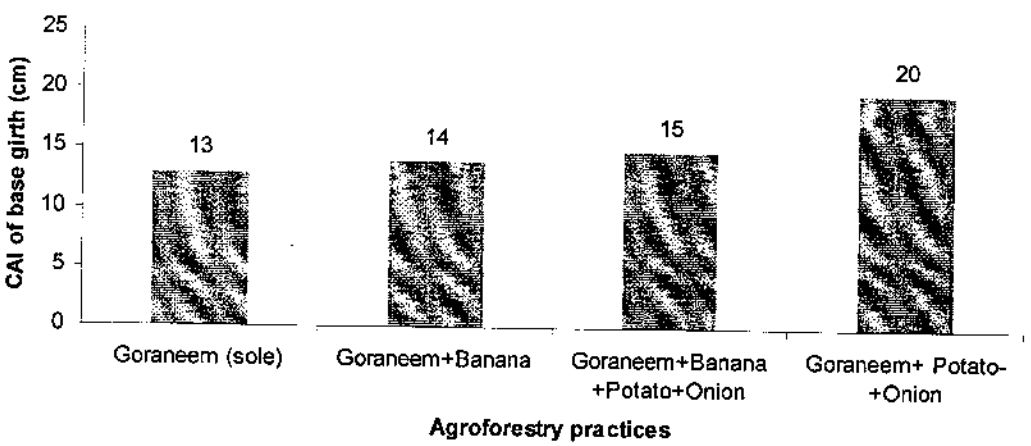

Fig 4.8.14: Current annual increment of base girth for goraneem in different multistory agroforestry practices

7.4.3 Girth at breast height: Current annual increment of girth at breast height was influenced positively but the ranking order was different. Among the different multistoried practice, highest girth (17cm) has been observed in goraneem+ potato+ onion and goraneem+ banana followed by goraneem+ banana+ potato+ onion(16cm). On the other hand lowest girth (10 cm) has been observed in goraneem (sole).

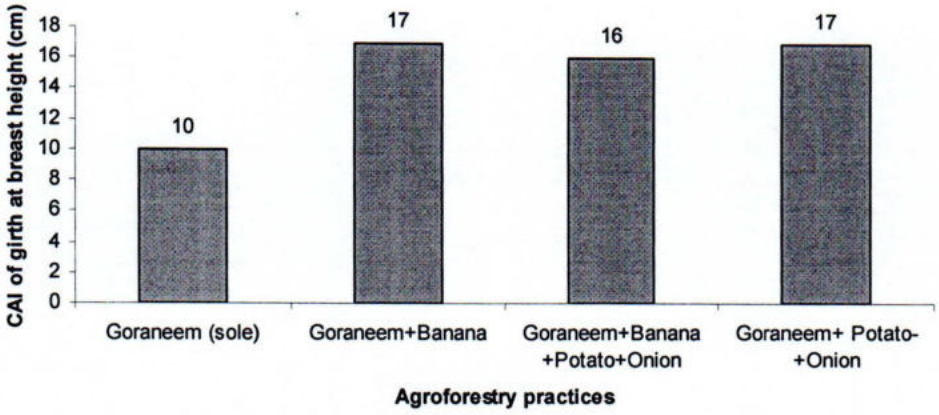

Fig 4.8.15: Current annual increment of girth at breast height for goraneem in different multistory agroforestry practices

7.4.4 Volume: Current annual increment of volumes was influenced positively and the ranking order was different ie, goraneem+ banana+ potato+ onion > goraneem+ potato+ onion > goraneem+ banana > goraneem (sole) but the different MAI value of agroforestry species and sole species were 57764.93, 41628.07 and 35990.6, 24124.95 cm3 in goraneem+ banana+ potato+ onion, goraneem+ potato+ onion, goraneem+ banana and goraneem, respectively.

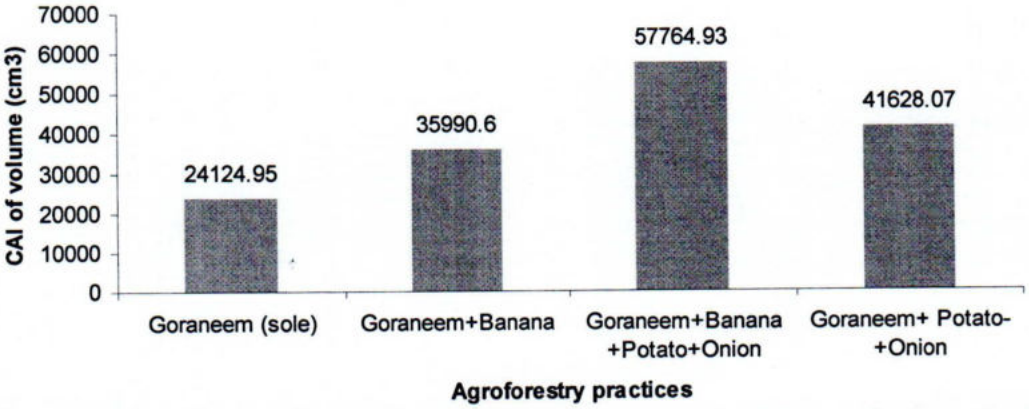

Fig 4.8.16: Current annual increment of volume for goraneem in different multistory agroforestry practices

7.4.3 Girth at breast height: Current annual increment of girth at breast height was influenced positively but the ranking order was different. Among the different multistoried practice, highest girth (17cm) has been observed in goraneem+ potato+ onion and goraneem+ banana followed by goraneem+ banana+ potato+ onion(16cm). On the other hand lowest girth (10 cm) has been observed in goraneem (sole).

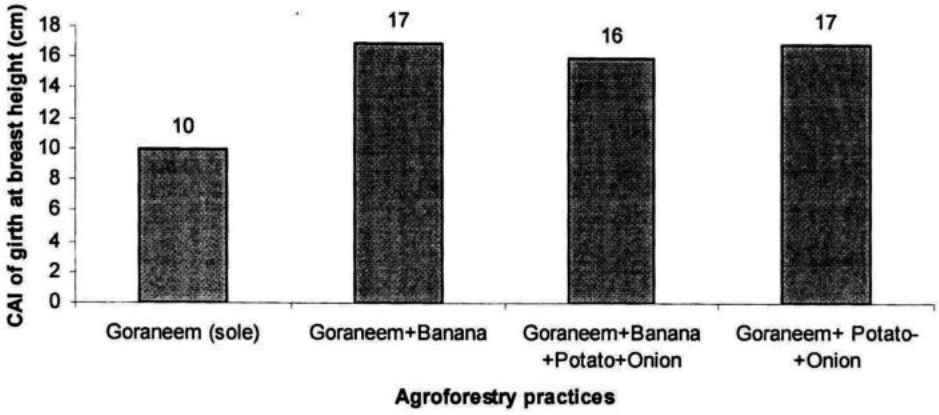

Fig 4.8.15: Current annual increment of girth at breast height for goraneem in different multistory agroforestry practices

7.4.4 Volume: Current annual increment of volumes was influenced positively and the ranking order was different ie, goraneem+ banana+ potato+ onion > goraneem+ potato+ onion > goraneem+ banana > goraneem (sole) but the different MAI value of agroforestry species and sole species were 57764.93, 41628.07 and 35990.6, 24124.95 cm3 in goraneem+ banana+ potato+ onion, goraneem+ potato+ onion, goraneem+ banana and goraneem, respectively.

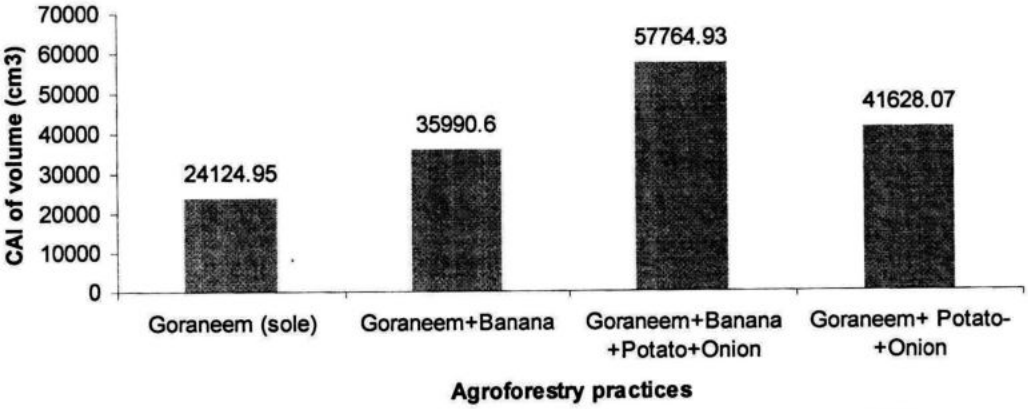

Fig 4.8.16: Current annual increment of volume for goraneem in different multistory agroforestry practices

7.4.3 Girth at breast height: Current annual increment of girth at breast height was influenced positively but the ranking order was different. Among the different multistoried practice, highest girth (17cm) has been observed in goraneem+ potato+ onion and goraneem+ banana followed by goraneem+ banana+ potato+ onion(16cm). On the other hand lowest girth (10 cm) has been observed in goraneem (sole).

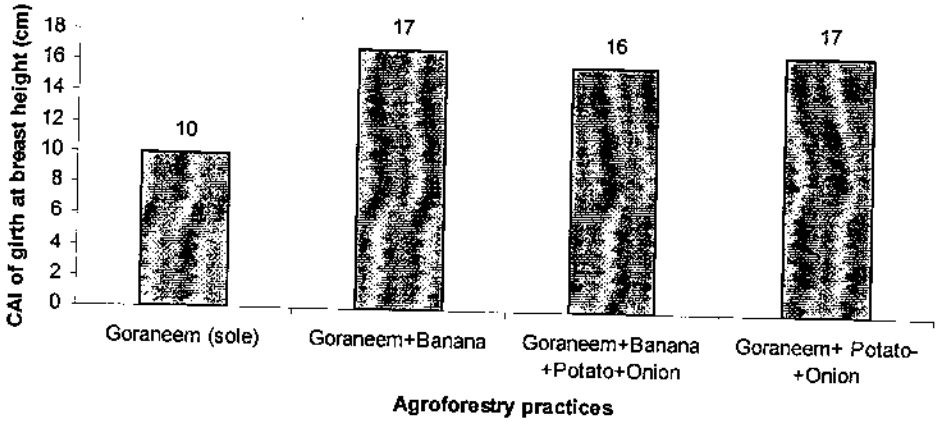

Fig 4.8.15: Current annual increment of girth at breast height for goraneem in different multistory agroforestry practices

7.4.4 Volume: Current annual increment of volumes was influenced positively and the ranking order was different ie, goraneem+ banana+ potato+ onion > goraneem+ potato+ onion > goraneem+ banana > goraneem (sole) but the different MAI value of agroforestry species and sole species were 57764.93, 41628.07 and 35990.6, 24124.95 cm3 in goraneem+ banana+ potato+ onion, goraneem+ potato+ onion, goraneem+ banana and goraneem, respectively.

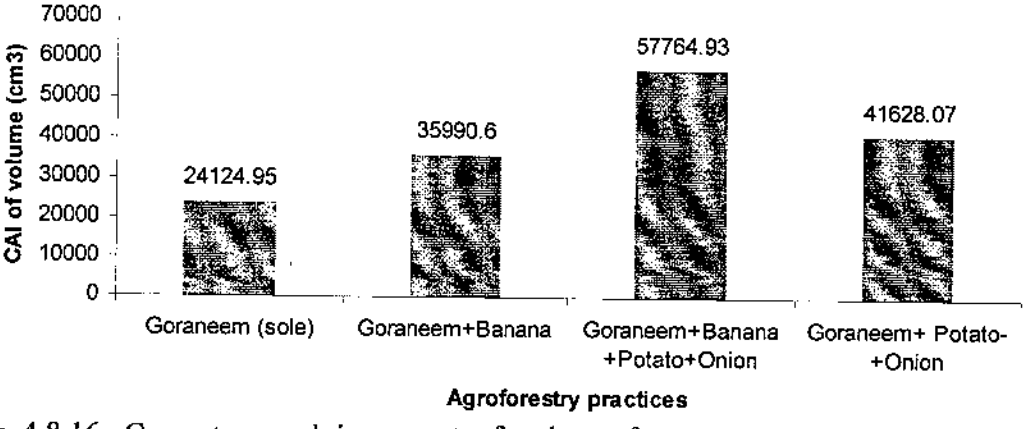

Fig 4.8.16: Current annual increment of volume for goraneem in different multistory agroforestry practices

7.5 Mean Annual Increment: Mean annual increment (MAI) is one of the most important growth parameters for tree species. It is usually used for height, girth, girth at breast height and volume which are described bellow-

7.5.1 Tree height: Mean annual increment of height of MPTs were influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest height (2.57m) has been observed in ipil-ipil+ banana+ potato+ onion followed by ipil-ipil+ potato+ onion (2.52 m). On the other hand lowest height (2.5 m) has been observed in ipil-ipil (sole).

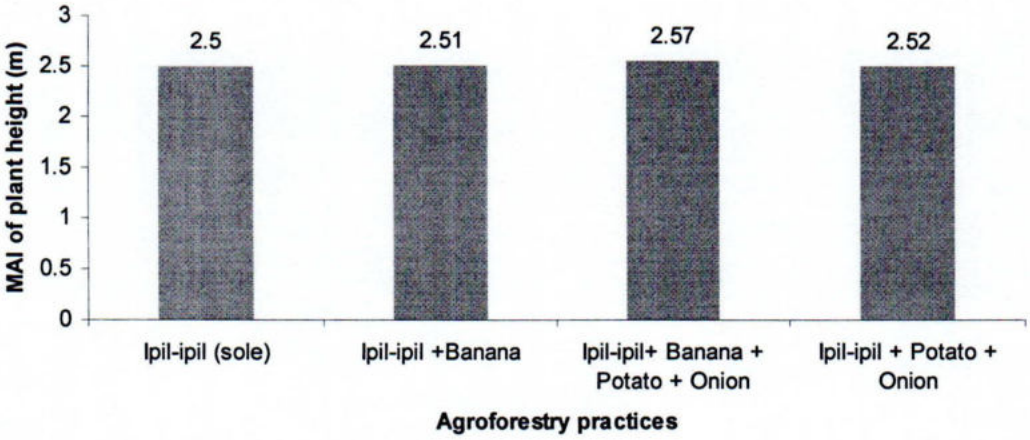

Fig 4.8.17: Mean annual increment of height for ipil-ipil in different multistory agroforestry practices

7.5.2 Base girth: Mean annual increment of base girths were also influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest base girth (13.51cm) has been observed in ipil-ipil+ potato+ onion followed by ipil-ipil (sole). On the other hand lowest base girth (12.15 cm) has been observed in ipil-ipil+ banana.

7.5 Mean Annual Increment: Mean annual increment (MAI) is one of the most important growth parameters for tree species. It is usually used for height, girth, girth at breast height and volume which are described bellow-

7.5.1 Tree height: Mean annual increment of height of MPTs were influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest height (2.57m) has been observed in ipil-ipil+ banana+ potato+ onion followed by ipil-ipil+ potato+ onion (2.52 m). On the other hand lowest height (2.5 m) has been observed in ipil-ipil (sole).

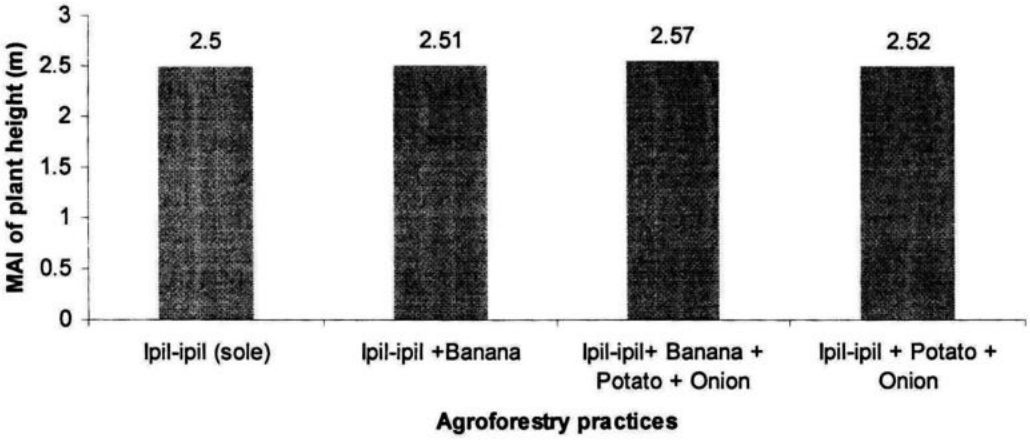

Fig 4.8.17: Mean annual increment of height for ipil-ipil in different multistory agroforestry practices

7.5.2 Base girth: Mean annual increment of base girths were also influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest base girth (13.51cm) has been observed in ipil-ipil+ potato+ onion followed by ipil-ipil (sole). On the other hand lowest base girth (12.15 cm) has been observed in ipil-ipil+ banana.

7.5 Mean Annual Increment: Mean annual increment (MAI) is one of the most important growth parameters for tree species. It is usually used for height, girth, girth at breast height and volume which are described bellow-

7.5.1 Tree height: Mean annual increment of height of MPTs were influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest height (2.57m) has been observed in ipil-ipil+ banana+ potato+ onion followed by ipil-ipil+ potato+ onion (2.52 m). On the other hand lowest height (2.5 m) has been observed in ipil-ipil (sole).

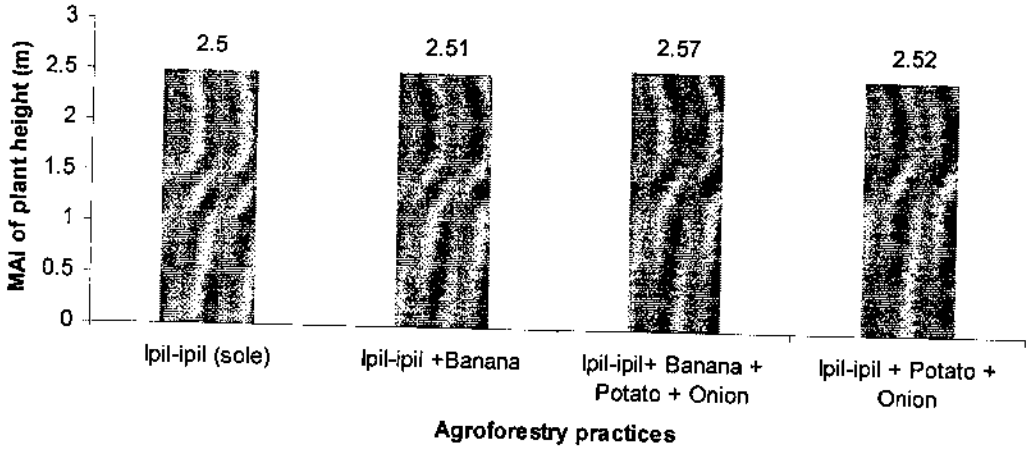

Fig 4.8.17: Mean annual increment of height for ipil-ipil in different multistory agroforestry practices

7.5.2 Base girth: Mean annual increment of base girths were also influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest base girth (13.51cm) has been observed in ipil-ipil+ potato+ onion followed by ipil-ipil (sole). On the other hand lowest base girth (12.15 cm) has been observed in ipil-ipil+ banana.

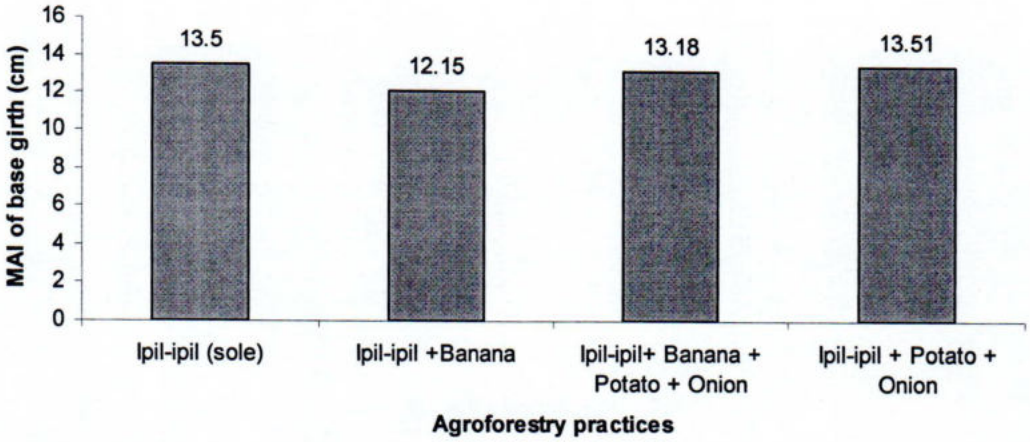

Fig 4.8.18: Mean annual increment of base girth for ipil-ipil in different multistory agroforestry practices

7.5.3 Girth at breast height: Mean annual increment of girth at breast height was influenced positively but the ranking order was different. Among the different multistoried practice, highest girth (12.83cm) has been observed in ipil-ipil (sole) and ipil-ipil+ banana+ potato+ onion followed by ipil-ipil+ potato+ onion(12.48cm). On the other hand lowest girth (10.8 cm) has been observed in ipil-ipil+ banana.

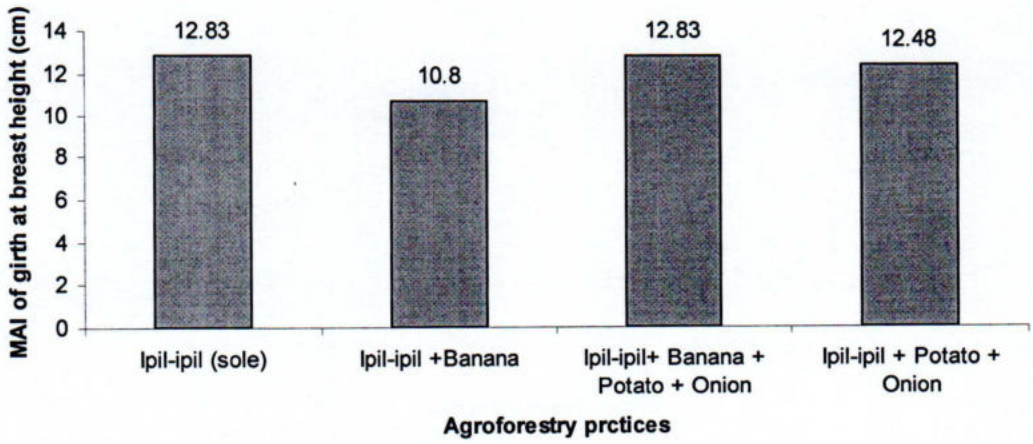

Fig 4.8.19: Mean annual increment of girth at breast height for ipil-ipil in different multistory agroforestry practices

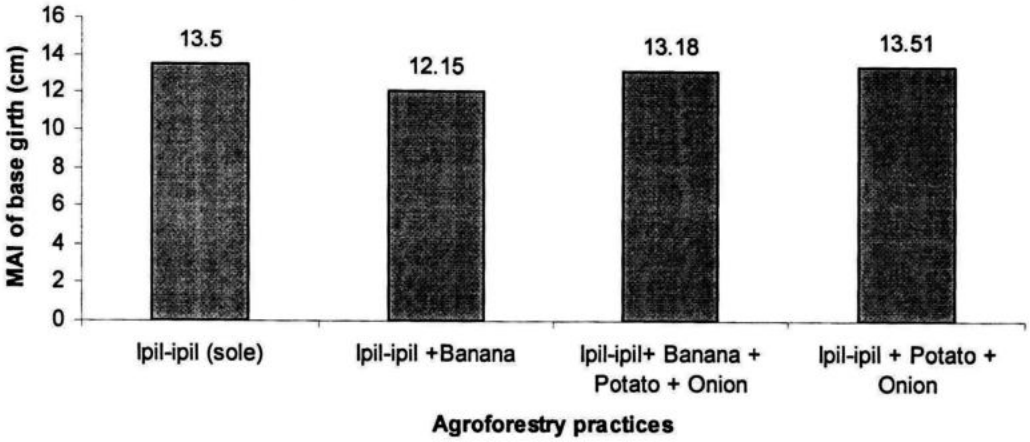

Fig 4.8.18: Mean annual increment of base girth for ipil-ipil in different multistory agroforestry practices

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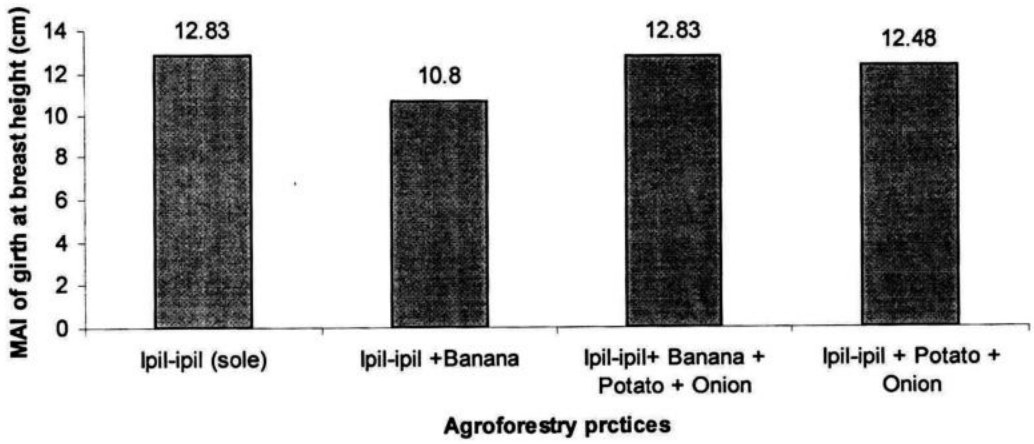

Fig 4.8.19: Mean annual increment of girth at breast height for ipil-ipil in different multistory agroforestry practices

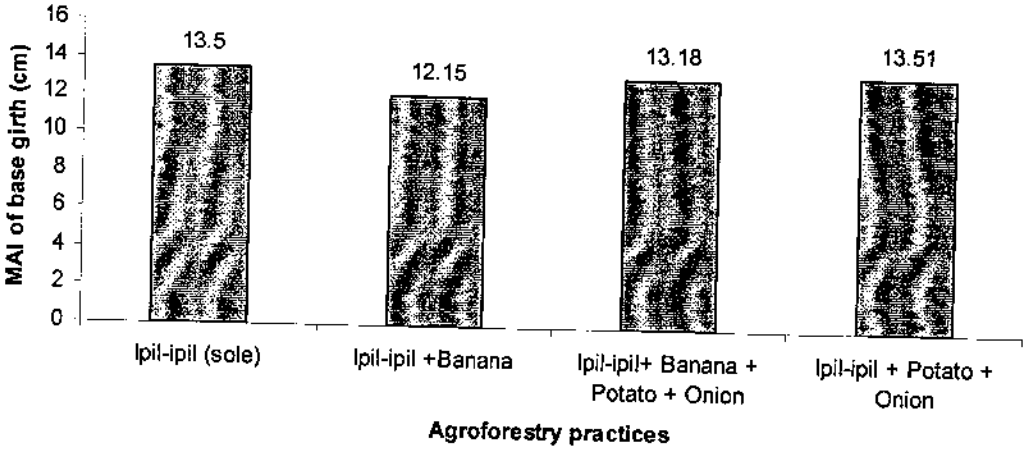

Fig 4.8.18: Mean annual increment of base girth for ipil-ipil in different multistory agroforestry practices

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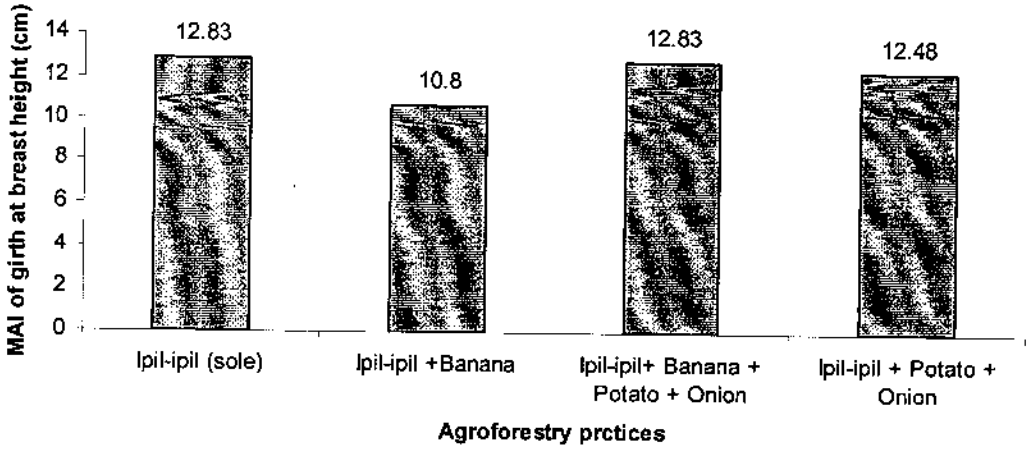

Fig 4.8.19: Mean annual increment of girth at breast height for ipil-ipil in different multistory agroforestry practices

7.5.4 Volume: Mean annual increment of volumes were influenced positively and the ranking order was different ie, ipil-ipil+ potato+ onion > ipil-ipil (sole) > ipil-ipil+ banana+ potato+ onion > ipil-ipil+ banana but the different MAI value of agroforestry species and sole species were 15463.78,15462.67,15093.17 and 12906 cm3 in ipil-ipil+ potato+ onion, ipil-ipil (sole), ipil-ipil+ banana+ potato+ onion and ipil-ipil+ banana respectively.

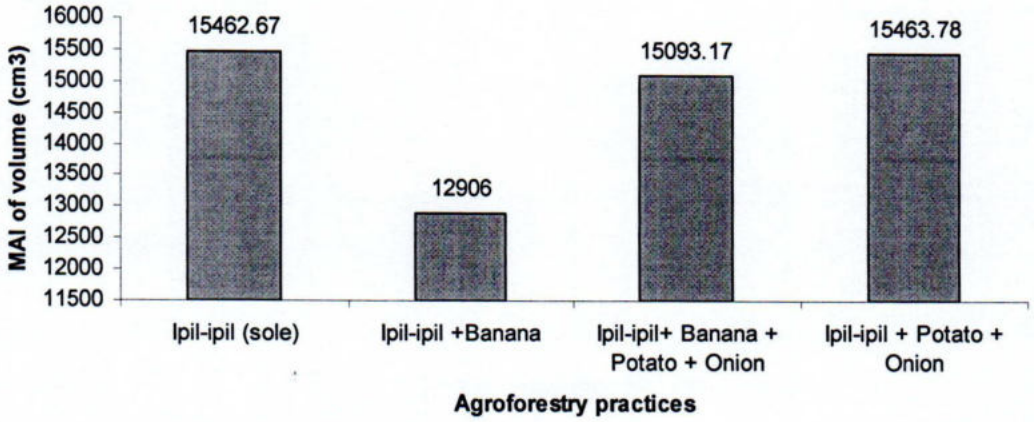

Fig 4.8.20: Mean annual increment of volume for ipil-ipil in different multistory agroforestry practices

7.6 Current Annual Increment: Current annual increment (CAI) is one of the most important growth parameter for tree species. It is usually used for height, girth, girth at breast height and volume which are described bellow-

7.6.1 Tree height: Current annual increment of height of MPTs were influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest height (2m) has been observed in ipil-ipil+ potato+ onion followed by ipil-ipil+ potato+ onion+ banana (1.8 m) and ipil-ipil+ banana . On the other hand lowest height (1.75 m) has been observed in ipil-ipil (sole).

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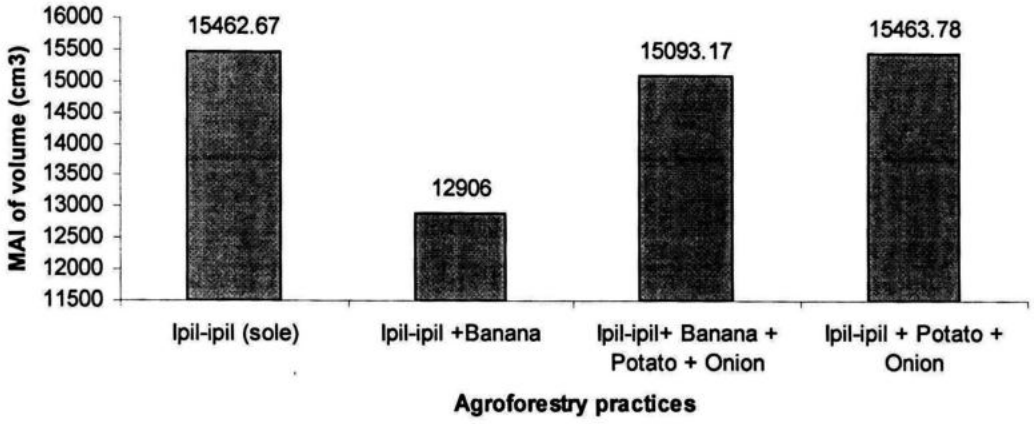

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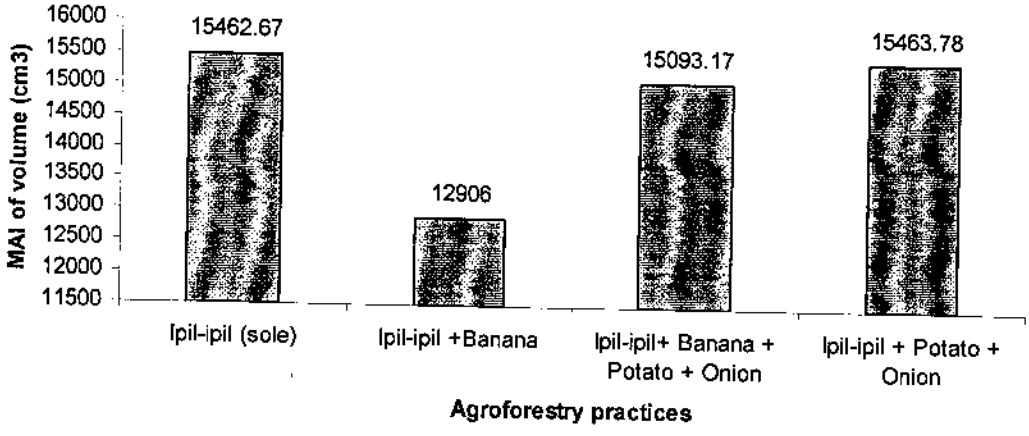

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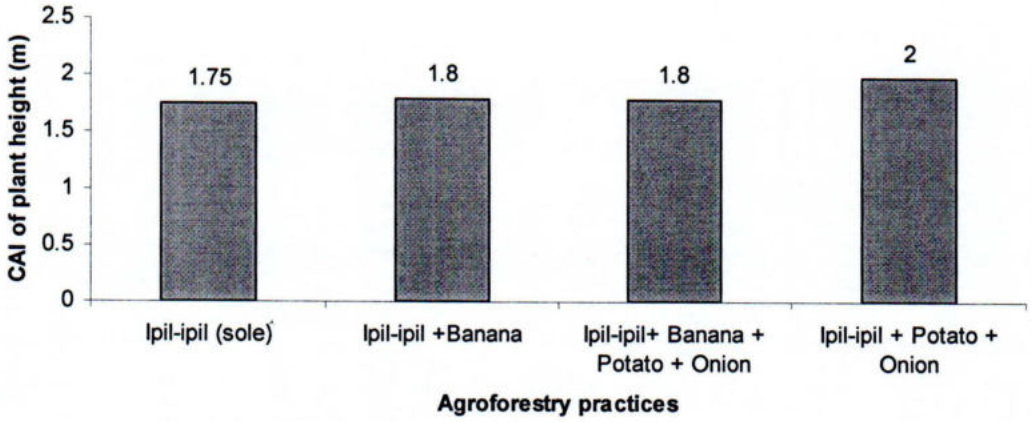


Fig 4.8.21: Current annual increment of plant height for ipil-ipil in different multistory agroforestry practices

7.6.2 Base girth: Current annual increment of base girths were also influenced positively by the lower storied crop cultivation irrespective of tree species. Among the different multistoried practice, highest base girth (19cm) has been observed in ipil-ipil (sole) followed by ipil-ipil+ potato+ onion (17cm). On the other hand lowest base girth (16 cm) has been observed in ipil-ipil+ banana and ipil-ipil+ potato+ onion+ banana.

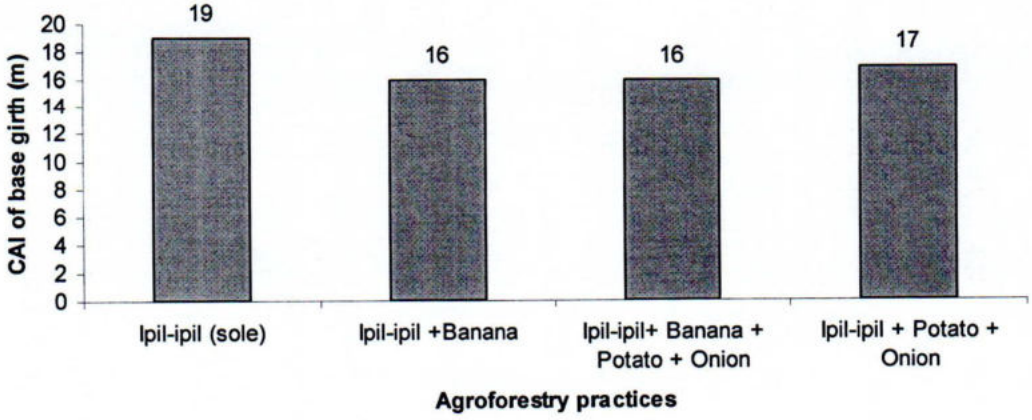
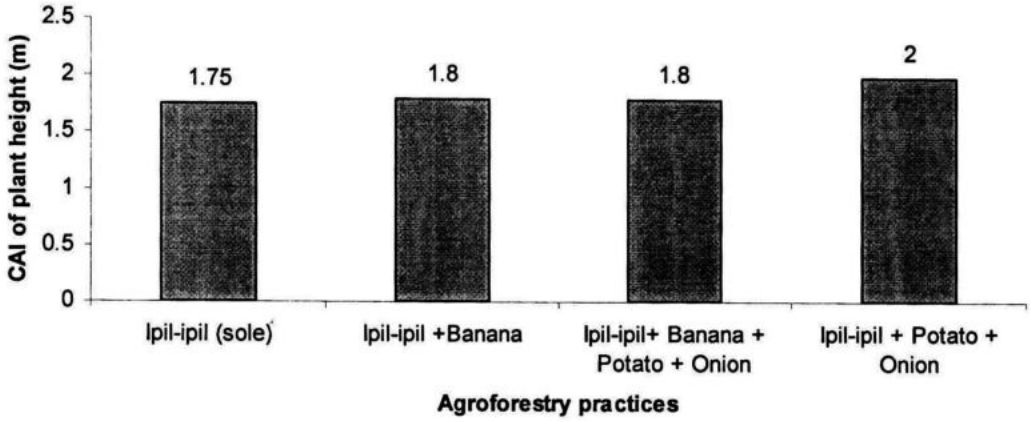


Fig 4.8.22: Current annual increment of base girth for ipil-ipil in different multistory agroforestry practices



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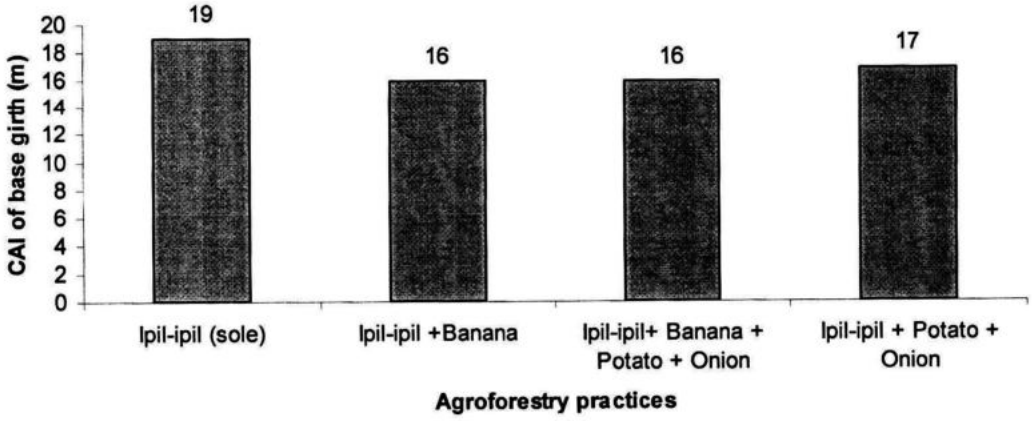
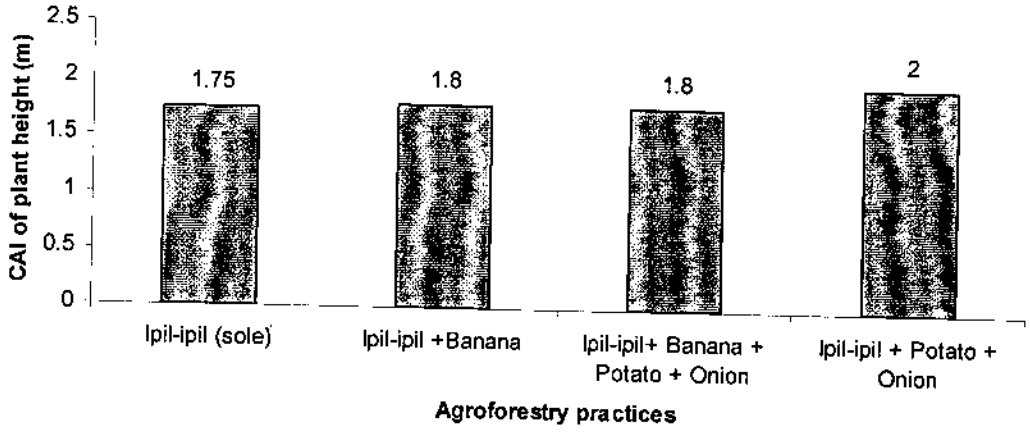


Fig 4.8.22: Current annual increment of base girth for ipil-ipil in different multistory agroforestry practices



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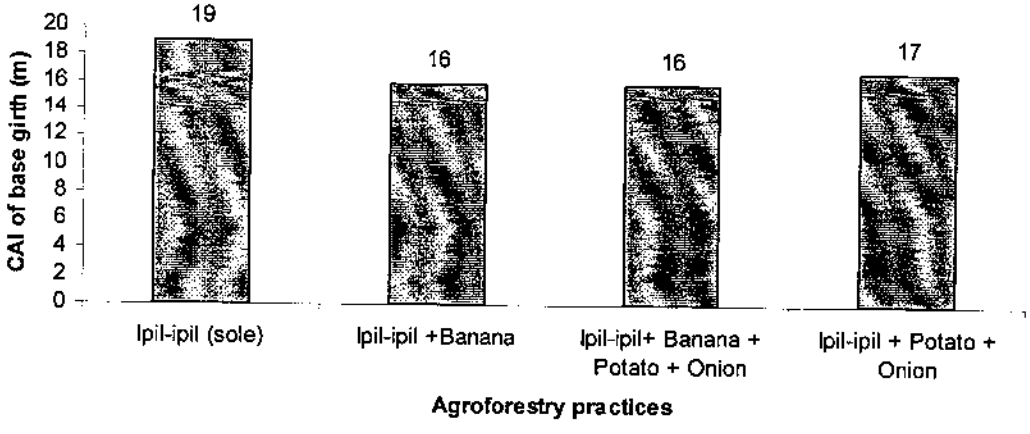

Fig 4.8.22: Current annual increment of base girth for ipil-ipil in different multistory agroforestry practices

7.6.3 Girth at breast height: Current annual increment of girth at breast height was influenced positively but the ranking order was different. Among the different multistoried practice, highest girth (23cm) has been observed in ipil-ipil (sole) followed by ipil-ipil+ potato+ onion (18cm). On the other hand lowest girth (15 cm) has been observed in ipil-inil+ banana.

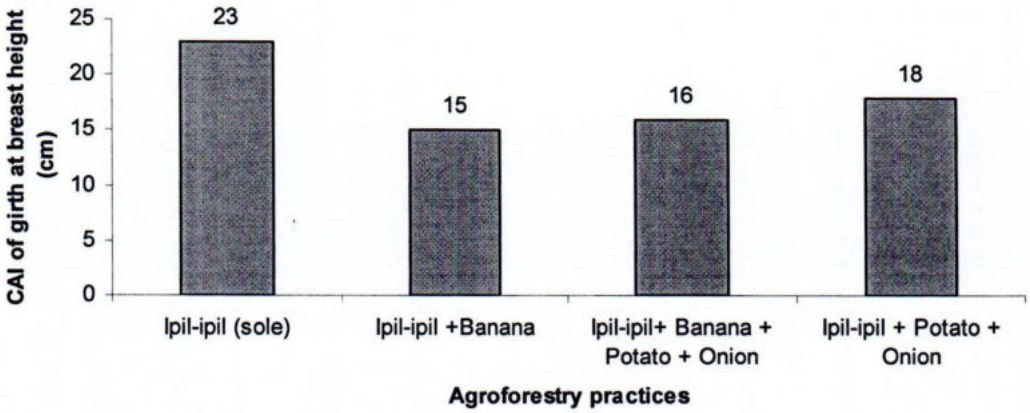

Fig 4.8.23: Current annual increment of girth at breast height for ipil-ipil in different multistory agroforestry practices

7.6.4 Volume: Current annual increment of volumes were influenced positively and the ranking order was different ie, ipil-ipil (sole) > ipil-ipil+ potato+ onion > ipil-ipil+ banana+ potato+ onion > ipil-ipil+ banana but the different MAI value of agroforestry species and sole species were 34378.89,32847.24,30960.41 and 27586.16 cm3 in ipil-ipil (sole), ipil-ipil+ potato+ onion, ipil-ipil+ banana+ potato+ onion and ipil-ipil+ banana respectively

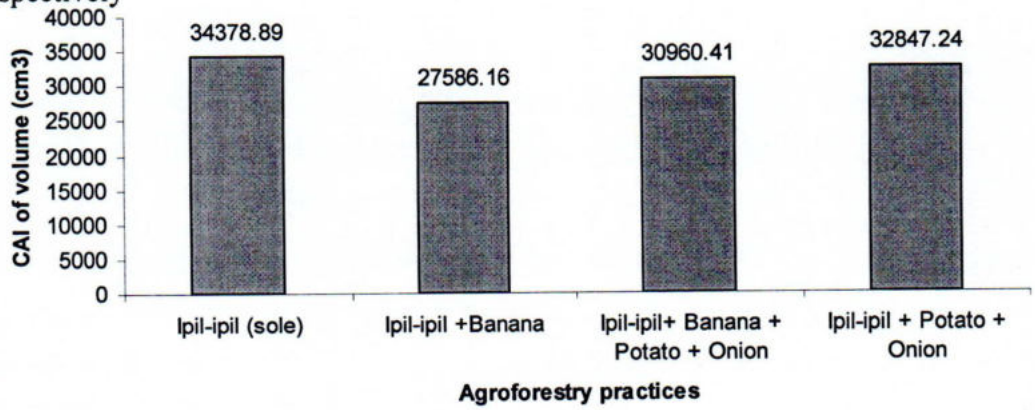

Fig 4.8.24: Current annual increment of volume for ipil-ipil in different multistory agroforestry practices.

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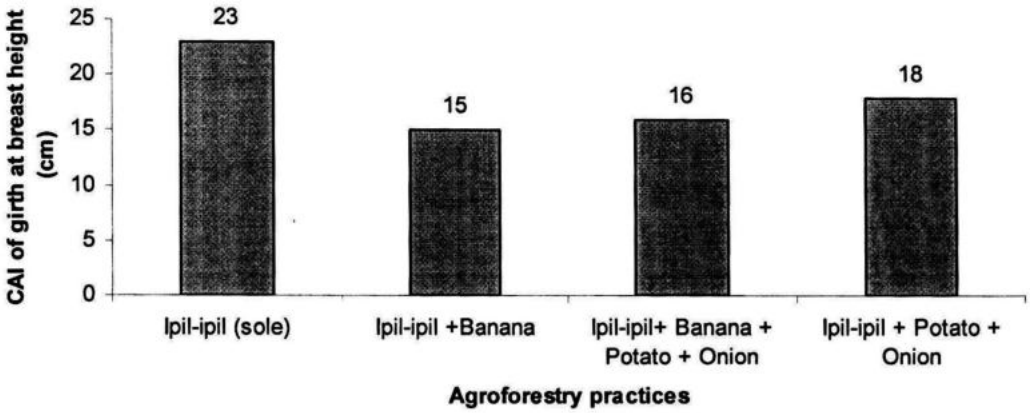

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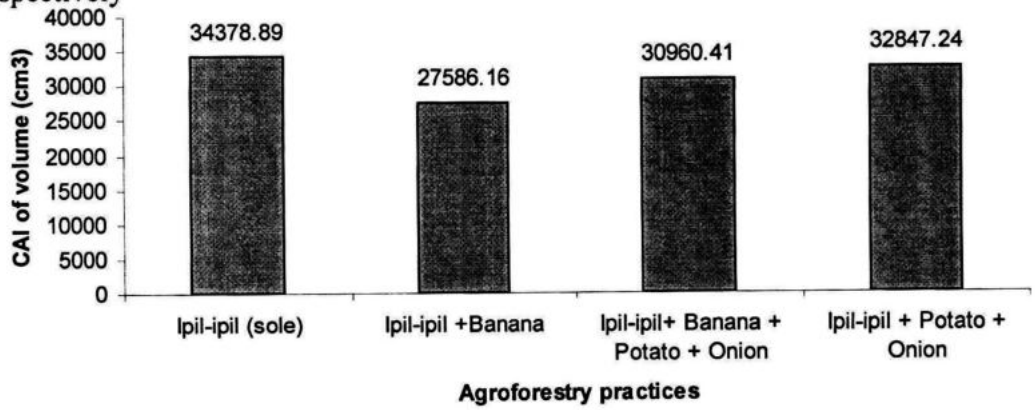

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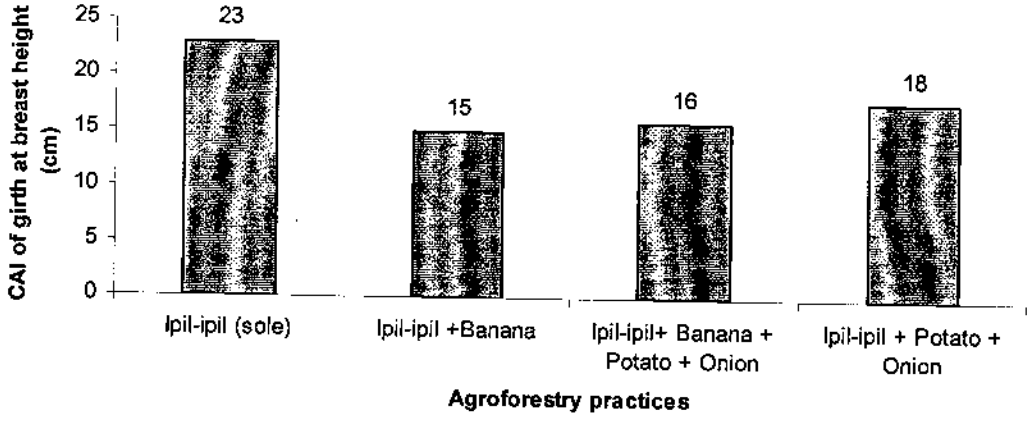

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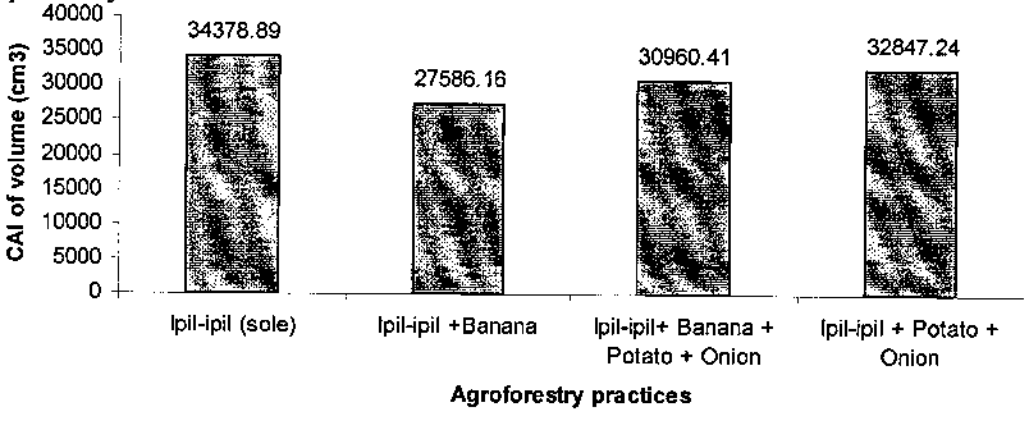

Fig 4.8.24: Current annual increment of volume for ipil-ipil in different multistory agroforestry practices.

Expt # 8 Effect of Different Agroforestry Practices on the Soil Health

4.8.1 Status of p^H, Ca, Mg and K in the upper soil of different agroforestry practices in 2006-2007

The Status of pH, Ca, Mg and K in initial soil as well as in soil after completion of two years experiment in different agroforestry practices have been shown in Table 4.8.1. Initially the pH of the soil was 5.1. After two years experimentation in different agroforestry systems, the pH reached towards neutrality ranging from 6.0 to 6.5 but the pH value of control plots (sole tree) remained almost unchanged and the range was 5.2 to 5.3. These drastic increase of pH value in the soil of agroforestry systems might be due to application of lime(Dholo-chone) in crop production at recommended dose and slide increase of pH in control plots (sole tree) might be due to addition of organic matter from leaf litter of tree species. Amount of calcium was found higher (1.3-1.75 Microgram/g soil) in 2006 and 2007 in all most all agroforestry field than that of 2005(1.3 Microgram/g soil).The status of calcium in the sole field crops were decreased and the amount were 0.8,0.9and 0.8 Microgram/g soil in sole banana, potato-onion and Potato - onion +banana field respectively. The control plots (sole tree) calcium content remained almost unchanged and the range was 1.3-1.42 Microgram/g soil. Status of magnesium in the upper soil of different agroforestry systems were varied irregularly. Comparatively higher content of mg was found in the field of wheat - mungbean -T. aman cropping pattern irrespective of tree combinations and the highest mg content was calculated in Black siris+ wheat - mungbean - T. aman (0.47 and 0.45 Microgram/g soil in 2006 and 2007 respectively).Some practices i.e. Potato – onion + banana + ipil ipil; Potato – onion + banana + Goraneem; Banana + Goraneem showed higher magnesium content(0.43,0.42 and 0.42 Microgram/g soil, respectively) than initial value(0.4) in 2006.Control plot (sole tree) remained almost similar mg content and the range was (0.38-0.45) up to 2007,But all other crop growing practices have loosed some amount of mg from their initial content in 2007 except sole tree plots and Potato – onion + banana + ipil ipil plot (Table 4.8.1).In case of K, Control plot (sole tree) remained almost unchanged from 2005 to 2007. Potassium content was found lower in all agroforestry plots irrespective of treatment combinations in compare to initial status except wheat- mungbean- T. aman cropping pattern with tree species. The reduction of potassium content after first year was negligible but after second year it was less than 50% in some production systems.

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4.8.1 Status of p^H, Ca, Mg and K in the upper soil of different agroforestry practices in 2006-2007

The Status of pH, Ca, Mg and K in initial soil as well as in soil after completion of two years experiment in different agroforestry practices have been shown in Table 4.8.1. Initially the pH of the soil was 5.1. After two years experimentation in different agroforestry systems, the pH reached towards neutrality ranging from 6.0 to 6.5 but the pH value of control plots (sole tree) remained almost unchanged and the range was 5.2 to 5.3. These drastic increase of pH value in the soil of agroforestry systems might be due to application of lime(Dholo-chone) in crop production at recommended dose and slide increase of pH in control plots (sole tree) might be due to addition of organic matter from leaf litter of tree species. Amount of calcium was found higher (1.3-1.75 Microgram/g soil) in 2006 and 2007 in all most all agroforestry field than that of 2005(1.3 Microgram/g soil).The status of calcium in the sole field crops were decreased and the amount were 0.8,0.9and 0.8 Microgram/g soil in sole banana, potato-onion and Potato - onion +banana field respectively. The control plots (sole tree) calcium content remained almost unchanged and the range was 1.3-1.42 Microgram/g soil. Status of magnesium in the upper soil of different agroforestry systems were varied irregularly. Comparatively higher content of mg was found in the field of wheat - mungbean -T. aman cropping pattern irrespective of tree combinations and the highest mg content was calculated in Black siris+ wheat - mungbean - T. aman (0.47 and 0.45 Microgram/g soil in 2006 and 2007 respectively).Some practices i.e. Potato – onion + banana + ipil ipil; Potato – onion + banana + Goraneem; Banana + Goraneem showed higher magnesium content(0.43,0.42 and 0.42 Microgram/g soil, respectively) than initial value(0.4) in 2006.Control plot (sole tree) remained almost similar mg content and the range was (0.38-0.45) up to 2007,But all other crop growing practices have loosed some amount of mg from their initial content in 2007 except sole tree plots and Potato – onion + banana + ipil ipil plot (Table 4.8.1).In case of K, Control plot (sole tree) remained almost unchanged from 2005 to 2007. Potassium content was found lower in all agroforestry plots irrespective of treatment combinations in compare to initial status except wheat- mungbean- T. aman cropping pattern with tree species. The reduction of potassium content after first year was negligible but after second year it was less than 50% in some production systems.

Table 4.8.1 Status of p^H, Ca, Mg and K in the upper soil of different agroforestry practices in 2006-2007

Soil sample	Name of the practices	Reaction (pH)		Ca		Mg		K	
		2006	2007	2006	2007	2006	2007	2006	2007
				Microgram/g soil					
T_1	Potato – onion + banana + ipil ipil	6.10	6.20	1.3	1.73	0.43	0.41	0.24	0.11
T_2	Potato – onion + banana + Goraneem	6.20	6.40	1.7	1.75	0.42	0.48	0.25	0.14
T_3	Potato – onion + ipil ipil	6.05	6.10	1.5	1.41	0.37	0.39	0.24	0.15
T_4	Potato - onion + Goraneem	6.15	6.30	1.4	1.40	0.40	0.42	0.23	0.16
T_5	Banana + ipil ipil	6.10	6.30	1.5	1.63	0.37	0.39	0.14	0.10
T_6	Banana + Goraneem	6.45	6.50	1.5	1.30	0.42	0.45	0.17	0.10
T_7	Potato - onion +banana	5.65	5.52	0.8	0.96	0.35	0.36	0.15	0.11
T_8	Potato - onion	5.65	5.51	0.9	0.93	0.38	0.34	0.14	0.10
T_9	Banana	5.25	5.20	0.8	0.90	0.28	0.23	0.14	0.11
T_{10}	Ipil ipil	5.20	5.20	1.3	1.35	0.39	0.32	0.26	0.25
T_{11}	Goraneem	5.25	5.30	1.4	1.43	0.38	0.39	0.25	0.24
T_{12}	Black siris+ wheat - mungbean - T aman	6.20	6.50	1.4	1.49	0.47	0.45	0.25	0.20
T_{13}	Guava + wheat - mungbean - T aman	6.15	6.50	1.4	1.09	0.45	0.42	0.29	0.27
T_{14}	Mango+ wheat – mungbean - T aman	6.10	6.40	1.5	1.28	0.46	0.43	0.28	0.26
T_{15}	Wheat - mungbean/ T aman	6.00	6.00	1.4	1.41	0.43	0.42	0.27	0.26
T_{16}	Black siris	5.2	5.25	1.35	1.30	0.45	0.41	0.27	0.27
T_{17}	Guava	5.25	5.25	1.35	1.35	0.41	0.40	0.26	0.26
T_{18}	Mango	5.2	5.25	1.3	1.35	0.42	0.42	0.25	0.26

Initial Soil Analysis Result 2005

Soil sample	Reaction (p^H)	Analyzed result													Soil textural class	Sand	Silt	Clay	CEC
		OM	Na	Ca	Mg	K	Total N	P	S	B	Cu	Fe	Mn	Zn		%	%	%	Meq/100g
		%	Meq/100g				%	Microgram/g soil											
1-(Upper level)	5.1	1.06	0.06	1.30	0.40	0.26	0.103	24.0	3.2	0.27	1.00	5.30	0.70	0.90	Silty loam	65	30	5	8.07

Table 4.8.1 Status of p^H, Ca, Mg and K in the upper soil of different agroforestry practices in 2006-2007

Soil sample	Name of the practices	Reaction (pH)		Ca		Mg		K	
		2006	2007	2006	2007	2006	2007	2006	2007
				Microgram/g soil					
T_1	Potato – onion + banana + ipil ipil	6.10	6.20	1.3	1.73	0.43	0.41	0.24	0.11
T_2	Potato – onion + banana + Goraneem	6.20	6.40	1.7	1.75	0.42	0.48	0.25	0.14
T_3	Potato – onion + ipil ipil	6.05	6.10	1.5	1.41	0.37	0.39	0.24	0.15
T_4	Potato - onion + Goraneem	6.15	6.30	1.4	1.40	0.40	0.42	0.23	0.16
T_5	Banana + ipil ipil	6.10	6.30	1.5	1.63	0.37	0.39	0.14	0.10
T_6	Banana + Goraneem	6.45	6.50	1.5	1.30	0.42	0.45	0.17	0.10
T_7	Potato - onion +banana	5.65	5.52	0.8	0.96	0.35	0.36	0.15	0.11
T_8	Potato - onion	5.65	5.51	0.9	0.93	0.38	0.34	0.14	0.10
T_9	Banana	5.25	5.20	0.8	0.90	0.28	0.23	0.14	0.11
T_{10}	Ipil ipil	5.20	5.20	1.3	1.35	0.39	0.32	0.26	0.25
T_{11}	Goraneem	5.25	5.30	1.4	1.43	0.38	0.39	0.25	0.24
T_{12}	Black siris+ wheat - mungbean - T aman	6.20	6.50	1.4	1.49	0.47	0.45	0.25	0.20
T_{13}	Guava + wheat - mungbean - T aman	6.15	6.50	1.4	1.09	0.45	0.42	0.29	0.27
T_{14}	Mango+ wheat – mungbean - T aman	6.10	6.40	1.5	1.28	0.46	0.43	0.28	0.26
T_{15}	Wheat - mungbean/ T aman	6.00	6.00	1.4	1.41	0.43	0.42	0.27	0.26
T_{16}	Black siris	5.2	5.25	1.35	1.30	0.45	0.41	0.27	0.27
T_{17}	Guava	5.25	5.25	1.35	1.35	0.41	0.40	0.26	0.26
T_{18}	Mango	5.2	5.25	1.3	1.35	0.42	0.42	0.25	0.26

Initial Soil Analysis Result 2005

Soil sample	Reaction (p^H)	Analyzed result													Soil textural class	Sand	Silt	Clay	CEC
		OM	Na	Ca	Mg	K	Total N	P	S	B	Cu	Fe	Mn	Zn		%	%	%	Meq/100g
		%	Meq/100g				%	Microgram/g soil											
1-(Upper level)	5.1	1.06	0.06	1.30	0.40	0.26	0.103	24.0	3.2	0.27	1.00	5.30	0.70	0.90	Silty loam	65	30	5	8.07

Table 4.8.1 Status of p^H, Ca, Mg and K in the upper soil of different agroforestry practices in 2006-2007

Soil sample	Name of the practices	Reaction (pH)		Ca		Mg		K	
		2006	2007	2006	2007	2006	2007	2006	2007
				Microgram/g soil					
T_1	Potato – onion + banana + ipil ipil	6.10	6.20	1.3	1.73	0.43	0.41	0.24	0.11
T_2	Potato – onion + banana + Goraneem	6.20	6.40	1.7	1.75	0.42	0.48	0.25	0.14
T_3	Potato – onion + ipil ipil	6.05	6.10	1.5	1.41	0.37	0.39	0.24	0.15
T_4	Potato - onion + Goraneem	6.15	6.30	1.4	1.40	0.40	0.42	0.23	0.16
T_5	Banana + ipil ipil	6.10	6.30	1.5	1.63	0.37	0.39	0.14	0.10
T_6	Banana + Goraneem	6.45	6.50	1.5	1.30	0.42	0.45	0.17	0.10
T_7	Potato - onion +banana	5.65	5.52	0.8	0.96	0.35	0.36	0.15	0.11
T_8	Potato - onion	5.65	5.51	0.9	0.93	0.38	0.34	0.14	0.10
T_9	Banana	5.25	5.20	0.8	0.90	0.28	0.23	0.14	0.11
T_{10}	Ipil ipil	5.20	5.20	1.3	1.35	0.39	0.32	0.26	0.25
T_{11}	Goraneem	5.25	5.30	1.4	1.43	0.38	0.39	0.25	0.24
T_{12}	Black siris+ wheat - mungbean - T aman	6.20	6.50	1.4	1.49	0.47	0.45	0.25	0.20
T_{13}	Guava + wheat - mungbean - T aman	6.15	6.50	1.4	1.09	0.45	0.42	0.29	0.27
T_{14}	Mango+ wheat – mungbean - T aman	6.10	6.40	1.5	1.28	0.46	0.43	0.28	0.26
T_{15}	Wheat - mungbean/ T aman	6.00	6.00	1.4	1.41	0.43	0.42	0.27	0.26
T_{16}	Black siris	5.2	5.25	1.35	1.30	0.45	0.41	0.27	0.27
T_{17}	Guava	5.25	5.25	1.35	1.35	0.41	0.40	0.26	0.26
T_{18}	Mango	5.2	5.25	1.3	1.35	0.42	0.42	0.25	0.26

Initial Soil Analysis Result 2005

Soil sample	Reaction (p^H)	Analyzed result													Soil textural class	Sand	Silt	Clay	CEC
		OM	Na	Ca	Mg	K	Total N	P	S	B	Cu	Fe	Mn	Zn		%	%	%	Meq/100g
		%	Meq/100g				%	Microgram/g soil											
1-(Upper level)	5.1	1.06	0.06	1.30	0.40	0.26	0.103	24.0	3.2	0.27	1.00	5.30	0.70	0.90	Silty loam	65	30	5	8.07

4.8.2 Status of organic mater, Total nitrogen, phosphorus and sulpher in the upper soil of different agroforestry practices in 2006-2007

The content of organic mater, total nitrogen, phosphorus and sulpher in the upper soil of different agroforestry practices was found different. (Table4.8.2).Almost all agroforestry practices slidely increased their organic matter content. The highest organic matter content (1.39%) was found after two years cropping in both T_4 (Potato - onion + Goraneem) and T_{12} (Black siris+ wheat - mungbean - T aman). Sole crop practices decreased their organic matter content from 1.06 to 0.91% after two years cropping, on the other hand sole tree cultivation maintained or increased their initial organic matter content after two years except guava tree. In 2007, organic matter content under guava trees was 1.05% which was lower than initial value (1.06%). Changing pattern of total nitrogen (percent) in the soil of different agroforestry practices including control plots, were almost similar to that of organic matter content. The highest total nitrogen (0.130%) was found in T_2 (Potato – onion + banana + Goraneem) and the lowest status was found in sole banana (0.070%). wheat - mungbean - T aman cropping pattern as sole and in agroforestry practice was found suitable for maintaining its initial total nitrogen content after consecutive two years cropping. Maintenance of organic matter and total nitrogen in the field of agroforestry and under sole tree cultivation might be due to addition of biomass of mungbean and leaf litter of tree species, respectively. Production of wheat – mungbean - T aman and potato followed by onion as sole or in agroforestry practices showed increasing tendency of phosphorus content but sole banana practice showed decreasing tendency of phosphorus content on the other hand sole ipil-ipil, goraneem ,black siris, guava and mango treatments showed almost stable status of phosphorus content(Table 4.8.2). The highest amount of phosphorus content (33.09 microgram/g soil) was found in T_{13} (blacksiris + wheat – mungbean - T aman) in 2007, which was followed by T_1 (potato – onion + banana + ipil ipil) and the amount was 32.39 microgram/g soil. The decreasing trend of phosphorus content was found in the treatment of T_9 (banana) and the values were 14.7 and13.42 microgram/g soil in 2006 and 2007 respectively. The status of sulpher in the upper soil of different agroforestry practices in course of experimental years was found to change in irregular fashions. The results showed that all the treatments numerically increased their sulpher content and the highest amount of sulpher (14.87 microgram/g soil) was found in T_{14} (Mango+ wheat – mungbean - T aman) followed by T_{12} (Black siris+ wheat - mungbean - T aman) and the amount was 13.17 microgram/g soil in 2007. The sole tree treatments and sole banana maintained their sulpher status unchanged as very low(less than 7.5).The lowest amount was recoded in sole guava (5 microgram/g soil)

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4.8.2 Status of organic mater, Total nitrogen, phosphorus and sulpher in the upper soil of different agroforestry practices in 2006-2007

The content of organic mater, total nitrogen, phosphorus and sulpher in the upper soil of different agroforestry practices was found different. (Table4.8.2).Almost all agroforestry practices slidely increased their organic matter content. The highest organic matter content (1.39%) was found after two years cropping in both T_4 (Potato - onion + Goraneem) and T_{12} (Black siris+ wheat - mungbean - T aman). Sole crop practices decreased their organic matter content from 1.06 to 0.91% after two years cropping, on the other hand sole tree cultivation maintained or increased their initial organic matter content after two years except guava tree. In 2007, organic matter content under guava trees was 1.05% which was lower than initial value (1.06%). Changing pattern of total nitrogen (percent) in the soil of different agroforestry practices including control plots, were almost similar to that of organic matter content. The highest total nitrogen (0.130%) was found in T_2 (Potato – onion + banana + Goraneem) and the lowest status was found in sole banana (0.070%). wheat - mungbean - T aman cropping pattern as sole and in agroforestry practice was found suitable for maintaining its initial total nitrogen content after consecutive two years cropping. Maintenance of organic matter and total nitrogen in the field of agroforestry and under sole tree cultivation might be due to addition of biomass of mungbean and leaf litter of tree species, respectively. Production of wheat – mungbean - T aman and potato followed by onion as sole or in agroforestry practices showed increasing tendency of phosphorus content but sole banana practice showed decreasing tendency of phosphorus content on the other hand sole ipil-ipil, goraneem ,black siris, guava and mango treatments showed almost stable status of phosphorus content(Table 4.8.2). The highest amount of phosphorus content (33.09 microgram/g soil) was found in T_{13} (blacksiris + wheat – mungbean - T aman) in 2007, which was followed by T_1 (potato – onion + banana + ipil ipil) and the amount was 32.39 microgram/g soil. The decreasing trend of phosphorus content was found in the treatment of T_9 (banana) and the values were 14.7 and13.42 microgram/g soil in 2006 and 2007 respectively. The status of sulpher in the upper soil of different agroforestry practices in course of experimental years was found to change in irregular fashions. The results showed that all the treatments numerically increased their sulpher content and the highest amount of sulpher (14.87 microgram/g soil) was found in T_{14} (Mango+ wheat – mungbean - T aman) followed by T_{12} (Black siris+ wheat - mungbean - T aman) and the amount was 13.17 microgram/g soil in 2007. The sole tree treatments and sole banana maintained their sulpher status unchanged as very low(less than 7.5).The lowest amount was recoded in sole guava (5 microgram/g soil)

Table 4.8.2 Status of organic mater, Total nitrogen, phosphorus and sulpher in the upper soil of different agroforestry practices in 2006-2007

Soil sample	Name of the practices	OM		Total N		P		S	
		2006	2007	2006	2007	2006	2007	2006	2007
		%				Microgram/g soil			
T_1	Potato – onion + banana + ipil ipil	1.13	1.26	0.108	0.120	25.88	32.39	12.40	7.10
T_2	Potato – onion + banana + Goraneem	1.10	1.33	0.107	0.130	24.77	30.23	12.48	10.70
T_3	Potato – onion + ipil ipil	1.07	1.29	0.107	0.120	28.47	31.18	14.27	10.12
T_4	Potato - onion + Goraneem	1.08	1.39	0.106	0.110	26.03	30.60	10.71	10.60
T_5	Banana + ipil ipil	1.13	1.38	0.106	0.109	18.72	17.06	7.98	6.98
T_6	Banana + Goraneem	1.10	1.36	0.106	0.110	16.49	15.83	9.44	5.55
T_7	Potato - onion +banana	0.99	0.91	0.090	0.080	25.06	30.28	7.90	8.21
T_8	Potato - onion	1.03	1.01	0.090	0.090	26.85	30.43	12.62	8.94
T_9	Banana	1.01	1.00	0.070	0.070	14.70	13.42	6.28	6.71
T_{10}	Ipil ipil	1.08	1.28	0.108	0.108	26.90	26.34	5.51	5.62
T_{11}	Goraneem	1.07	1.34	0.107	0.108	26.64	24.88	9.67	7.21
T_{12}	Black siris+ wheat - mungbean - T aman	1.09	1.39	0.104	0.105	27.25	33.09	12.13	13.17
T_{13}	Guava + wheat - mungbean - T aman	1.08	1.21	0.103	0.103	25.78	31.02	12.13	10.71
T_{14}	Mango+ wheat – mungbean - T aman	1.08	1.25	0.104	0.104	26.05	32.63	12.44	14.87
T_{15}	Wheat - mungbean/ T aman	1.07	1.05	0.102	0.104	25.95	32.32	12.05	10.91
T_{16}	Black siris	1.08	1.18	0.113	0.114	24.5	27.60	6.50	6.0
T_{17}	Guava	1.05	1.05	0.102	0.103	23.0	25.00	4.65	5.0
T_{18}	Mango	1.06	1.07	0.103	0.104	25.0	26.00	5.0	5.1

Table 4.8.2 Status of organic mater, Total nitrogen, phosphorus and sulpher in the upper soil of different agroforestry practices in 2006-2007

Soil sample	Name of the practices	OM		Total N		P		S	
		2006	2007	2006	2007	2006	2007	2006	2007
		%				Microgram/g soil			
T_1	Potato – onion + banana + ipil ipil	1.13	1.26	0.108	0.120	25.88	32.39	12.40	7.10
T_2	Potato – onion + banana + Goraneem	1.10	1.33	0.107	0.130	24.77	30.23	12.48	10.70
T_3	Potato – onion + ipil ipil	1.07	1.29	0.107	0.120	28.47	31.18	14.27	10.12
T_4	Potato - onion + Goraneem	1.08	1.39	0.106	0.110	26.03	30.60	10.71	10.60
T_5	Banana + ipil ipil	1.13	1.38	0.106	0.109	18.72	17.06	7.98	6.98
T_6	Banana + Goraneem	1.10	1.36	0.106	0.110	16.49	15.83	9.44	5.55
T_7	Potato - onion +banana	0.99	0.91	0.090	0.080	25.06	30.28	7.90	8.21
T_8	Potato - onion	1.03	1.01	0.090	0.090	26.85	30.43	12.62	8.94
T_9	Banana	1.01	1.00	0.070	0.070	14.70	13.42	6.28	6.71
T_{10}	Ipil ipil	1.08	1.28	0.108	0.108	26.90	26.34	5.51	5.62
T_{11}	Goraneem	1.07	1.34	0.107	0.108	26.64	24.88	9.67	7.21
T_{12}	Black siris+ wheat - mungbean - T aman	1.09	1.39	0.104	0.105	27.25	33.09	12.13	13.17
T_{13}	Guava + wheat - mungbean - T aman	1.08	1.21	0.103	0.103	25.78	31.02	12.13	10.71
T_{14}	Mango+ wheat – mungbean - T aman	1.08	1.25	0.104	0.104	26.05	32.63	12.44	14.87
T_{15}	Wheat - mungbean/ T aman	1.07	1.05	0.102	0.104	25.95	32.32	12.05	10.91
T_{16}	Black siris	1.08	1.18	0.113	0.114	24.5	27.60	6.50	6.0
T_{17}	Guava	1.05	1.05	0.102	0.103	23.0	25.00	4.65	5.0
T_{18}	Mango	1.06	1.07	0.103	0.104	25.0	26.00	5.0	5.1

Table 4.8.2 Status of organic mater, Total nitrogen, phosphorus and sulpher in the upper soil of different agroforestry practices in 2006-2007

Soil sample	Name of the practices	OM		Total N		P		S	
		2006	2007	2006	2007	2006	2007	2006	2007
		%				Microgram/g soil			
T_1	Potato – onion + banana + ipil ipil	1.13	1.26	0.108	0.120	25.88	32.39	12.40	7.10
T_2	Potato – onion + banana + Goraneem	1.10	1.33	0.107	0.130	24.77	30.23	12.48	10.70
T_3	Potato – onion + ipil ipil	1.07	1.29	0.107	0.120	28.47	31.18	14.27	10.12
T_4	Potato - onion + Goraneem	1.08	1.39	0.106	0.110	26.03	30.60	10.71	10.60
T_5	Banana + ipil ipil	1.13	1.38	0.106	0.109	18.72	17.06	7.98	6.98
T_6	Banana + Goraneem	1.10	1.36	0.106	0.110	16.49	15.83	9.44	5.55
T_7	Potato - onion +banana	0.99	0.91	0.090	0.080	25.06	30.28	7.90	8.21
T_8	Potato - onion	1.03	1.01	0.090	0.090	26.85	30.43	12.62	8.94
T_9	Banana	1.01	1.00	0.070	0.070	14.70	13.42	6.28	6.71
T_{10}	Ipil ipil	1.08	1.28	0.108	0.108	26.90	26.34	5.51	5.62
T_{11}	Goraneem	1.07	1.34	0.107	0.108	26.64	24.88	9.67	7.21
T_{12}	Black siris+ wheat - mungbean - T aman	1.09	1.39	0.104	0.105	27.25	33.09	12.13	13.17
T_{13}	Guava + wheat - mungbean - T aman	1.08	1.21	0.103	0.103	25.78	31.02	12.13	10.71
T_{14}	Mango+ wheat – mungbean - T aman	1.08	1.25	0.104	0.104	26.05	32.63	12.44	14.87
T_{15}	Wheat - mungbean/ T aman	1.07	1.05	0.102	0.104	25.95	32.32	12.05	10.91
T_{16}	Black siris	1.08	1.18	0.113	0.114	24.5	27.60	6.50	6.0
T_{17}	Guava	1.05	1.05	0.102	0.103	23.0	25.00	4.65	5.0
T_{18}	Mango	1.06	1.07	0.103	0.104	25.0	26.00	5.0	5.1

4.8.3 Status of B, Cu, Fe, Mn and Zn in the upper soil of different agroforestry practices in 2006-2007

Status of B and Fe in the upper soil of the experimental plots were increasing in all production practices in course of experimental period but the amount of Cu content was decreasing irrespective of treatment combinations while the status of Zn and Mn were higher than initial status but remained unchanged their category as medium for Zn (0.91-1.35) and low for Mn (0.75-1.5).The range of boron(B) content was 0.28-4.0 Microgram/g soil in 2006,it was 0.31-0.56 Microgram/g soil in 2007. The highest B content was recorded in T_7 (Potato - onion +banana) in both the years but lowest values were recorded for mango and ipil-ipil in 2006 and 2007 respectively. Application of boric acid in potato, onion and banana as per recommended dose might be the causes of higher B content. Sole tree plots remained their B category unchanged as no B fertilizer were used there but the slide increased of B content might be due to leaf litter addition of tree species. All the treatments loosed some amount of Cu from their initial status. The minimum loss was found in T_{15} (Wheat - mungbean-T aman) and maximum loss was found in T_9 (Banana) and T_7 (Potato - onion +banana). The initial Fe content (5.3 Microgram/g soil) in the soil laid in low category (3.1-6.0) but two years agroforestry practices improved the Fe status in to medium category (6.1-9.0 Microgram/g soil). The maximum amount Fe content was found in T_{12} (Black siris+ wheat - mungbean - T aman) and the value was 9.6 and 9.7 Microgram/g soil in 2006 and 2007 respectively while the minimum amount was found in sole guava plots(6.1 and 6.3 Microgram/g soil in 2006 and 2007 respectively). The initial status of Mn in the experimental field was very low (.7) but after two years experimentations most of the agroforestry practices improved its status from very low to low. Although T_7 (Potato - onion +banana), T_8 (Potato - onion) and T_9 (Banana) showed decreasing tendency and sole tree plots maintained their initial Mn status. Status of Zn in the upper soil of the experimental plots were increased in all production practices after two years crop productions except banana plot. In 2007, the lowest amount of Zn (0.85 Microgram/g soil) was found in T_9 (banana) and the highest amount of Zn(1.45 Microgram/g soil) was found in T_8 (Potato – onion)

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Table 4.8.3 Status of B, Cu, Fe, Mn and Zn in the upper soil of different agroforestry practices in 2006-2007

Soil sample	Name of the practices	B		Cu		Fe		Mn		Zn	
		2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
		Microgram/g soil									
T_1	Potato – onion + banana + ipil ipil	0.34	0.46	0.72	0.72	8.5	8.9	.74	.82	1.1	1.35
T_2	Potato – onion + banana + Goraneem	0.39	0.50	0.60	0.58	8.4	8.7	.76	.76	1.0	1.34
T_3	Potato – onion + ipil ipil	0.33	0.45	0.64	0.63	9.6	9.5	.76	.72	1.3	1.36
T_4	Potato - onion + Goraneem	0.35	0.44	0.80	0.63	9.2	9.2	.78	.74	1.4	1.35
T_5	Banana + ipil ipil	0.38	0.42	0.90	0.65	6.6	6.5	.70	.76	0.8	0.92
T_6	Banana + Goraneem	0.35	0.43	0.72	0.62	6.8	6.0	.74	.76	0.9	0.93
T_7	Potato - onion +banana	0.40	0.56	0.64	0.56	8.6	8.8	.60	.52	1.0	1.14
T_8	Potato - onion	0.37	0.51	0.66	0.69	6.9	7.8	.66	.64	1.2	1.45
T_9	Banana	0.36	0.42	0.64	0.56	6.0	6.3	.52	.47	0.7	0.85
T_{10}	Ipil ipil	0.29	0.31	0.94	0.98	6.8	7.5	.76	.77	0.9	1.35
T_{11}	Goraneem	0.28	0.38	0.90	0.98	7.2	7.3	.72	.78	1.3	1.35
T_{12}	Black siris+ wheat - mungbean - T aman	0.37	0.46	0.99	0.98	9.6	9.7	.94	.96	1.6	1.37
T_{13}	Guava + wheat - mungbean - T aman	0.32	0.38	0.78	0.64	9.4	9.6	1.0	1.1	1.2	1.25
T_{14}	Mango+ wheat – mungbean - T aman	0.34	0.41	0.96	0.98	9.2	9.5	.96	.99	1.3	1.35
T_{15}	Wheat - mungbean-T aman	0.34	0.4	0.90	0.99	8.8	9.4	.86	.87	1.0	1.35
T_{16}	Black siris	0.31	0.37	0.90	0.94	6.5	6.6	.75	.77	1.1	1.33
T_{17}	Guava	0.29	0.32	0.81	0.89	6.1	6.3	.73	.84	0.9	1.14
T_{18}	Mango	0.28	0.33	0.95	0.96	6.3	6.3	.71	.76	1.2	1.25

Table 4.8.3 Status of B, Cu, Fe, Mn and Zn in the upper soil of different agroforestry practices in 2006-2007

Soil sample	Name of the practices	B		Cu		Fe		Mn		Zn	
		2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
		Microgram/g soil									
T_1	Potato – onion + banana + ipil ipil	0.34	0.46	0.72	0.72	8.5	8.9	.74	.82	1.1	1.35
T_2	Potato – onion + banana + Goraneem	0.39	0.50	0.60	0.58	8.4	8.7	.76	.76	1.0	1.34
T_3	Potato – onion + ipil ipil	0.33	0.45	0.64	0.63	9.6	9.5	.76	.72	1.3	1.36
T_4	Potato - onion + Goraneem	0.35	0.44	0.80	0.63	9.2	9.2	.78	.74	1.4	1.35
T_5	Banana + ipil ipil	0.38	0.42	0.90	0.65	6.6	6.5	.70	.76	0.8	0.92
T_6	Banana + Goraneem	0.35	0.43	0.72	0.62	6.8	6.0	.74	.76	0.9	0.93
T_7	Potato - onion +banana	0.40	0.56	0.64	0.56	8.6	8.8	.60	.52	1.0	1.14
T_8	Potato - onion	0.37	0.51	0.66	0.69	6.9	7.8	.66	.64	1.2	1.45
T_9	Banana	0.36	0.42	0.64	0.56	6.0	6.3	.52	.47	0.7	0.85
T_{10}	Ipil ipil	0.29	0.31	0.94	0.98	6.8	7.5	.76	.77	0.9	1.35
T_{11}	Goraneem	0.28	0.38	0.90	0.98	7.2	7.3	.72	.78	1.3	1.35
T_{12}	Black siris+ wheat - mungbean - T aman	0.37	0.46	0.99	0.98	9.6	9.7	.94	.96	1.6	1.37
T_{13}	Guava + wheat - mungbean - T aman	0.32	0.38	0.78	0.64	9.4	9.6	1.0	1.1	1.2	1.25
T_{14}	Mango+ wheat – mungbean - T aman	0.34	0.41	0.96	0.98	9.2	9.5	.96	.99	1.3	1.35
T_{15}	Wheat - mungbean-T aman	0.34	0.4	0.90	0.99	8.8	9.4	.86	.87	1.0	1.35
T_{16}	Black siris	0.31	0.37	0.90	0.94	6.5	6.6	.75	.77	1.1	1.33
T_{17}	Guava	0.29	0.32	0.81	0.89	6.1	6.3	.73	.84	0.9	1.14
T_{18}	Mango	0.28	0.33	0.95	0.96	6.3	6.3	.71	.76	1.2	1.25

Table 4.8.3 Status of B, Cu, Fe, Mn and Zn in the upper soil of different agroforestry practices in 2006-2007

Soil sample	Name of the practices	B		Cu		Fe		Mn		Zn	
		2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
		Microgram/g soil									
T_1	Potato – onion + banana + ipil ipil	0.34	0.46	0.72	0.72	8.5	8.9	.74	.82	1.1	1.35
T_2	Potato – onion + banana + Goraneem	0.39	0.50	0.60	0.58	8.4	8.7	.76	.76	1.0	1.34
T_3	Potato – onion + ipil ipil	0.33	0.45	0.64	0.63	9.6	9.5	.76	.72	1.3	1.36
T_4	Potato - onion + Goraneem	0.35	0.44	0.80	0.63	9.2	9.2	.78	.74	1.4	1.35
T_5	Banana + ipil ipil	0.38	0.42	0.90	0.65	6.6	6.5	.70	.76	0.8	0.92
T_6	Banana + Goraneem	0.35	0.43	0.72	0.62	6.8	6.0	.74	.76	0.9	0.93
T_7	Potato - onion +banana	0.40	0.56	0.64	0.56	8.6	8.8	.60	.52	1.0	1.14
T_8	Potato - onion	0.37	0.51	0.66	0.69	6.9	7.8	.66	.64	1.2	1.45
T_9	Banana	0.36	0.42	0.64	0.56	6.0	6.3	.52	.47	0.7	0.85
T_{10}	Ipil ipil	0.29	0.31	0.94	0.98	6.8	7.5	.76	.77	0.9	1.35
T_{11}	Goraneem	0.28	0.38	0.90	0.98	7.2	7.3	.72	.78	1.3	1.35
T_{12}	Black siris+ wheat - mungbean - T aman	0.37	0.46	0.99	0.98	9.6	9.7	.94	.96	1.6	1.37
T_{13}	Guava + wheat - mungbean - T aman	0.32	0.38	0.78	0.64	9.4	9.6	1.0	1.1	1.2	1.25
T_{14}	Mango+ wheat – mungbean - T aman	0.34	0.41	0.96	0.98	9.2	9.5	.96	.99	1.3	1.35
T_{15}	Wheat - mungbean-T aman	0.34	0.4	0.90	0.99	8.8	9.4	.86	.87	1.0	1.35
T_{16}	Black siris	0.31	0.37	0.90	0.94	6.5	6.6	.75	.77	1.1	1.33
T_{17}	Guava	0.29	0.32	0.81	0.89	6.1	6.3	.73	.84	0.9	1.14
T_{18}	Mango	0.28	0.33	0.95	0.96	6.3	6.3	.71	.76	1.2	1.25

4.9 Economic and sustainability evaluation of agroforestry practices through two years average result

4.9.1 Economics of Rice-Wheat-Mungbean cropping pattern in different agroforestry systems

Economic of Rice-Wheat-Mungbean cropping pattern in different agroforestry systems are described below on the basis of two years average results of net return (Tk/ha) and BCR. From the individual experiment of each crop superior varieties were selected (i.e. BR11 for T.aman, Shatabdi for wheat and BARI Mung 6 for Mungbean). The economics of different agroforestry practice comprising the best varieties of each crop were evaluated here, (Table 4.9.1). The highest net return (34,8282 Tk) and BCR (3.14) were recorded from the cropping pattern comprising BR11- Shatabdi- BARI Mug 6 produced under mango, followed by black siris based agroforestry practice (The net return and BCR were 12,4418 Tk and 2.05 respectively). The lowest net returns (173643 Tk) as BCR (1.13) were found in guava based agroforestry. Even sole cropping produced the higher BCR (1.64) than that of guava based agroforestry (1.13). This might be due to higher cost of production of guava sapling but less return from the guava fruits and minimum income from the crop grown under guava.

4.9.2 Economics of multistoried agroforestry systems

Multistoried agroforestry systems were also economically evaluated on the basis of two years average results. The highest net return (163819 Tk) was obtained from potato-onion+banana+goraneem combination although this combination was secured 4th position in consideration of BCR. The highest BCR (2.28) was recorded for sole potato followed by onion practice. 2nd and 3rd year BCR values were 2.15 and 2.12 recorded for banana and potato-onion+banana practice respectively (Table 4.9.2). These three sole cropping practices showed higher BCR than agroforestry practice might be due to low cost of production. In agroforestry practice initial cost of saplings and their plantation cost is higher which was the main reason for low BCR value. Although, goraneem based multistoried produced the highest BCR among all multistoried practice. Among all agroforestry practices mango based (T.aman-wheat-mungbean cropping pattern) agroforestry was found highly profitable (BCR 3.14) which was produce followed by black siris based agroforestry practice (BCR 2.05) and

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then potato-onion+banana+goraneem based multistoried agroforestry (BCR 2.04). These systems were further evaluated by total factor productivity for their sustainability.

4.9.3 Sustainability evaluation

Sustainability of agroforestry systems were measured by Total Factor Productivity (TFP) which was calculated by the formula

$$Ytot= E_c x Y_c + E_t x Y_t + E_l x \Delta l$$

Total 9(nine) agroforestry systems were used in this experiment excluding control practice, which were evaluated by the above formula (Table 4.9.4)

According to this evaluation the most sustainable system was found mango based agroforestry followed by potato-onion+banana+ goraneem based multistoried practice. The 3rd sustainable system was found potato-onion+ banana+ ipil-ipil based multistoried system. Black siris based (BR 11- Shatabdi- BARI Mug 6) agroforestry was stood 4th position in the sustainability rank order.

The study revealed that mango (Var Amrapali) based farm land agroforestry accommodating BR 11 for T. aman, Shatabdi for wheat and BARI Mug 6 for mungbean was found the most profitable and sustainable practice. Goraneem+banana+ potato-onion multistoried was found better which can be used in homestead for best utilization of land use, diversified production and higher fiscal gain.

then potato-onion+banana+goraneem based multistoried agroforestry (BCR 2.04). These systems were further evaluated by total factor productivity for their sustainability.

4.9.3 Sustainability evaluation

Sustainability of agroforestry systems were measured by Total Factor Productivity (TFP) which was calculated by the formula

$$Ytot= E_c x Y_c + E_t x Y_t + E_l x \Delta l$$

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then potato-onion+banana+goraneem based multistoried agroforestry (BCR 2.04). These systems were further evaluated by total factor productivity for their sustainability.

4.9.3 Sustainability evaluation

Sustainability of agroforestry systems were measured by Total Factor Productivity (TFP) which was calculated by the formula

$$Ytot= E_c x Y_c + E_t x Y_t + E_l x \Delta l$$

Total 9(nine) agroforestry systems were used in this experiment excluding control practice, which were evaluated by the above formula (Table 4.9.4)

According to this evaluation the most sustainable system was found mango based agroforestry followed by potato-onion+banana+ goraneem based multistoried practice. The 3rd sustainable system was found potato-onion+ banana+ ipil-ipil based multistoried system. Black siris based (BR 11- Shatabdi- BARI Mug 6) agroforestry was stood 4th position in the sustainability rank order.

The study revealed that mango (Var Amrapali) based farm land agroforestry accommodating BR 11 for T. aman, Shatabdi for wheat and BARI Mug 6 for mungbean was found the most profitable and sustainable practice. Goraneem+banana+ potato-onion multistoried was found better which can be used in homestead for best utilization of land use, diversified production and higher fiscal gain.

Table 4.9.1. Economics of Rice-Wheat-Mungbean cropping pattern under in different agroforestry systems (average of two years)

Treatment	Return (Tk ha^{-1})				Gross return (Tk ha^{-1})	Cost of production(Tk ha^{-1})				Total cost of production	Net Return (Tk ha^{-1})	BCR
	T-aman	Wheat	Mungbean	Tree		T-aman	Wheat	Mungbean	Tree			
T_1(BR_{11}+Satabdi+BARI Mung 6)	54700	48575	41850	0	145125	32305.5	33309	22703	-	88317.5	56807.5	1.64
T_2(BR_{11}+Satabdi+BARI Mung 6)	51485	44145	38250	109096.8	242977	32305.5	33309	22703	30241	118558.5	124418	2.05
T_3(BR_{11}+Satabdi+BARI Mung 6)	41710	40320	31050	33962.75	147043	32305.5	33309	22703	41361	129678.5	17364.3	1.13
T_4(BR_{11}+Satabdi+BARI Mung 6)	49675	43075	35400	383170	511320	32305.5	33309	22703	74721	163038.5	348282	3.14
Assumed price rice @ 10 Tk/kg, wheat @15Tk/kg, Mungbean @30 Tk /kg												

Table 4.9.2. Economics of Banana based multistory agroforestry systems (average of two years)

Treatment	Return (Tk ha^{-1})				Gross return (Tk ha^{-1})	Cost of production(Tk ha^{-1})				Total cost of production	Net Return (Tk ha^{-1})	BCR
	Potato	onion	banana	Tree		Potato	onion	banana	Tree			
Potato-onion + banana + ipil ipil	59025	74900	84450	30024	248399	47487	26929	52828	30241	157485	90914	1.58
Potato-onion +banana + Goraneem	64575	71800	79950	104979	321304	47487	26929	52828	30241	157485	163819	2.04
Potato-onion + ipil ipil	46250	70800	0	30946	147996	50820	29429	0	30241	110490	37506	1.34
Potato-onion + Goraneem	57625	68250	0	77205	203080	50820	29429	0	30241	110490	92590	1.84
Banana + ipil ipil	0	0	92475	26247	118722	0	0	52828	30241	83069	35653	1.43
Banana + Goraneem	0	0	87450	69659	157109	0	0	52828	30241	83069	74040	1.89
Potato-onion + banana	86875	76900	106275	0	270050	47487	26929	52828	0	127244	142806	2.12
Potato - onion	97025	86100	0	0	183125	50820	29429	0	0	80249	102876	2.28
Banana	0	0	113400	0	113400	0	0	52828	0	52828	60572	2.15
Ipil ipil	0	0	0	31296	31296	0	0	0	30241	30241	1055	1.03
Goraneem	0	0	0	47471	47471	0	0	0	30241	30241	17230	1.57

*Price of Banana assumed as Tk. 15 per Kg, Price of Potato assumed as Tk. 5 per Kg. Price of Onion assumed as Tk. 10 per Kg.

Table 4.9.1. Economics of Rice-Wheat-Mungbean cropping pattern under in different agroforestry systems (average of two years)

Treatment	Return (Tk ha^{-1})				Gross return (Tk ha^{-1})	Cost of production(Tk ha^{-1})				Total cost of production	Net Return (Tk ha^{-1})	BCR
	T-aman	Wheat	Mungbean	Tree		T-aman	Wheat	Mungbean	Tree			
T_1(BR_{11}+Satabdi+BARI Mung 6)	54700	48575	41850	0	145125	32305.5	33309	22703	-	88317.5	56807.5	1.64
T_2(BR_{11}+Satabdi+BARI Mung 6)	51485	44145	38250	109096.8	242977	32305.5	33309	22703	30241	118558.5	124418	2.05
T_3(BR_{11}+Satabdi+BARI Mung 6)	41710	40320	31050	33962.75	147043	32305.5	33309	22703	41361	129678.5	17364.3	1.13
T_4(BR_{11}+Satabdi+BARI Mung 6)	49675	43075	35400	383170	511320	32305.5	33309	22703	74721	163038.5	348282	3.14

Assumed price rice @ 10 Tk/kg, wheat @15Tk/kg, Mungbean @30 Tk /kg

Table 4.9.2. Economics of Banana based multistory agroforestry systems (average of two years)

Treatment	Return (Tk ha^{-1})				Gross return (Tk ha^{-1})	Cost of production(Tk ha^{-1})				Total cost of production	Net Return (Tk ha^{-1})	BCR
	Potato	onion	banana	Tree		Potato	onion	banana	Tree			
Potato-onion + banana + ipil ipil	59025	74900	84450	30024	248399	47487	26929	52828	30241	157485	90914	1.58
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Potato-onion + Goraneem	57625	68250	0	77205	203080	50820	29429	0	30241	110490	92590	1.84
Banana + ipil ipil	0	0	92475	26247	118722	0	0	52828	30241	83069	35653	1.43
Banana + Goraneem	0	0	87450	69659	157109	0	0	52828	30241	83069	74040	1.89
Potato-onion + banana	86875	76900	106275	0	270050	47487	26929	52828	0	127244	142806	2.12
Potato - onion	97025	86100	0	0	183125	50820	29429	0	0	80249	102876	2.28
Banana	0	0	113400	0	113400	0	0	52828	0	52828	60572	2.15
Ipil ipil	0	0	0	31296	31296	0	0	0	30241	30241	1055	1.03
Goraneem	0	0	0	47471	47471	0	0	0	30241	30241	17230	1.57

*Price of Banana assumed as Tk. 15 per Kg, Price of Potato assumed as Tk. 5 per Kg. Price of Onion assumed as Tk. 10 per Kg.

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Treatment	Return (Tk ha^{-1})				Gross return (Tk ha^{-1})	Cost of production(Tk ha^{-1})				Total cost of production	Net Return (Tk ha^{-1})	BCR
	Potato	onion	banana	Tree		Potato	onion	banana	Tree			
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Table 4.9.3: Sustainability evaluation through total factor productivity of the studied agroforestry systems

Agroforestry systems	Ec XYc	Et X Yt	El X ΔL	Ytot	Rank order
Blacksiris+T.aman+wheat+mungbean	133880	109096.8	675	243651.8	4th
Guava+T.aman+wheat+mungbean	113080	33962.75	675	147717.8	8th
Mango+T.aman+wheat+mungbean	128150	383170	675	511995.0	1st
Ipil-ipil+ Banana+Potato+Onion	218375	30024	0	248399.0	3rd
Gora-neem+Banana+Potato+Onion	216325	104979	0	321304.0	2nd
Ipil-ipil+ Potato+Onion	117050	30946	0	147996.0	6th
Gora-neem+ Potato+Onion	125875	77205	0	203080.0	5th
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CHAPTER 5

SUMMARY CONCLUSION AND RECOMMENDATION

5.1 Summary

The first experiment was conducted in two years old orchard of black siris, guava and mango to observe the performance of five T. aman varieties ie. BR 10 (V_1), BR 11 (V_2), BRRI Dhan 33 (V_3), BRRI Dhan 39 (V_4) and Sorna (V_5) in close association of the tree species. From the combined effects on yield and yield contributing characters of T. aman ie. Panicle length, no. of grains panicle^{-1}, Thousand grain weight, grain yields were found highest in T_1V_2 combination (BR 11 in open field) which was followed by T_2V_2/T_4V_4/ T_1V_1. The study revealed that BR 11 showed better performance in every treatment combination, followed by V_1 (BR 10) considering HI and LER value agroforestry practice showed higher performance irrespective of varieties. Among the different practice BR 11 under black siris (T_2V_2 combination) showed highest values (HI and LER values were 42.6 % and 2.12 respectively in 2nd year cropping). From the economic evaluation (Table 4.1.8) V_3, V_4 and V_5 were found not profitable in agroforestry practices as they gave negative net return in case of guava and mango. BR 11 and BR 10 grown under black siris and mango showed higher BCR value than the open field BCR of BRRI dhan 33 (V_3) BRRI dhan 39 (V_4) and sorna (V_5), although these two varieties (V_1 and V_2) showed higher BCR in open field condition as compared to that of agroforestry practices.

In 2nd experiment five wheat varieties were tested in the same field. Most of the yield contributing characters, i.e. length of spike, grain weight per hill, thousand grain weight and yield were not influenced significantly by the combined effect of trees and varieties although the highest yield (2.9 and 2.87 t ha^{-1} in first and second year respectively) was recorded from T_1V_3 combination (Shatabdi in open field).

The highest HI was calculated for T_1V_1 combination (35.01 and 35.57% in 2006-07 and 2007-08, respectively) T_1V_2 and T_1V_3 showed 2nd highest HI in 2006 and 2007 respectively. The values of HI showed that under shaded treatments (T_2, T_3 and T_4). V_1 (Gourave) and V_3 (Shatabdi) performed better in both the cropping seasons.

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In 2006-07 cropping season the range of LER was 2.12-2.55 but in 2007-08 cropping seasons it was 2.0 to 2.69. It indicates that all the varieties of wheat under every selected tree have more than two times land use efficiency.

The highest BCR was 1.45 for Satabdi in sole crop and the lowest BCR was 0.97 found for T_3V_4 combination. In 2005-06 all treatment combinations showed positive net return but in 2nd year (2006-07) T_3V_5, T_3V_4 and T_3V_2 combination showed negative net return. It indicated that V_5 (protiva), V_4 (karamcha) and V_2 (sourav) were not capable to produce economically profitable yield under heaviest shade of guava (T_3). The result revealed that the most suitable variety of wheat for agroforestry was V_3 (Satabdi) followed by V_1 (Gourave). The rank order of agroforestry species considering benefit cost ratio was openfield (1.47) > mango (1.36)> black siris (1.35) > guava (1.32).

In 3rd experiment five mungbean varieties were tested followed by wheat in the same field. For vegetative growth (plant height and fresh biomass production) BARI Mug4 was found better over other varieties in all treatment conditions. In case of yield and yield contributing characters BARI Mug 6 was found the best followed by BARIMug 5 in almost all treatment combinations. Considering Harvest Index the best combination in 2007, was T_4V_4 combination (17.65 %) followed by T_3V_4 (17.24%). On the other hand T_1V_4 produced the highest HI (17.28 %) in the following years (2008) followed by T_1V_3 (15.64 %) and third highest HI (15.58%) was recorded in T_2V_4 followed by T_4V_4 (14.83 %). The HI study revealed that V_4 under mango can produced higher HI than that of three other (V_1, V_2 and V_5) varieties when grown in open field. Incase of land equivalent ratio for different agroforestry systems varied differently by the varieties as well as cropping years. In 2007, highest LER was recorded for guava based agroforestry system (2.1-2.17%) except T_3V_4 combination (2.08) followed by black siris based agroforestry system (1.09-2.13%). Mango based system produced lowest LER and the range was 1.83-2.03%. In 2008, maximum LER was recorded in mango based system (5.22-5.44%) which was followed by black siris based system (2.29-2.39%) in this year guava based system produced lowest LER and the range was 1.75-1.91%. The following year (2008) highest LER from mango based system due to higher increment of mango tree in agroforestry system than sole tree production and this ratio (Ti/Ts) was 4.55 although grain yield ratio of mung bean varieties between agroforestry and sole cropping was 0.87. The result proved that effect of under storey crops on the increment of trees was found higher in

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In 2006-07 cropping season the range of LER was 2.12-2.55 but in 2007-08 cropping seasons it was 2.0 to 2.69. It indicates that all the varieties of wheat under every selected tree have more than two times land use efficiency.

The highest BCR was 1.45 for Satabdi in sole crop and the lowest BCR was 0.97 found for T_3V_4 combination. In 2005-06 all treatment combinations showed positive net return but in 2nd year (2006-07) T_3V_5, T_3V_4 and T_3V_2 combination showed negative net return. It indicated that V_5 (protiva), V_4 (karamcha) and V_2 (sourav) were not capable to produce economically profitable yield under heaviest shade of guava (T_3). The result revealed that the most suitable variety of wheat for agroforestry was V_3 (Satabdi) followed by V_1 (Gourave). The rank order of agroforestry species considering benefit cost ratio was openfield (1.47) > mango (1.36)> black siris (1.35) > guava (1.32).

In 3rd experiment five mungbean varieties were tested followed by wheat in the same field. For vegetative growth (plant height and fresh biomass production) BARI Mug4 was found better over other varieties in all treatment conditions. In case of yield and yield contributing characters BARI Mug 6 was found the best followed by BARIMug 5 in almost all treatment combinations. Considering Harvest Index the best combination in 2007, was T_4V_4 combination (17.65 %) followed by T_3V_4 (17.24%). On the other hand T_1V_4 produced the highest HI (17.28 %) in the following years (2008) followed by T_1V_3 (15.64 %) and third highest HI (15.58%) was recorded in T_2V_4 followed by T_4V_4 (14.83 %). The HI study revealed that V_4 under mango can produced higher HI than that of three other (V_1, V_2 and V_5) varieties when grown in open field. Incase of land equivalent ratio for different agroforestry systems varied differently by the varieties as well as cropping years. In 2007, highest LER was recorded for guava based agroforestry system (2.1-2.17%) except T_3V_4 combination (2.08) followed by black siris based agroforestry system (1.09-2.13%). Mango based system produced lowest LER and the range was 1.83-2.03%. In 2008, maximum LER was recorded in mango based system (5.22-5.44%) which was followed by black siris based system (2.29-2.39%) in this year guava based system produced lowest LER and the range was 1.75-1.91%. The following year (2008) highest LER from mango based system due to higher increment of mango tree in agroforestry system than sole tree production and this ratio (Ti/Ts) was 4.55 although grain yield ratio of mung bean varieties between agroforestry and sole cropping was 0.87. The result proved that effect of under storey crops on the increment of trees was found higher in

mango followed by black siris and then guava. From the economic analysis, The highest BCR was recorded for T_1V_4 combination (BARI Mug 6 in open field) in both the cropping years (1.84 and 1.85 in 2007 and 2008 respectively) followed by T_4V_4 (BARI Mug 6 in mango). BARI Mug 6 always found profitable over other varieties in each treatment combination, followed by BARIMug 5. Local variety (V_5) always gave negative net return as well as poor BCR (<1) in both the cropping years irrespective of treatment combinations. The study revealed that BARI Mug 6 was more profitable grown under mango (BCR was 1.33) than the variety BARI Mug 3 and BARI Mug 4 grown in open field (BCR values 1.2 and 1.27, respectively) on the other hand BARI Mug 4 was the best one for producing higher biomass.

In 4th experiment performance of banana was studied in different tree crop combinations. The treatments were T_1 = Sole banana, T_2 = Banana with Potato - Onion, T_3 = Banana with Ipil-ipil, T_4 = Banana with Gora neem, T_5 = Banana with Ipil-ipil + Potato - Onion,T_6 = Banana with Gora neem + Potato – onion.Various responses of different parameter of banana were due to combined effect of partial shade provided by different MPTs and bellow ground interactions among the components. Fresh yield (t ha^{-1}) is the ultimate object of banana cultivation. The fresh yield of banana is mainly depended on the yield contributing characters like number of hand/ bunch, number of finger hand^{-1} and finger weight. Degree of light intensity provided by different MPTs in addition to below ground competitions for growth resources had significant impact on fresh yield of banana (Table 4.4.3). In 2006 the highest fresh yield was recorded in Sole banana (8.72 ton ha^{-1}) followed by Banana with Potato-Onion (7.53 t ha^{-1}). Significantly lowest yield (5.93 t ha^{-1}) was recorded in T_5 (Banana with Ipil-ipil + Potato - Onion) which was similar to that of all other treatments except T_2 (Banana with Potato – Onion). In 2007, the highest fresh yield (6.64 ton /ha) was obtained from T_2 (Banana with Potato - Onion) followed by T_1 (6.4 t ha^{-1}). Again the lowest yield (4.63 t ha^{-1}) was observed from T_6 (Banana with Gora neem + Potato – onion) which was statistically similar with T_5 (5.33 t ha^{-1}), T_4 (5.37), and T_3 (6.03).This results showed that production of potato followed by onion in association of banana might be the cause of higher fresh yield of bananas and other decreased yield was directly correlated with the low light intensity.

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In 5th experiment performance of potato was studied as lower storied crop in different tree crop combinations. The treatments were T_1 = Sole potato (control), T_2 = Potato with banana, T_3 = Potato with ipil-ipil, T_4 = Potato with goraneem, T_5 = Potato with banana + ipil-ipil, T_6 = Potato with banana + goraneem. Plant height is one of the most important growth parameter of tomato which was significantly influenced by different upper storied tree species. In 2006, the highest plant height (49.23cm) was observed from T_5 followed by T_6 (49.00cm) and T_3 (47.63cm). T_6, T_5 and T_3 were statistically identical. The lowest plant height was obtained from T_1 (43.42cm) which was statistically similar to T_2 (44.7cm). In 2007, significantly the longest plant (57.67cm) was produced by T_5 followed by T_6 (54.03cm). The plant height recorded from T_4(51.47cm) and T_3 (53.37cm) were statistically identical to T_6. The lowest plant height was observed from T_1(45.33cm) which was statistically identical to T_2(48.25cm). The response of plant height revealed that increase of light intensity might be caused of shorter plant.

The tuber yield (t ha^{-1}) was greatly affected by the different configuration of the component in both cropping seasons. The variation was identical to that of tuber yield per hill. In both the year significantly the highest yield was recorded in T_1 i.e. open field (18.51 and 20.3 t ha^{-1}in 2006 and 2007 irrespectively followed by T_2 (Table 4.5.2). Significantly the lowest yield (9.0 and 9.5 t ha^{-1}in 1st and 2nd year, respectively) was obtained by T_3 (potato with ipil ipil) which was similar to T_5 (12.11 and 11.5 in 2006 and 2007 respectively). T_6 produced the moderate yield in both the cropping season (13.03 and 12.8 t/ha in 2006 and 2007 respectively. Performance of potato under different treatment combinations proved that low light intensity created by multistoried system hampered its yield. For higher yield of potato banana + gora neem association is better than banana + ipil ipil.

In 6th experiment Performance of onion was studied as a lower storied crop for multistoried Agroforestry systems. The treatments were T_1 = Sole onion (control), T_2 = Onion with banana, T_3 = Onion with ipil- ipil, T_4 = Onion with goraneem, T_5 = Onion with banana + ipil- ipil and T_6 = Onion with banan +goraneem.

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In 7th experiment, effect of lower storied crop on the performance of MPTs were studied. Total five MPTs were used in this studies among them blacksiris, guava and mango were used with wheat-mungbean-T.aman cropping pattern, other two species i.e. ipil-ipil and goraneem were used in multistoried experiment. All growth parameter of MPTs i.e, plant height, base girth, girth at breast height, bole volume and crown diameter were calculated in CAI and MAI basis but in both cases blacksiris, guava and mango trees grown in agroforestry practice showed higher values than in sole tree production. In multistoried systems goraneem responded higher than ipil-ipil. Almost all growth parameter of goraneem was found remarkably higher in goraneem+banana+potato-onion production system. CAI for volume of gora neem from this system was more than double of sole goraneem, where as it was very scanty for ipil-ipil. There was negative effect of lower storied crop production on flowering and bearing habit of guava while these made positive effect for mango flowering and fruiting.

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In 8th experiment, soil physical and chemical properties were analyzed every year. From the soil fertility point of view, blacksiris based T.aman-wheat-mungbean cropping pattern was found highly sustainable followed by mango based system. Sole tree production plots remained unchanged their initial fertility status except one or two elements. Incase of multistoried production elemental status was not found stable it fluctuated in irregular fashion.

Selection of the systems on the basis of economic and sustainability evaluation:

Economic of Rice-Wheat-Mungbean cropping pattern in different agroforestry systems are summarized on the basis of two years average results of net return (Tk ha^{-1}) and BCR . Mango based T.aman-wheat- mungbean cropping pattern (comprising the varieties BR11, Shatabdi and BARI Mug 6 for rice, wheat and mungbean respectively) showed the highest net return (34,8282 Tk) and BCR (3.14) followed by black siris based agroforestry practice (The net return and BCR were 12,4418 Tk and 2.05 respectively). The lowest net return (173643 Tk) and BCR (1.13) were found in guava based agroforestry. Even sole cropping produced the higher BCR (1.64) than that of guava based agroforestry (1.13).

Multistoried agroforestry systems were also economically evaluated on the basis of two years average results. The highest net return (163819 Tk) was obtained from potato-onion+banana+goraneem combination although this combination was secured 4th position in consideration of BCR. The highest BCR (2.28) was recorded for sole potato followed by onion practice. These sole cropping practice showed higher BCR than agroforestry practice might be due to low cost of production. In agroforestry practice initial cost of saplings and their plantation cost is higher which was the main reason for low BCR value. Although, goraneem based multistoried produced the highest BCR among all multistoried practice.

Among all agroforestry practices mango based (T.aman-wheat-mungbean cropping pattern) agroforetsry was found highly profitable (BCR 3.14) which was produce followed by black siris based agroforestry practice (BCR 2.05) and then potato-onion+banana+goraneem based multistoried agroforestry (BCR 2.04).

The total 9 agroforestry systems (Blacksiris+T.aman+wheat+mungbean, Guava +T. aman +wheat + mungbean, Mango +T. aman + wheat + mungbean, Ipil-ipil + Banana + Potato + Onion, Gora-neem + Banana + Potato + Onion, Ipil-ipil + Potato + Onion, Gora-neem + Potato + Onion, Ipil-ipil + Banana, Gora-neem + Banana) were used in this experiment

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Multistoried agroforestry systems were also economically evaluated on the basis of two years average results. The highest net return (163819 Tk) was obtained from potato-onion+banana+goraneem combination although this combination was secured 4th position in consideration of BCR. The highest BCR (2.28) was recorded for sole potato followed by onion practice. These sole cropping practice showed higher BCR than agroforestry practice might be due to low cost of production. In agroforestry practice initial cost of saplings and their plantation cost is higher which was the main reason for low BCR value. Although, goraneem based multistoried produced the highest BCR among all multistoried practice.

Among all agroforestry practices mango based (T.aman-wheat-mungbean cropping pattern) agroforetsry was found highly profitable (BCR 3.14) which was produce followed by black siris based agroforestry practice (BCR 2.05) and then potato-onion+banana+goraneem based multistoried agroforestry (BCR 2.04).

The total 9 agroforestry systems (Blacksiris+T.aman+wheat+mungbean, Guava +T. aman +wheat + mungbean, Mango +T. aman + wheat + mungbean, Ipil-ipil + Banana + Potato + Onion, Gora-neem + Banana + Potato + Onion, Ipil-ipil + Potato + Onion, Gora-neem + Potato + Onion, Ipil-ipil + Banana, Gora-neem + Banana) were used in this experiment

In 8th experiment, soil physical and chemical properties were analyzed every year. From the soil fertility point of view, blacksiris based T.aman-wheat-mungbean cropping pattern was found highly sustainable followed by mango based system. Sole tree production plots remained unchanged their initial fertility status except one or two elements. Incase of multistoried production elemental status was not found stable it fluctuated in irregular fashion.

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excluding control practice, which were evaluated by the total factor productivity for their sustainability. According to this evaluation, the mango based agroforestry system was found most sustainable followed by potato-onion+banana+ goraneem based multistoried practice. The 3rd sustainable system was found potato-onion + banana+ ipil-ipil based multistoried system. Black siris based (BR 11- Shatabdi- BARI Mug 6) agroforestry was stood 4th position in the sustainability rank order. The study revealed that mango (Var Amrapali) based farm land agroforestry accommodating BR 11 for T. aman, Shatabdi for wheat and BARI Mug 6 for mungbean was found the most profitable and sustainable practice. Goraneem+banana+ potato-onion multistoried was found better which can be used in homestead for best utilization of land use, diversified production and higher fiscal gain.

5.2 Conclusion

The findings of the present investigation revealed that diversification of farming system and intensification of land use growing wheat-mungbean-T.aman cropping pattern with fruit trees; combination of fruit, vegetables, spices and forest tree species as multistoried agroforestry systems had great option for increasing yield as well as higher income of farmers. Among nine agroforestry practice, mango (Var. Amrapali) based farm land agroforestry, accommodating BR 11 for T. aman, Shatabdi for wheat and BARI Mug 6 for mungbean was found the most profitable and sustainable practice which can be used as farmland agroforestry system. This system can save 49% nitrogenous fertilizer for T. aman and save total irrigation and fertilization cost for mango tree.

The second profitable practice was found Goraneem based multistoried agroforestry system comprising banana as middle storey and potato followed by onion as lower storey crops which can be used in homestead or in high land practice for best utilization of natural resourses, diversified production and higher income. Despite some negative effects of upper storied trees on the growth, yield and physiological attributes of lower layered crops, particularly at closer distance to the tree rows, screened two agroforestry practices are still beneficial as they ensure higher land use ratio and benefit cost ratio in comparison to sole cropping.

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The investigations proved that there were some positive effects of lower storied cropping on the growth of all MPTs but little adverse effect on bearing of guava trees. Continuous cropping enhanced vegetative growth of guava but decreased fruiting in compared to sole guava, on the other hand, continuous cropping had notable boosting effect on growth, flowering and fruiting of mango.

Soil PH, soil organic matter and most of other elements were found to increase in agroforestry systems containing wheat-mungbean- T.aman cropping pattern. Among the tree species blacksiris based system was found highly sustainable followed by mango based system. Sole tree production plots remained unchanged their initial fertility status except one or two elements. Incase of multistoried production elemental status was not found stable, it fluctuated in irregular fashion.

5.3 Recommendations and suggestions

1. Mango (Var Amrapali) based farm land agroforestry, accommodating BR 11 for T. aman, Shatabdi for wheat and BARI Mug 6 for mungbean can be advocated for farmers' practice which was found more profitable and sustainable practice and can be used as one of the foremost poverty reduction tools. Number of trees per hectare should be standardized by further research.

2. Goraneem based multistoried agroforestry system comprising banana as middle storey and potato followed by onion as lower storey crops which can be used in homesteads, hill or any other high land practice for better utilization of natural resources by unemployed people. It will increase vertical space utilization and diversified production for rural poor of Bangladesh.

3. Sowing time of under storied crops should be maintained properly otherwise effect of lower storied crops on tree performance may be changed specially for fruit trees.

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4. The current study opened a new era for further investigation into the screening of more tree species suitable for Farm Land Agroforestry (FLA) and Multistoried Agroforestry Systems (MAF) with the existing crop species.

5. This study should be repeated in different location of the country with existing crop combinations.

6. There is also a good scope for more in-depth studies on below ground competition for growth resources (soil moisture and nutrient) by arable crops and upper layered tree species in different agroforestry systems.

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REFERENCES

Abedin, M.Z., Akter, M.S. and Alam, M.S. 1991. Multipurpose trees and their uses on the small farmers of low rainfall Ganges Floodplain Soils of Bangladesh. *Proceeding on an International Workshop on multipurpose tree species for small farm use;* held on November 2-5, 1987 at Patty, Thailand.

Ahmed, F. 2005. Performance of medicinal plants and spices in coconut based agroforestry system. *MS Thesis*, Department of Agroforestry, Bangladesh Agricultural Univversity, Mymensing. p . 1.

Akber,G., Rafique, M., and Babar, K. N. 1990. Effects of trees on the yield of wheat crops. Agroforestry sys. 11: 1-10.

Akter, M.S., Abedin, M.Z. and Quddus, M.A. 1989. Why farmers grow trees in agricultural fields: some thoughts, some results, *Research Report*, 1988-89. On Farm Research Division, Joydebpur.

Akter, M.S., Abedin, M.Z. and Quddus, M.A. 1990. Why farmer grow trees in agricultural fields; some results. *Proc. Regional Symposium on Tree Plantation in the Humid/Sub-humid Tropics in Asia;* held on May 5-9, 1988 in University Partanian, Malaysia. and tree in the Sahel. *Agroforestry Today* 7(1): 9-11.

Ali, M.A.1998. Growth and Yield of Mungbean Genotype under Sun and Shade Conditions. An MS Thesis, BSMRAU, Bangladesh.

Ali, M.S. and M.A.Q. Sheikh. 1987. Variability and correlation studies in summer Mungbean *(Vigna radiate L.)*. Bangladesh. 7. Agric. 12: 63-67.

Alvim, R. 1977. Combination of cacao with other plantation crops an Agroforestry system is southest Bahia, Brazil. Agroforestry system 4: 3-15, 1986.

Amin, M. H. A. 2007. Performance of Transplanted Aman Rice Under Different Multipurpose Tree speices as Agroforetry System. An MS Thesis, HSTU, Dinajpur, Bangladesh.

Anderson, T.B., Hanson, P., Sordoz and Zomorlic. K. 1993. Effect of light and leaf shoot removals on growth distribution and fruit drop. Sixth In. Symp. Rubus and Ribes, Poland, 5-10 July, 1993. Acta, Hort. 35:237-245.

Anon, 2005. Perticipatory forestry newsletter, bulletin no. Forest Department, Bangladesh.

REFERENCES

Abedin, M.Z., Akter, M.S. and Alam, M.S. 1991. Multipurpose trees and their uses on the small farmers of low rainfall Ganges Floodplain Soils of Bangladesh. *Proceeding on an International Workshop on multipurpose tree species for small farm use;* held on November 2-5, 1987 at Patty, Thailand.

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Anon, 2005. Perticipatory forestry newsletter, bulletin no. Forest Department, Bangladesh.

REFERENCES

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Anon, 2005. Perticipatory forestry newsletter, bulletin no. Forest Department, Bangladesh.

Anon, 2007. Bangladesh:State of the Environment 2001. http://www.rrcap .unep. org/ reports soe/bangladesh_landpdf, Accesed on November 2007.

Anon. 2009. Monthly Bulletin, Bangladesh Bureau of Statistics. Ministry of Planning Government of the people Republic of Bangladesh, Dhaka, Bangladesh.

Araki, Y., Inoue, S., Murakami, K., Lee, J. and Gross, K.C. 1999. Effect of shading on growth and quality A summer spinach. Acta. Hort. 485: 105-110.

Ashour, N.; Saad, A.; Tayel, M. and Kabesh, M. 1997. Lentil and wheat production in peach orchards under rainfed marginal conditions of North Sinai. Egypt J. Soils. Sci. 37: 549-565.

Azad, K. and Sikka, B. 1991. Production and marketing of temperate fruits in Northwest region of India. Acta Hort. 271: 67-74.

BARC. 1997. *Fertilizer recommendation guide*. Bangladesh Agricultural Research Council, Farmgate, Dhaka.

Basri, I.H., Mercado, A.R. and Gamity, D.P. 1990. Upland rice cultivation using leguminous tree hedgerows on strongly acid soils. Paper presented at the IRRI Saturday seminar, 31 March 1990. p. 14.

BBS. 2006. *Statistical Year Book of Bangladesh.* Bangladesh Bureau of Statistics. Ministry of Planning Government of the People Republic of Bangladesh, Dhaka, Bangladesh.

Bhatia, K.S. and Singh, R.P. 1994. Trees for sustainable agriculture production. *Agroforestry Abstract* 7(3): 125.

Binchy, A. and Morgan, J.V. 1970. Influence of light intensity and photo period inflorescence initiation in tomatoes. Iris. J. Agril. Res. 8: 261-267.

Bose, T.K; Mitra S.K. and Sanyal D. 2004. Fruits: Tropical and subtropical Vd: 1, 3rd Ed. New Sarder Press, 9c, Shibnarayan, Das Lane, Calcata- 700, 006, India .pp.12-13.

Cannell, M.G.R. 1983. Plant management in agroforestry: manipulation of trees, population densities and mixture of trees and herbaceous crops. In: Huxley, P.A. (ed.), *Plant research and agroforestry*, pp.455-486. ICRAF, Nirobi, Kenya.

Casavajda, E. 2002. Productivity investigations of some green manure crops as valuable factors in the maintenance of soil fertility *I. Acta Agronomica Ovariensis.* 44(2): 121-133.

Anon, 2007. Bangladesh:State of the Environment 2001. http://www.rrcap .unep. org/ reports soe/bangladesh_landpdf, Accesed on November 2007.

Anon. 2009. Monthly Bulletin, Bangladesh Bureau of Statistics. Ministry of Planning Government of the people Republic of Bangladesh, Dhaka, Bangladesh.

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BARC. 1997. *Fertilizer recommendation guide*. Bangladesh Agricultural Research Council, Farmgate, Dhaka.

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BBS. 2006. *Statistical Year Book of Bangladesh.* Bangladesh Bureau of Statistics. Ministry of Planning Government of the People Republic of Bangladesh, Dhaka, Bangladesh.

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Anon, 2007. Bangladesh:State of the Environment 2001. http://www.rrcap .unep. org/ reports soe/bangladesh_landpdf, Accesed on November 2007.

Anon. 2009. Monthly Bulletin, Bangladesh Bureau of Statistics. Ministry of Planning Government of the people Republic of Bangladesh, Dhaka, Bangladesh.

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BARC. 1997. *Fertilizer recommendation guide*. Bangladesh Agricultural Research Council, Farmgate, Dhaka.

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BBS. 2006. *Statistical Year Book of Bangladesh.* Bangladesh Bureau of Statistics. Ministry of Planning Government of the People Republic of Bangladesh, Dhaka, Bangladesh.

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Casavajda, E. 2002. Productivity investigations of some green manure crops as valuable factors in the maintenance of soil fertility *I. Acta Agronomica Ovariensis.* 44(2): 121-133.

Chowdhury, M.A., M.A. Khaleque and M.M. Rahman. 1988. Variability and correlation among some yield contributing characters in Mungbean. Bangladesh Plant Breeding and Genetics 1 (1 &2): 62-65.

Chowdhury, M.K. and Mahat, T.B.S. 1993. Agroforestry systems of Bangladesh. In: Agroforestry farming systems linkage in Bangladesh, Chowdhury, M.K. and Mahat T.B.S. (eds.), BARC, Winrock Int; Dhaka. P. 119.

Chowdhury, M.K. and Satter, M.A.1993. Homestead and cropland agroforestry practices in the high Ganges river floodplain. pp. 23-56. In: Agroforestry farming systems linkage in Bangladesh. BARC Winrock International. Dhaka, Bangladesh.

CIA, 2007. https:/www.cia.gov/library/publications/ the-world- factbook/goes/bg.html (accessed on November, 2007).

Crookston, R.K., Trehame, K.J., Ludford, P. and Ozbun, J.I. 1975. Response of beans to shading. *Crop Sci.* 15: 412-416.

Das, M., Pal, M., Zaidi, P. H., Raj, A. and Sengupta, U. K. 1999. Growth response of mungbean to elevated level of carbon dioxide. *Indian J. Plant. Physiol.,* 5(2): 132-135.

Das, S.; Sharma, S., Sharma, K. Saharan, N., Nimbole, N. and Reddy, Y. 1993. Land use options on a semi-arid Alfisol. Amer. J. Alt.Agric. 8: 34-39.

Dhukia, R.s., Lodhi, G.p., Jatasra, D.S and Ram, S. 1988. Productivity of forage and food crops in agroforestry system under shisham and siris trees. Indian J. Range. Manage. 9: 53-57.

Dhyani, S.; Chauhan, D, Kumar, D, Kushwaha and Lepcha, S. 1996. Sericulture-based agroforestry systems for hilly areas of north-east India. Agrofor. Sys. 34: 247-258.

Douglas, J.J.1982. *Consumption and supply of wood and bamboo in Bangladesh.* Field document no. 3, UNDP/ FAO project. BGD/ 78/010, Bangladesh Planning Commission, Dhaka.

Fakir, M. S. A. 1997. A study of morphophysiological selection criteria related to yield in pigeonpea (*Cajanus cajan* (L.) Millsp.*). Ph. D. Thesis,* Department of Life Sciences. The University of West Indies. St. Augustine, Trinidad. p. 8-29.

Fakir, M. S. A., Umaharan, P. and McDavid, C. R. 1998. A modified method for estimating floral abscission in pigeonpea. Trop. Agric. (Trinidad), 75(3): 393-395.

Chowdhury, M.A., M.A. Khaleque and M.M. Rahman. 1988. Variability and correlation among some yield contributing characters in Mungbean. Bangladesh Plant Breeding and Genetics 1 (1 &2): 62-65.

Chowdhury, M.K. and Mahat, T.B.S. 1993. Agroforestry systems of Bangladesh. In: Agroforestry farming systems linkage in Bangladesh, Chowdhury, M.K. and Mahat T.B.S. (eds.), BARC, Winrock Int; Dhaka. P. 119.

Chowdhury, M.K. and Satter, M.A.1993. Homestead and cropland agroforestry practices in the high Ganges river floodplain. pp. 23-56. In: Agroforestry farming systems linkage in Bangladesh. BARC Winrock International. Dhaka, Bangladesh.

CIA, 2007. https:/www.cia.gov/library/publications/ the-world- factbook/goes/bg.html (accessed on November, 2007).

Crookston, R.K., Trehame, K.J., Ludford, P. and Ozbun, J.I. 1975. Response of beans to shading. *Crop Sci.* 15: 412-416.

Das, M., Pal, M., Zaidi, P. H., Raj, A. and Sengupta, U. K. 1999. Growth response of mungbean to elevated level of carbon dioxide. *Indian J. Plant. Physiol.,* 5(2): 132-135.

Das, S.; Sharma, S., Sharma, K. Saharan, N., Nimbole, N. and Reddy, Y. 1993. Land use options on a semi-arid Alfisol. Amer. J. Alt.Agric. 8: 34-39.

Dhukia, R.s., Lodhi, G.p., Jatasra, D.S and Ram, S. 1988. Productivity of forage and food crops in agroforestry system under shisham and siris trees. Indian J. Range. Manage. 9: 53-57.

Dhyani, S.; Chauhan, D, Kumar, D, Kushwaha and Lepcha, S. 1996. Sericulture-based agroforestry systems for hilly areas of north-east India. Agrofor. Sys. 34: 247-258.

Douglas, J.J.1982. *Consumption and supply of wood and bamboo in Bangladesh.* Field document no. 3, UNDP/ FAO project. BGD/ 78/010, Bangladesh Planning Commission, Dhaka.

Fakir, M. S. A. 1997. A study of morphophysiological selection criteria related to yield in pigeonpea (*Cajanus cajan* (L.) Millsp.*). Ph. D. Thesis,* Department of Life Sciences. The University of West Indies. St. Augustine, Trinidad. p. 8-29.

Fakir, M. S. A., Umaharan, P. and McDavid, C. R. 1998. A modified method for estimating floral abscission in pigeonpea. Trop. Agric. (Trinidad), 75(3): 393-395.

Chowdhury, M.A., M.A. Khaleque and M.M. Rahman. 1988. Variability and correlation among some yield contributing characters in Mungbean. Bangladesh Plant Breeding and Genetics 1 (1 &2): 62-65.

Chowdhury, M.K. and Mahat, T.B.S. 1993. Agroforestry systems of Bangladesh. In: Agroforestry farming systems linkage in Bangladesh, Chowdhury, M.K. and Mahat T.B.S. (eds.), BARC, Winrock Int; Dhaka. P. 119.

Chowdhury, M.K. and Satter, M.A.1993. Homestead and cropland agroforestry practices in the high Ganges river floodplain. pp. 23-56. In: Agroforestry farming systems linkage in Bangladesh. BARC Winrock International. Dhaka, Bangladesh.

CIA, 2007. https:/www.cia.gov/library/publications/ the-world- factbook/goes/bg.html (accessed on November, 2007).

Crookston, R.K., Trehame, K.J., Ludford, P. and Ozbun, J.I. 1975. Response of beans to shading. *Crop Sci.* 15: 412-416.

Das, M., Pal, M., Zaidi, P. H., Raj, A. and Sengupta, U. K. 1999. Growth response of mungbean to elevated level of carbon dioxide. *Indian J. Plant. Physiol.*, 5(2): 132-135.

Das, S.; Sharma, S., Sharma, K. Saharan, N., Nimbole, N. and Reddy, Y. 1993. Land use options on a semi-arid Alfisol. Amer. J. Alt.Agric. 8: 34-39.

Dhukia, R.s., Lodhi, G.p., Jatasra, D.S and Ram, S. 1988. Productivity of forage and food crops in agroforestry system under shisham and siris trees. Indian J. Range. Manage. 9: 53-57.

Dhyani, S.; Chauhan, D, Kumar, D, Kushwaha and Lepcha, S. 1996. Sericulture-based agroforestry systems for hilly areas of north-east India. Agrofor. Sys. 34: 247-258.

Douglas, J.J.1982. *Consumption and supply of wood and bamboo in Bangladesh.* Field document no. 3, UNDP/ FAO project. BGD/ 78/010, Bangladesh Planning Commission, Dhaka.

Fakir, M. S. A. 1997. A study of morphophysiological selection criteria related to yield in pigeonpea (*Cajanus cajan* (L.) Millsp.*). Ph. D. Thesis,* Department of Life Sciences. The University of West Indies. St. Augustine, Trinidad. p. 8-29.

Fakir, M. S. A., Umaharan, P. and McDavid, C. R. 1998. A modified method for estimating floral abscission in pigeonpea. Trop. Agric. (Trinidad), 75(3): 393-395.

Fawaz, K., Mussaddak, J. and Khalaf, K. 2003. Growth and nitrogen fixation and uptake in dhaincha/sorghum intercropping system under saline and non-saline conditions. *Communications in Soil Science and Plant Analysis.* 34(17/18).

Fernandes, E.C.M. amd Nair, P.K.R. 1986. An evaluation of structure and function of some tropical home gardens. Agricultural systems 21: 179-210.

Fernandes, E.C.M; O'Kting'ati, A; and Maghembe, J. 1984. The chagga home gardens: A multistoried agroforestry cropping systems on Mt. Kilimanjaro, Northern Tanzania. Agroforestry Systems 2: 73-86.

Follett J. 1997. Ginseng production in New Zealand forests: experiences from Tiketere. *New Zealand Tree Grower* 18(3): 19-21.

Gardner, F.P; Pearce, R.B. and Mitchell, R.I. 1985. Physiology of crop lands. Iowa State Uni. Press. Iowa. p.66.

Garrity, D.P., Mescado, A. Jr. and Solera, C. 1992. The nature of species interference and soil change in contour hedge row system on slopping acidic lands. Paper presented at the Int. Conf. Alley Farming IITA (Int. Inst. Trop. Agric) Ibam, Nigeria, 14-18 Sept.1992.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research (2nd edn.). John Wiley and Sons. Singapore.

Gomez, K.A. and Gomez, A.A.1984. Statistical procedures for Agricultural Res. 2nd Edn. Johnwiley and Sons, New York. P. 680.

Groot, J.J.R. and Sourmare, A. 1995. The roots of the matter: Soil quality development issue. *New Zealand Tree Grower* 18(3): 30-32.

Gupta R. 1986. Integration of medicinal plants cultivation in forest and forest plantations of northwestern Himalaya. pp. 59-67. *In: Agroforestry Systems: A New Challenge.* Indian Society of Tree Scientists, Solan, India.

Gupta, R.K. 1993. Multipurpose trees for agroforestry utilization on ford 13th publishing co. PVT. LTD. Mumbai; India B: 132.

Hager N. and Otterstedt J. 1996. Coope San Juan, a farmers' cooperative. Sustainable use of the natural forest-past and future: a minor field study. *Working Paper No. 302.* International Rural Development Centre, Swedish University of Agricultural Sciences, Uppsala, Sweden. p.59.

Haris, A., Rai, R.K., Safeena, A.N., Mukherjee, P.K. and Haris, A. 1999. Available 'N' status of the soil as influenced by phosphorus application and some kharif green manure crops grown in succession with some rabi crops. *Annals of Agricultural Research.* 20(4): 522-523.

Fawaz, K., Mussaddak, J. and Khalaf, K. 2003. Growth and nitrogen fixation and uptake in dhaincha/sorghum intercropping system under saline and non-saline conditions. *Communications in Soil Science and Plant Analysis.* 34(17/18).

Fernandes, E.C.M. amd Nair, P.K.R. 1986. An evaluation of structure and function of some tropical home gardens. Agricultural systems 21: 179-210.

Fernandes, E.C.M; O'Kting'ati, A; and Maghembe, J. 1984. The chagga home gardens: A multistoried agroforestry cropping systems on Mt. Kilimanjaro, Northern Tanzania. Agroforestry Systems 2: 73-86.

Follett J. 1997. Ginseng production in New Zealand forests: experiences from Tiketere. *New Zealand Tree Grower* 18(3): 19-21.

Gardner, F.P; Pearce, R.B. and Mitchell, R.I. 1985. Physiology of crop lands. Iowa State Uni. Press. Iowa. p.66.

Garrity, D.P., Mescado, A. Jr. and Solera, C. 1992. The nature of species interference and soil change in contour hedge row system on slopping acidic lands. Paper presented at the Int. Conf. Alley Farming IITA (Int. Inst. Trop. Agric) Ibam, Nigeria, 14-18 Sept.1992.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research (2nd edn.). John Wiley and Sons. Singapore.

Gomez, K.A. and Gomez, A.A.1984. Statistical procedures for Agricultural Res. 2nd Edn. Johnwiley and Sons, New York. P. 680.

Groot, J.J.R. and Sourmare, A. 1995. The roots of the matter: Soil quality development issue. *New Zealand Tree Grower* 18(3): 30-32.

Gupta R. 1986. Integration of medicinal plants cultivation in forest and forest plantations of northwestern Himalaya. pp. 59-67. *In: Agroforestry Systems: A New Challenge.* Indian Society of Tree Scientists, Solan, India.

Gupta, R.K. 1993. Multipurpose trees for agroforestry utilization on ford 13th publishing co. PVT. LTD. Mumbai; India B: 132.

Hager N. and Otterstedt J. 1996. Coope San Juan, a farmers' cooperative. Sustainable use of the natural forest-past and future: a minor field study. *Working Paper No. 302.* International Rural Development Centre, Swedish University of Agricultural Sciences, Uppsala, Sweden. p.59.

Haris, A., Rai, R.K., Safeena, A.N., Mukherjee, P.K. and Haris, A. 1999. Available 'N' status of the soil as influenced by phosphorus application and some kharif green manure crops grown in succession with some rabi crops. *Annals of Agricultural Research.* 20(4): 522-523.

Fawaz, K., Mussaddak, J. and Khalaf, K. 2003. Growth and nitrogen fixation and uptake in dhaincha/sorghum intercropping system under saline and non-saline conditions. *Communications in Soil Science and Plant Analysis.* 34(17/18).

Fernandes, E.C.M. amd Nair, P.K.R. 1986. An evaluation of structure and function of some tropical home gardens. Agricultural systems 21: 179-210.

Fernandes, E.C.M; O'Kting'ati, A; and Maghembe, J. 1984. The chagga home gardens: A multistoried agroforestry cropping systems on Mt. Kilimanjaro, Northern Tanzania. Agroforestry Systems 2: 73-86.

Follett J. 1997. Ginseng production in New Zealand forests: experiences from Tiketere. *New Zealand Tree Grower* 18(3): 19-21.

Gardner, F.P; Pearce, R.B. and Mitchell, R.I. 1985. Physiology of crop lands. Iowa State Uni. Press. Iowa. p.66.

Garrity, D.P., Mescado, A. Jr. and Solera, C. 1992. The nature of species interference and soil change in contour hedge row system on slopping acidic lands. Paper presented at the Int. Conf. Alley Farming IITA (Int. Inst. Trop. Agric) Ibam, Nigeria, 14-18 Sept.1992.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research (2nd edn.). John Wiley and Sons. Singapore.

Gomez, K.A. and Gomez, A.A.1984. Statistical procedures for Agricultural Res. 2nd Edn. Johnwiley and Sons, New York. P. 680.

Groot, J.J.R. and Sourmare, A. 1995. The roots of the matter: Soil quality development issue. *New Zealand Tree Grower* 18(3): 30-32.

Gupta R. 1986. Integration of medicinal plants cultivation in forest and forest plantations of northwestern Himalaya. pp. 59-67. *In: Agroforestry Systems: A New Challenge.* Indian Society of Tree Scientists, Solan, India.

Gupta, R.K. 1993. Multipurpose trees for agroforestry utilization on ford 13th publishing co. PVT. LTD. Mumbai; India B: 132.

Hager N. and Otterstedt J. 1996. Coope San Juan, a farmers' cooperative. Sustainable use of the natural forest-past and future: a minor field study. *Working Paper No. 302.* International Rural Development Centre, Swedish University of Agricultural Sciences, Uppsala, Sweden. p.59.

Haris, A., Rai, R.K., Safeena, A.N., Mukherjee, P.K. and Haris, A. 1999. Available 'N' status of the soil as influenced by phosphorus application and some kharif green manure crops grown in succession with some rabi crops. *Annals of Agricultural Research.* 20(4): 522-523.

Harou, 1983. Economic principles of appraise agroforestry project. *Agricultural Administration* 12: 127-139.

Hazra, C.R and Tripathi,S.B. 1989. Performance of wheat genotypes under different tree covers and open area. Indian J. Agric. Sci. Digest Karnal. 9(3): 146-148.

Herzog, F. 1998. Streuobst: a traditional agroforestry system as a model for agroforestry development in temperate Europe. Agrofor. Sys. 42: 61-80.

Hill, D.B. and Buck, L.E. 2000. Forest farming practices. pp.283-320. In : Garrett H.E., Rietveld W.J. and Fisher R.F. (eds.), *North American Agroforestry: An Integrated Science and Practice*. American Society of Agronomy Inc., Madison, W.I., USA.

Hillman,J.R. 1984. Apical dominance In: wilking,M.b. (ed). Advanced Plant Physiology. Pitman, London, Pp: 127-148.

Hocking, D and Islam, K. 1997. Trees on farms in Bangladesh: Growth of top and root pruned trees in woodland rice fields and yields of understory crops. Agroforestry systems.39: 101-115.

Hossain, K. L., Wadud, M. A., Hossain, K. S. and Abdullah, M. R. 2005. Performance of Indian spinach in association with Eucalyptus for agroforestry system. *J. Bangladesh Agril. Univ*. 3(1): 29-35.

Hossain, M.S .2007. Study on the jackfruit pulp on the quality of cake. Journ. of Sci. and Tech. Vol. 5:35-43.

Hossain, S. M. A., Salam, M. U., Alam, A. B. M. M. and Kashem, M. A. 1997. Declining soil organic matter: Farmers management and strategies for improvement. *J. Rural Dev*. 27(1): 1-18.

Hossain, S.M.A. and Bari, M.N. 1993. Agroforestry farming system. In: Haque, M.A. (ed). *Agroforestry in Bangladesh*. Swiss Development Corporation (SDC), Dhaka and Bangladesh Agricultural University (BAU), Mymensingh, pp. 21-28.

Howard, S.B., Ong, C.K., Rao, M.R., Mathuva, M. and Black, C.R. 1995. The partitioning of light and water in *Leucaena*-maize agroforestry systems. In : Sinoquet, H. and Cruz P. (ed.). *Ecophysiology of tropical intercropping* IRNA Edition, Paris, France.

Iqbal, M.A; Ahmed, S. and Razzaque, A. 2002. Balancing crop with environment: Agroforestry Bangladesh Perspective, Pp: 120-128.

Harou, 1983. Economic principles of appraise agroforestry project. *Agricultural Administration* 12: 127-139.

Hazra, C.R and Tripathi,S.B. 1989. Performance of wheat genotypes under different tree covers and open area. Indian J. Agric. Sci. Digest Karnal. 9(3): 146-148.

Herzog, F. 1998. Streuobst: a traditional agroforestry system as a model for agroforestry development in temperate Europe. Agrofor. Sys. 42: 61-80.

Hill, D.B. and Buck, L.E. 2000. Forest farming practices. pp.283-320. In : Garrett H.E., Rietveld W.J. and Fisher R.F. (eds.), *North American Agroforestry: An Integrated Science and Practice*. American Society of Agronomy Inc., Madison, W.I., USA.

Hillman,J.R. 1984. Apical dominance In: wilking,M.b. (ed). Advanced Plant Physiology. Pitman, London, Pp: 127-148.

Hocking, D and Islam, K. 1997. Trees on farms in Bangladesh: Growth of top and root pruned trees in woodland rice fields and yields of understory crops. Agroforestry systems.39: 101-115.

Hossain, K. L., Wadud, M. A., Hossain, K. S. and Abdullah, M. R. 2005. Performance of Indian spinach in association with Eucalyptus for agroforestry system. *J. Bangladesh Agril. Univ*. 3(1): 29-35.

Hossain, M.S .2007. Study on the jackfruit pulp on the quality of cake. Journ. of Sci. and Tech. Vol. 5:35-43.

Hossain, S. M. A., Salam, M. U., Alam, A. B. M. M. and Kashem, M. A. 1997. Declining soil organic matter: Farmers management and strategies for improvement. *J. Rural Dev*. 27(1): 1-18.

Hossain, S.M.A. and Bari, M.N. 1993. Agroforestry farming system. In: Haque, M.A. (ed). *Agroforestry in Bangladesh*. Swiss Development Corporation (SDC), Dhaka and Bangladesh Agricultural University (BAU), Mymensingh, pp. 21-28.

Howard, S.B., Ong, C.K., Rao, M.R., Mathuva, M. and Black, C.R. 1995. The partitioning of light and water in *Leucaena*-maize agroforestry systems. In : Sinoquet, H. and Cruz P. (ed.). *Ecophysiology of tropical intercropping* IRNA Edition, Paris, France.

Iqbal, M.A; Ahmed, S. and Razzaque, A. 2002. Balancing crop with environment: Agroforestry Bangladesh Perspective, Pp: 120-128.

Harou, 1983. Economic principles of appraise agroforestry project. *Agricultural Administration* 12: 127-139.

Hazra, C.R and Tripathi,S.B. 1989. Performance of wheat genotypes under different tree covers and open area. Indian J. Agric. Sci. Digest Karnal. 9(3): 146-148.

Herzog, F. 1998. Streuobst: a traditional agroforestry system as a model for agroforestry development in temperate Europe. Agrofor. Sys. 42: 61-80.

Hill, D.B. and Buck, L.E. 2000. Forest farming practices. pp.283-320. In : Garrett H.E., Rietveld W.J. and Fisher R.F. (eds.), *North American Agroforestry: An Integrated Science and Practice*. American Society of Agronomy Inc., Madison, W.I., USA.

Hillman,J.R. 1984. Apical dominance In: wilking,M.b. (ed). Advanced Plant Physiology. Pitman, London, Pp: 127-148.

Hocking, D and Islam, K. 1997. Trees on farms in Bangladesh: Growth of top and root pruned trees in woodland rice fields and yields of understory crops. Agroforestry systems.39: 101-115.

Hossain, K. L., Wadud, M. A., Hossain, K. S. and Abdullah, M. R. 2005. Performance of Indian spinach in association with Eucalyptus for agroforestry system. *J. Bangladesh Agril. Univ.* 3(1): 29-35.

Hossain, M.S .2007. Study on the jackfruit pulp on the quality of cake. Journ. of Sci. and Tech. Vol. 5:35-43.

Hossain, S. M. A., Salam, M. U., Alam, A. B. M. M. and Kashem, M. A. 1997. Declining soil organic matter: Farmers management and strategies for improvement. *J. Rural Dev.* 27(1): 1-18.

Hossain, S.M.A. and Bari, M.N. 1993. Agroforestry farming system. In: Haque, M.A. (ed). *Agroforestry in Bangladesh.* Swiss Development Corporation (SDC), Dhaka and Bangladesh Agricultural University (BAU), Mymensingh, pp. 21-28.

Howard, S.B., Ong, C.K., Rao, M.R., Mathuva, M. and Black, C.R. 1995. The partitioning of light and water in *Leucaena*-maize agroforestry systems. In : Sinoquet, H. and Cruz P. (ed.). *Ecophysiology of tropical intercropping* IRNA Edition, Paris, France.

Iqbal, M.A; Ahmed, S. and Razzaque, A. 2002. Balancing crop with environment: Agroforestry Bangladesh Perspective, Pp: 120-128.

Islam, M.J, 2005. Performance of lemon and guava grown under coconut based multistoried agroforestry system. *M. S. Thesis*, Dept. of Agroforestry, Bangladesh Agricultural University, Mymensingh.

Islam, S.M.T., P. Kubuta, M.F.H. Mollah and W. Agata. 1993. Effect of shading on the growth and yield of Mungbean *Vigna radiate (L.)* Wikjel., J. Agron. And Agroforestry. Icraf, Nairobi.

Islam. M.S. 1996. Effect of shading on gas exchange characteristics and productivity of Mungbean and blacgram. An M.S. Thesis. Dept. of Agron, IPSA, Gazipur. Bangladesh.

Jackson J.E. 1987. Tree and crop selection and management to optimize overall system productivity, especially light utilization in Agroforestry. Meteorology and Agroforestry , ICRAF, WMO and UNEP.

Jadhav, B.B. 1987. Effect of partial shading on the yield of rice. *Indian J. Agric. Sci.* 57(7): 193-205.

Jaing, JP; Zhu, J.J; Liu, T.Z.: He, S.N; Zhou, Z.M. and S.U.FJ. 1994. Related changes of wheat yield and photo synthetically active radiation in paulownia tree and wheat intercropping system. Henan Agricultural University, Hennan, China. Acta. Agril.Boreati Sinica: Suppliment 133-137.

Jurdali, F. 2004. Estimates of dry matter yield and nitrogen uptake in sorghum grown on saline and non-saline soils manured with dhaincha plant residues. *Journal of Plant Nutrition.* 27(9): 1611-1633.

Kang, B.T., Wilson, G.F. and Lawson, T.L. 1984. *Alley cropping a stable alternative to shifting cultivation.* IITA, Ibadan, Nigeria.

Khan, G.S and R.M. Aslam, 1974. Extend of damage of wheat by sisso. Proceeding of the Pakistan Forestry Continence. Pakistan Forest Ins., Peshwar, Pp. 37-40.

Khanum, M., M.Q. Islam, M.A.K. Mia and M.A Islam .1982. Estimation A genotype and phenotypic variation, habitability and genetic advance of some important quantitative characters in Mungbean (*Vigna radiata*) In proc. Nat I. Workshop on pulses. (Aug. 18-19-1981) BARI, Joydebpur, Gazipur, Bangladesh. Pp. 26-31.

Kurdrjavcev, V.A. 1964. The effect and light intensity on accumulation and dry matter and carbohydrate metabolism in tomatos. Figiol. Rast. 11:409-416. [Cited from Kalloo 1985. tomato (*Lycopersicon esculentum Niller*). A lliced Publ. Pvt. Ltd. P. 185-1495]

Islam, M.J, 2005. Performance of lemon and guava grown under coconut based multistoried agroforestry system. *M. S. Thesis*, Dept. of Agroforestry, Bangladesh Agricultural University, Mymensingh.

Islam, S.M.T., P. Kubuta, M.F.H. Mollah and W. Agata. 1993. Effect of shading on the growth and yield of Mungbean *Vigna radiate (L.)* Wikjel., J. Agron. And Agroforestry. Icraf, Nairobi.

Islam. M.S. 1996. Effect of shading on gas exchange characteristics and productivity of Mungbean and blacgram. An M.S. Thesis. Dept. of Agron, IPSA, Gazipur. Bangladesh.

Jackson J.E. 1987. Tree and crop selection and management to optimize overall system productivity, especially light utilization in Agroforestry. Meteorology and Agroforestry , ICRAF, WMO and UNEP.

Jadhav, B.B. 1987. Effect of partial shading on the yield of rice. *Indian J. Agric. Sci.* 57(7): 193-205.

Jaing, JP; Zhu, J.J; Liu, T.Z.: He, S.N; Zhou, Z.M. and S.U.FJ. 1994. Related changes of wheat yield and photo synthetically active radiation in paulownia tree and wheat intercropping system. Henan Agricultural University, Hennan, China. Acta. Agril.Boreati Sinica: Suppliment 133-137.

Jurdali, F. 2004. Estimates of dry matter yield and nitrogen uptake in sorghum grown on saline and non-saline soils manured with dhaincha plant residues. *Journal of Plant Nutrition.* 27(9): 1611-1633.

Kang, B.T., Wilson, G.F. and Lawson, T.L. 1984. *Alley cropping a stable alternative to shifting cultivation.* IITA, Ibadan, Nigeria.

Khan, G.S and R.M. Aslam, 1974. Extend of damage of wheat by sisso. Proceeding of the Pakistan Forestry Continence. Pakistan Forest Ins., Peshwar, Pp. 37-40.

Khanum, M., M.Q. Islam, M.A.K. Mia and M.A Islam .1982. Estimation A genotype and phenotypic variation, habitability and genetic advance of some important quantitative characters in Mungbean (*Vigna radiata*) In proc. Nat I. Workshop on pulses. (Aug. 18-19-1981) BARI, Joydebpur, Gazipur, Bangladesh. Pp. 26-31.

Kurdrjavcev, V.A. 1964. The effect and light intensity on accumulation and dry matter and carbohydrate metabolism in tomatos. Figiol. Rast. 11:409-416. [Cited from Kalloo 1985. tomato (*Lycopersicon esculentum Niller*). A lliced Publ. Pvt. Ltd. P. 185-1495]

Islam, M.J, 2005. Performance of lemon and guava grown under coconut based multistoried agroforestry system. *M. S. Thesis*, Dept. of Agroforestry, Bangladesh Agricultural University, Mymensingh.

Islam, S.M.T., P. Kubuta, M.F.H. Mollah and W. Agata. 1993. Effect of shading on the growth and yield of Mungbean *Vigna radiate (L.)* Wikjel., J. Agron. And Agroforestry. Icraf, Nairobi.

Islam. M.S. 1996. Effect of shading on gas exchange characteristics and productivity of Mungbean and blacgram. An M.S. Thesis. Dept. of Agron, IPSA, Gazipur. Bangladesh.

Jackson J.E. 1987. Tree and crop selection and management to optimize overall system productivity, especially light utilization in Agroforestry. Meteorology and Agroforestry , ICRAF, WMO and UNEP.

Jadhav, B.B. 1987. Effect of partial shading on the yield of rice. *Indian J. Agric. Sci.* 57(7): 193-205.

Jaing, JP; Zhu, J.J; Liu, T.Z.: He, S.N; Zhou, Z.M. and S.U.FJ. 1994. Related changes of wheat yield and photo synthetically active radiation in paulownia tree and wheat intercropping system. Henan Agricultural University, Hennan, China. Acta. Agril.Boreati Sinica: Suppliment 133-137.

Jurdali, F. 2004. Estimates of dry matter yield and nitrogen uptake in sorghum grown on saline and non-saline soils manured with dhaincha plant residues. *Journal of Plant Nutrition*. 27(9): 1611-1633.

Kang, B.T., Wilson, G.F. and Lawson, T.L. 1984. *Alley cropping a stable alternative to shifting cultivation.* IITA, Ibadan, Nigeria.

Khan, G.S and R.M. Aslam, 1974. Extend of damage of wheat by sisso. Proceeding of the Pakistan Forestry Continence. Pakistan Forest Ins., Peshwar, Pp. 37-40.

Khanum, M., M.Q. Islam, M.A.K. Mia and M.A Islam .1982. Estimation A genotype and phenotypic variation, habitability and genetic advance of some important quantitative characters in Mungbean (*Vigna radiata*) In proc. Nat I. Workshop on pulses. (Aug. 18-19-1981) BARI, Joydebpur, Gazipur, Bangladesh. Pp. 26-31.

Kurdrjavcev, V.A. 1964. The effect and light intensity on accumulation and dry matter and carbohydrate metabolism in tomatos. Figiol. Rast. 11:409-416. [Cited from Kalloo 1985. tomato (*Lycopersicon esculentum Niller*). A lliced Publ. Pvt. Ltd. P. 185-1495]

Lal, R. 1989. Agroforestry system and soil surface management of a tropical altisol: I: Soil moisture and crop yield. Agroforestry systems 8: 7-29.

Lartican, R.M. and i.G. Catedral. 1977. Evaluation of legumes for adaptation to intensive cropping systems. I. Mungbean, *Vigna radiate(L.)* . Wikzel. Philippine J. of crop science. Z: 62-66.

Leaky, R.R. B. 1996. Definition of agroforestry revisited. Agroforestry today 8(1): 5-7.

Leonardi, C. 1996. Effect of Shading on pepper. Cure. Protytte (Italy), 25(7). 61-65. [Cited from CAB Abst. 1996, 989.

Leopold, A.C. 1964. *Plant growth and Development*. McGraw-Hill, New York.

MacDicken, K.G. and Vergara, N. 1990. Agroforestry : Classification and Management. John Willey, New York, USA.

Mary, F.; Dupraz, C.; Delannoy, E. and Liagre, F. 1999. Incorporating agroforestry practices in the management of walnut plantation in Dauphine, France: An analysis of farmers motivations. Agrofor. Sys. 43: 243-256.

Mc, Master, G.S; Margan, JA and Wiltis. W.O. 1987. Effect of shading on winter wheat yield, spike characteristics and carbohydrate allocation. Natural Res. Ecol. Lab. Colorado State Univ. Fort Collins. Co. 80523. USA.

Miah, M.G. 1993. Performance of selected multipurpose tree species and field crops grown in associations as affected by tree branch pruning. A *Ph D. Dissertation*, Crop Science. Agronomy. CLSU, Philippines.

Miah, M.G., Garrity, D.Y. and Agron, M.L. 1995. Light availability, to the understorey annual crops in an Agroforestry system. In Sinoquet, H. and Cruz, P. (ed) *Ecophysiology of tropical inter cropping*. IRNA Editions, Paris, France.

Miah, M.G., Rahman, M.A. and Haque, M.M. 1999. Performance of onion under different reduced light level for agroforestry and intercropping systems. Bulletin of Tropical Agriculture, 22 (in press).

Miah, M.G; Ahned, F U; Ahmed, M.M; Alam, M.N; Chowdhury N.H. and Hamid M.A.2002. Agroforestry in Bangladesh, Country paper, presented at the ICRAF's South Asia Regional Agroforestry Consultation Meeting held on 23-25 November 2002 at New Delhi, India.

Miah, M.M. 2001. Performance of five winter vegetables under different light condition for Agroforestry system. An M.S. Thesis. BSMRAU, Gazipur. Bangladesh.

Lal, R. 1989. Agroforestry system and soil surface management of a tropical altisol: I: Soil moisture and crop yield. Agroforestry systems 8: 7-29.

Lartican, R.M. and i.G. Catedral. 1977. Evaluation of legumes for adaptation to intensive cropping systems. I. Mungbean, *Vigna radiate(L.)* . Wikzel. Philippine J. of crop science. Z: 62-66.

Leaky, R.R. B. 1996. Definition of agroforestry revisited. Agroforestry today 8(1): 5-7.

Leonardi, C. 1996. Effect of Shading on pepper. Cure. Protytte (Italy), 25(7). 61-65. [Cited from CAB Abst. 1996, 989.

Leopold, A.C. 1964. *Plant growth and Development*. McGraw-Hill, New York.

MacDicken, K.G. and Vergara, N. 1990. Agroforestry : Classification and Management. John Willey, New York, USA.

Mary, F.; Dupraz, C.; Delannoy, E. and Liagre, F. 1999. Incorporating agroforestry practices in the management of walnut plantation in Dauphine, France: An analysis of farmers motivations. Agrofor. Sys. 43: 243-256.

Mc, Master, G.S; Margan, JA and Wiltis. W.O. 1987. Effect of shading on winter wheat yield, spike characteristics and carbohydrate allocation. Natural Res. Ecol. Lab. Colorado State Univ. Fort Collins. Co. 80523. USA.

Miah, M.G. 1993. Performance of selected multipurpose tree species and field crops grown in associations as affected by tree branch pruning. A *Ph D. Dissertation*, Crop Science. Agronomy. CLSU, Philippines.

Miah, M.G., Garrity, D.Y. and Agron, M.L. 1995. Light availability, to the understorey annual crops in an Agroforestry system. In Sinoquet, H. and Cruz, P. (ed) *Ecophysiology of tropical inter cropping*. IRNA Editions, Paris, France.

Miah, M.G., Rahman, M.A. and Haque, M.M. 1999. Performance of onion under different reduced light level for agroforestry and intercropping systems. Bulletin of Tropical Agriculture, 22 (in press).

Miah, M.G; Ahned, F U; Ahmed, M.M; Alam, M.N; Chowdhury N.H. and Hamid M.A.2002. Agroforestry in Bangladesh, Country paper, presented at the ICRAF's South Asia Regional Agroforestry Consultation Meeting held on 23-25 November 2002 at New Delhi, India.

Miah, M.M. 2001. Performance of five winter vegetables under different light condition for Agroforestry system. An M.S. Thesis. BSMRAU, Gazipur. Bangladesh.

Lal, R. 1989. Agroforestry system and soil surface management of a tropical altisol: I: Soil moisture and crop yield. Agroforestry systems 8: 7-29.

Lartican, R.M. and i.G. Catedral. 1977. Evaluation of legumes for adaptation to intensive cropping systems. I. Mungbean, *Vigna radiate(L.)* . Wikzel. Philippine J. of crop science. Z: 62-66.

Leaky, R.R. B. 1996. Definition of agroforestry revisited. Agroforestry today 8(1): 5-7.

Leonardi, C. 1996. Effect of Shading on pepper. Cure. Protytte (Italy), 25(7). 61-65. [Cited from CAB Abst. 1996, 989.

Leopold, A.C. 1964. *Plant growth and Development*. McGraw-Hill, New York.

MacDicken, K.G. and Vergara, N. 1990. Agroforestry : Classification and Management. John Willey, New York, USA.

Mary, F.; Dupraz, C.; Delannoy, E. and Liagre, F. 1999. Incorporating agroforestry practices in the management of walnut plantation in Dauphine, France: An analysis of farmers motivations. Agrofor. Sys. 43: 243-256.

Mc, Master, G.S; Margan, JA and Wiltis. W.O. 1987. Effect of shading on winter wheat yield, spike characteristics and carbohydrate allocation. Natural Res. Ecol. Lab. Colorado State Univ. Fort Collins. Co. 80523. USA.

Miah, M.G. 1993. Performance of selected multipurpose tree species and field crops grown in associations as affected by tree branch pruning. A *Ph D. Dissertation*, Crop Science. Agronomy. CLSU, Philippines.

Miah, M.G., Garrity, D.Y. and Agron, M.L. 1995. Light availability, to the understorey annual crops in an Agroforestry system. In Sinoquet, H. and Cruz, P. (ed) *Ecophysiology of tropical inter cropping*. IRNA Editions, Paris, France.

Miah, M.G., Rahman, M.A. and Haque, M.M. 1999. Performance of onion under different reduced light level for agroforestry and intercropping systems. Bulletin of Tropical Agriculture, 22 (in press).

Miah, M.G; Ahned, F U; Ahmed, M.M; Alam, M.N; Chowdhury N.H. and Hamid M.A.2002. Agroforestry in Bangladesh, Country paper, presented at the ICRAF's South Asia Regional Agroforestry Consultation Meeting held on 23-25 November 2002 at New Delhi, India.

Miah, M.M. 2001. Performance of five winter vegetables under different light condition for Agroforestry system. An M.S. Thesis. BSMRAU, Gazipur. Bangladesh.

Miah, M.M.U; Amin, M.R and Mandal, M.A.S.2007. Farmers perception towards the consequences of homestead agroforestry in Dinajpur district. J.Agrof. and Env. 1(1): 55-59.

Miah, M.M.U; Islam, M.S; Sarker, M.A.M; Ahmed, M.B. and Amin, M.R.2006. Yield performance of mungbean under different multipurpose trees. South Asian J.Agril,2006, 1(2): 35-38.

Miah, M.M.U; Sarker, M.A.M; Hossain, M.I and Amin, M.H.A.2007. Performance of mungbean as green manuring crop in agroforestry systems. J.Agrof. and Env. 1(2): 87-90.

Michon G; Mary F and Bompard J. 1987. Multistoried agroforestry garden system in West Sumatra, Indonesia. Agroforestry systems 4: 315-338.

Michon, G. 1983. Village-forest-gardens in West Java. In: Hoxley, P.A (ed.). *Plant Research and Agroforestry.* Pp.13-24. ICRAF, Nirobi, Kenya.

Millate-e-Mostofa, 1997. Floristics and Indigenous Management Techniques of Home garden in Bangladesh. Alam, M.K., Ahmed, F.U. and Amin, (eds). *Agroforestry Bangladesh Perspective*. APAN, NAWG and BARC, Dhaka, Bangladesh.

MoA, 2007. Ministry of Agriculture. http://www.bangladeshgov.org./moa/moa.html, Accessed on October,2007.

Murray, D.B. 1953. *A Shade Fertilizer Experiment with Cocoa 11 Research* Institute. Imperial College of Tropical Agriculture (ICTA), Trinidad, pp. 11-24.

Nadeau L., Oliver A., Semard R.R., Coulobe J. and Yelle S. 1999. Growing american ginseng in maple forests as an alternative land use system in Quebec, Canada. *Agroforestry System* 44: 345-353.

Nair, P.K.R. 1987. Agroforestry in the context of land clearing and development in the tropics. In : Lal, R. *et al.* (eds) *Tropical land clearing for sustainable agriculture.* IBSRAM. Proc. Series No. 3, Bangkok, Thailand: pp. 29-44.

Nair, P.K.R. 1990. An Introduction to Agroforestry. Kluwer Academic Publishers/ICRAF

Nair, P.K.R. 1993. An Introduction to Agroforestry. Kluwer Academic Publishers in cooperation with International Centre for Research in Agroforestry (ICRAF). P.315.

Nair, P.K.R.1983. Agroforestry System in the Tropics. Kluwer Academic Publishers/ICRAF.

Miah, M.M.U; Amin, M.R and Mandal, M.A.S.2007. Farmers perception towards the consequences of homestead agroforestry in Dinajpur district. J.Agrof. and Env. 1(1): 55-59.

Miah, M.M.U; Islam, M.S; Sarker, M.A.M; Ahmed, M.B. and Amin, M.R.2006. Yield performance of mungbean under different multipurpose trees. South Asian J.Agril,2006, 1(2): 35-38.

Miah, M.M.U; Sarker, M.A.M; Hossain, M.I and Amin, M.H.A.2007. Performance of mungbean as green manuring crop in agroforestry systems. J.Agrof. and Env. 1(2): 87-90.

Michon G; Mary F and Bompard J. 1987. Multistoried agroforestry garden system in West Sumatra, Indonesia. Agroforestry systems 4: 315-338.

Michon, G. 1983. Village-forest-gardens in West Java. In: Hoxley, P.A (ed.). *Plant Research and Agroforestry.* Pp.13-24. ICRAF, Nirobi, Kenya.

Millate-e-Mostofa, 1997. Floristics and Indigenous Management Techniques of Home garden in Bangladesh. Alam, M.K., Ahmed, F.U. and Amin, (eds). *Agroforestry Bangladesh Perspective*. APAN, NAWG and BARC, Dhaka, Bangladesh.

MoA, 2007. Ministry of Agriculture. http://www.bangladeshgov.org./moa/moa.html, Accessed on October,2007.

Murray, D.B. 1953. *A Shade Fertilizer Experiment with Cocoa 11 Research* Institute. Imperial College of Tropical Agriculture (ICTA), Trinidad, pp. 11-24.

Nadeau L., Oliver A., Semard R.R., Coulobe J. and Yelle S. 1999. Growing american ginseng in maple forests as an alternative land use system in Quebec, Canada. *Agroforestry System* 44: 345-353.

Nair, P.K.R. 1987. Agroforestry in the context of land clearing and development in the tropics. In : Lal, R. *et al.* (eds) *Tropical land clearing for sustainable agriculture.* IBSRAM. Proc. Series No. 3, Bangkok, Thailand: pp. 29-44.

Nair, P.K.R. 1990. An Introduction to Agroforestry. Kluwer Academic Publishers/ICRAF

Nair, P.K.R. 1993. An Introduction to Agroforestry. Kluwer Academic Publishers in cooperation with International Centre for Research in Agroforestry (ICRAF). P.315.

Nair, P.K.R.1983. Agroforestry System in the Tropics. Kluwer Academic Publishers/ICRAF.

Miah, M.M.U; Amin, M.R and Mandal, M.A.S.2007. Farmers perception towards the consequences of homestead agroforestry in Dinajpur district. J.Agrof. and Env. 1(1): 55-59.

Miah, M.M.U; Islam, M.S; Sarker, M.A.M; Ahmed, M.B. and Amin, M.R.2006. Yield performance of mungbean under different multipurpose trees. South Asian J.Agril,2006, 1(2): 35-38.

Miah, M.M.U; Sarker, M.A.M; Hossain, M.I and Amin, M.H.A.2007. Performance of mungbean as green manuring crop in agroforestry systems. J.Agrof. and Env. 1(2): 87-90.

Michon G; Mary F and Bompard J. 1987. Multistoried agroforestry garden system in West Sumatra, Indonesia. Agroforestry systems 4: 315-338.

Michon, G. 1983. Village-forest-gardens in West Java. In: Hoxley, P.A (ed.). *Plant Research and Agroforestry.* Pp.13-24. ICRAF, Nirobi, Kenya.

Millate-e-Mostofa, 1997. Floristics and Indigenous Management Techniques of Home garden in Bangladesh. Alam, M.K., Ahmed, F.U. and Amin, (eds). *Agroforestry Bangladesh Perspective*. APAN, NAWG and BARC, Dhaka, Bangladesh.

MoA, 2007. Ministry of Agriculture. http://www.bangladeshgov.org./moa/moa.html, Accessed on October,2007.

Murray, D.B. 1953. *A Shade Fertilizer Experiment with Cocoa 11 Research* Institute. Imperial College of Tropical Agriculture (ICTA), Trinidad, pp. 11-24.

Nadeau L., Oliver A., Semard R.R., Coulobe J. and Yelle S. 1999. Growing american ginseng in maple forests as an alternative land use system in Quebec, Canada. *Agroforestry System* 44: 345-353.

Nair, P.K.R. 1987. Agroforestry in the context of land clearing and development in the tropics. In : Lal, R. *et al.* (eds) *Tropical land clearing for sustainable agriculture.* IBSRAM. Proc. Series No. 3, Bangkok, Thailand: pp. 29-44.

Nair, P.K.R. 1990. An Introduction to Agroforestry. Kluwer Academic Publishers/ICRAF

Nair, P.K.R. 1993. An Introduction to Agroforestry. Kluwer Academic Publishers in cooperation with International Centre for Research in Agroforestry (ICRAF). P.315.

Nair, P.K.R.1983. Agroforestry System in the Tropics. Kluwer Academic Publishers/ICRAF.

Nandal, D.P., P. Rana and A. Kumar. 1999. Growth and Yield of wheat under different tree spacing of *Dalbergia sissoo* based agriculture. Ind.J. Agron., 44: 256-260.

Nayak, S.K. and Murty, K.S. 1980. Effect varying light intensities on yield and growth parameters in rice. *Indian J. Plant Physiology* 23: 309-316.

Nayak, S.K., Murty, P.S.S. and Murty, K.S. 1979. Photosynthesis and translocation in rice during ripening as influenced by different light intensities. J. *Nuclear Agric. Biol.* 8(1): 23-25.

Nazir, M.S., Ahmed, R., Ehsanullah and Cheema, S.A. 1993. Quantitaive analysis of effect of Shisham (Sissoo) tree shade in wheat. Dept. Agron., Univ. Agric. Faisalabad, Pakistan J. Agril. Res. 14: 1, 12-17.

Neumann, F. and Pietrowicz, P. 1989. Light and water availability in fields with and without trees. An example from Nyabisindu in Rwanda. In: Reifsynder, W.S. and Darnhofer, T.O. (eds.), Meteorology and agrodorestry, pp.401-406. ICRAF, Nirobi, Kenya.

Okafor, J.C and Fernandes, E.C.M. 1987. Compound farms (Home gardens): A predominant Agroforestry system involving food and fruit trees with crops and small livestock in the humid low lands of south eastern Nigeria. *Agroforestry system* 5: 153-168.

Okigbo B.N.1980. The importance of mixed stands in tropical agriculture. In RG Hurd, P.V.Biscoe and C.Dennis (eds.) Opportunities for increasing crops yields. Pitman, London.

Okigbo, B.N. and Greenland D.J. 1976. Intercropping systems in tropical Africa. Mutiple cropping. American society of agriculture. Publication no. 27.

Ong, C.K. 1988. The interaction of light, water and nutrients in Agroforestry system. Chapter for book on "*Application of Biological Research on Asian Agroforestry system*". J.A. 885.

Ong, C.K. Rao, M.R. andd Mathuva, M. 1992. Trees and crops. Composition for resources above and below ground. Agroforest. Today 4(2): 4-5.

Ong, C.K; Corlett, J.E; Singh, R.P. and Black, C.R. 1991. Above and below ground interactions in agroforestry systems. Forest ecoloy and management 45: 45-57.

Pandey, C.B., Pandey, K.S., Pandey, D. and Sharma, R.B. 1999. Growth and productivity of rice *(Oryza sativa)* as affected by *Acacia nilotica* in a traditional agroforestry system. Trop. Ecol. 40: 1009-177.

Nandal, D.P., P. Rana and A. Kumar. 1999. Growth and Yield of wheat under different tree spacing of *Dalbergia sissoo* based agriculture. Ind.J. Agron., 44: 256-260.

Nayak, S.K. and Murty, K.S. 1980. Effect varying light intensities on yield and growth parameters in rice. *Indian J. Plant Physiology* 23: 309-316.

Nayak, S.K., Murty, P.S.S. and Murty, K.S. 1979. Photosynthesis and translocation in rice during ripening as influenced by different light intensities. J. *Nuclear Agric. Biol.* 8(1): 23-25.

Nazir, M.S., Ahmed, R., Ehsanullah and Cheema, S.A. 1993. Quantitaive analysis of effect of Shisham (Sissoo) tree shade in wheat. Dept. Agron., Univ. Agric. Faisalabad, Pakistan J. Agril. Res. 14: 1, 12-17.

Neumann, F. and Pietrowicz, P. 1989. Light and water availability in fields with and without trees. An example from Nyabisindu in Rwanda. In: Reifsynder, W.S. and Darnhofer, T.O. (eds.), Meteorology and agrodorestry, pp.401-406. ICRAF, Nirobi, Kenya.

Okafor, J.C and Fernandes, E.C.M. 1987. Compound farms (Home gardens): A predominant Agroforestry system involving food and fruit trees with crops and small livestock in the humid low lands of south eastern Nigeria. *Agroforestry system* 5: 153-168.

Okigbo B.N.1980. The importance of mixed stands in tropical agriculture. In RG Hurd, P.V.Biscoe and C.Dennis (eds.) Opportunities for increasing crops yields. Pitman, London.

Okigbo, B.N. and Greenland D.J. 1976. Intercropping systems in tropical Africa. Mutiple cropping. American society of agriculture. Publication no. 27.

Ong, C.K. 1988. The interaction of light, water and nutrients in Agroforestry system. Chapter for book on "*Application of Biological Research on Asian Agroforestry system*". J.A. 885.

Ong, C.K. Rao, M.R. andd Mathuva, M. 1992. Trees and crops. Composition for resources above and below ground. Agroforest. Today 4(2): 4-5.

Ong, C.K; Corlett, J.E; Singh, R.P. and Black, C.R. 1991. Above and below ground interactions in agroforestry systems. Forest ecoloy and management 45: 45-57.

Pandey, C.B., Pandey, K.S., Pandey, D. and Sharma, R.B. 1999. Growth and productivity of rice *(Oryza sativa)* as affected by *Acacia nilotica* in a traditional agroforestry system. Trop. Ecol. 40: 1009-177.

Nandal, D.P., P. Rana and A. Kumar. 1999. Growth and Yield of wheat under different tree spacing of *Dalbergia sissoo* based agriculture. Ind.J. Agron., 44: 256-260.

Nayak, S.K. and Murty, K.S. 1980. Effect varying light intensities on yield and growth parameters in rice. *Indian J. Plant Physiology* 23: 309-316.

Nayak, S.K., Murty, P.S.S. and Murty, K.S. 1979. Photosynthesis and translocation in rice during ripening as influenced by different light intensities. J. *Nuclear Agric. Biol.* 8(1): 23-25.

Nazir, M.S., Ahmed, R., Ehsanullah and Cheema, S.A. 1993. Quantitaive analysis of effect of Shisham (Sissoo) tree shade in wheat. Dept. Agron., Univ. Agric. Faisalabad, Pakistan J. Agril. Res. 14: 1, 12-17.

Neumann, F. and Pietrowicz, P. 1989. Light and water availability in fields with and without trees. An example from Nyabisindu in Rwanda. In: Reifsynder, W.S. and Darnhofer, T.O. (eds.), Meteorology and agrodorestry, pp.401-406. ICRAF, Nirobi, Kenya.

Okafor, J.C and Fernandes, E.C.M. 1987. Compound farms (Home gardens): A predominant Agroforestry system involving food and fruit trees with crops and small livestock in the humid low lands of south eastern Nigeria. *Agroforestry system* 5: 153-168.

Okigbo B.N.1980. The importance of mixed stands in tropical agriculture. In RG Hurd, P.V.Biscoe and C.Dennis (eds.) Opportunities for increasing crops yields. Pitman, London.

Okigbo, B.N. and Greenland D.J. 1976. Intercropping systems in tropical Africa. Mutiple cropping. American society of agriculture. Publication no. 27.

Ong, C.K. 1988. The interaction of light, water and nutrients in Agroforestry system. Chapter for book on "*Application of Biological Research on Asian Agroforestry system*". J.A. 885.

Ong, C.K. Rao, M.R. andd Mathuva, M. 1992. Trees and crops. Composition for resources above and below ground. Agroforest. Today 4(2): 4-5.

Ong, C.K; Corlett, J.E; Singh, R.P. and Black, C.R. 1991. Above and below ground interactions in agroforestry systems. Forest ecoloy and management 45: 45-57.

Pandey, C.B., Pandey, K.S., Pandey, D. and Sharma, R.B. 1999. Growth and productivity of rice *(Oryza sativa)* as affected by *Acacia nilotica* in a traditional agroforestry system. Trop. Ecol. 40: 1009-177.

Parvin, N., Chowdhury, M. A. H. and Ferdous, H. S. J. 2005. Decomposition pattern of two green manures in BAU farm soil. *J. Bangladesh Agril. Univ.* 3(1): 37-42.

PCARRD 1983 Technology of Agroforestry. Agroforestry in perspective. Proc. Agro. Symp. Work. Dec. 19-20, 1979, PCARRD, Los Banos.

Pierre, C.S. 1991. Evolution of agroforestry in the Xinshuangbanna region of tropical China. Agroforestry system 13: 159-176.

Pieters, A.J. 2004. Green Manuring *Principle and Practices.*Agobios (India). pp. 09-194.

Puri, S. and K.S. Bangarwa, 1993. Effect of tree on the yield of irrigated wheat crop in semi arid regions. Agroforestry Abst., 6:9.

Rachie, K. 0. 1983. Intercropping tree legume with annual crops. *Plant Research and Agroforestry,* ICRAF.

Rahim, M. A. 1994. Agroforestry and horticultural diversification. In: An adoption of Farmers Field. University Press Limited (UPL), Dhaka, pp 7-20.

Rahman, M. M., Miah, A. A., Maniruzzaman, A. F. M., Rahman, A. K. M. M. and Khan, K. 1995. Growth analysis of mungbean (*Vigna radiata* (L.) Wilczek) under variable population densities at different dates of sowing. *Bangladesh J. Bot.* 24(1): 53-59.

Rang, A. Bhat, M.L., Makaya, A.S., Masoodi, N.A., Anani, A.Z. and Sharma, D.P. 1990. Agroforestry Research in India. *Indian J. Agril.* 68(8): 559-566.

Rao, L.G. and Mittra, B.N. 1988. Growth and yield of peanut as influenced by degree and duration of shading. J. Agronomy and Crop Science 160 : 260-265.

Rao, M.R. and Govindarajan, M. 1996. Agroforestry field experiments controlling interference among plots, Agroforestry Today 8(1): 15-18.

Rao, T. P. and Ito, O. 1998. An intercropping study of banana with annuals. *Japanese Agricultural Research Quarterly* (JARC), 32: 97-103.

Ravi, K., A.K. Agnihotri and R. Kiran, 2001. Effect of partial shading on yield and yield attributes of wheat intercropped with Sisso (*Dalbergia sissoo*) under shallow water table conditions. Dept. soil. Sci./ Agromet., G.B Pant Unik Agric. Tech. (Uttaranchal). India. Ind. Fon., 127: 799-803.

Reifsnyder, W.E. 1987. Control of solar radiation in Agroforestry practices. *Meteorology and Agroforestry.* ICRAF, WHO and UNEP.

Parvin, N., Chowdhury, M. A. H. and Ferdous, H. S. J. 2005. Decomposition pattern of two green manures in BAU farm soil. *J. Bangladesh Agril. Univ.* 3(1): 37-42.

PCARRD 1983 Technology of Agroforestry. Agroforestry in perspective. Proc. Agro. Symp. Work. Dec. 19-20, 1979, PCARRD, Los Banos.

Pierre, C.S. 1991. Evolution of agroforestry in the Xinshuangbanna region of tropical China. Agroforestry system 13: 159-176.

Pieters, A.J. 2004. Green Manuring *Principle and Practices.*Agobios (India). pp. 09-194.

Puri, S. and K.S. Bangarwa, 1993. Effect of tree on the yield of irrigated wheat crop in semi arid regions. Agroforestry Abst., 6:9.

Rachie, K. 0. 1983. Intercropping tree legume with annual crops. *Plant Research and Agroforestry,* ICRAF.

Rahim, M. A. 1994. Agroforestry and horticultural diversification. In: An adoption of Farmers Field. University Press Limited (UPL), Dhaka, pp 7-20.

Rahman, M. M., Miah, A. A., Maniruzzaman, A. F. M., Rahman, A. K. M. M. and Khan, K. 1995. Growth analysis of mungbean (*Vigna radiata* (L.) Wilczek) under variable population densities at different dates of sowing. *Bangladesh J. Bot.* 24(1): 53-59.

Rang, A. Bhat, M.L., Makaya, A.S., Masoodi, N.A., Anani, A.Z. and Sharma, D.P. 1990. Agroforestry Research in India. *Indian J. Agril.* 68(8): 559-566.

Rao, L.G. and Mittra, B.N. 1988. Growth and yield of peanut as influenced by degree and duration of shading. J. Agronomy and Crop Science 160 : 260-265.

Rao, M.R. and Govindarajan, M. 1996. Agroforestry field experiments controlling interference among plots, Agroforestry Today 8(1): 15-18.

Rao, T. P. and Ito, O. 1998. An intercropping study of banana with annuals. *Japanese Agricultural Research Quarterly* (JARC), 32: 97-103.

Ravi, K., A.K. Agnihotri and R. Kiran, 2001. Effect of partial shading on yield and yield attributes of wheat intercropped with Sisso (*Dalbergia sissoo*) under shallow water table conditions. Dept. soil. Sci./ Agromet., G.B Pant Unik Agric. Tech. (Uttaranchal). India. Ind. Fon., 127: 799-803.

Reifsnyder, W.E. 1987. Control of solar radiation in Agroforestry practices. *Meteorology and Agroforestry.* ICRAF, WHO and UNEP.

Parvin, N., Chowdhury, M. A. H. and Ferdous, H. S. J. 2005. Decomposition pattern of two green manures in BAU farm soil. *J. Bangladesh Agril. Univ.* 3(1): 37-42.

PCARRD 1983 Technology of Agroforestry. Agroforestry in perspective. Proc. Agro. Symp. Work. Dec. 19-20, 1979, PCARRD, Los Banos.

Pierre, C.S. 1991. Evolution of agroforestry in the Xinshuangbanna region of tropical China. Agroforestry system 13: 159-176.

Pieters, A.J. 2004. Green Manuring *Principle and Practices.*Agobios (India). pp. 09-194.

Puri, S. and K.S. Bangarwa, 1993. Effect of tree on the yield of irrigated wheat crop in semi arid regions. Agroforestry Abst., 6:9.

Rachie, K. 0. 1983. Intercropping tree legume with annual crops. *Plant Research and Agroforestry,* ICRAF.

Rahim, M. A. 1994. Agroforestry and horticultural diversification. In: An adoption of Farmers Field. University Press Limited (UPL), Dhaka, pp 7-20.

Rahman, M. M., Miah, A. A., Maniruzzaman, A. F. M., Rahman, A. K. M. M. and Khan, K. 1995. Growth analysis of mungbean (*Vigna radiata* (L.) Wilczek) under variable population densities at different dates of sowing. *Bangladesh J. Bot.* 24(1): 53-59.

Rang, A. Bhat, M.L., Makaya, A.S., Masoodi, N.A., Anani, A.Z. and Sharma, D.P. 1990. Agroforestry Research in India. *Indian J. Agril.* 68(8): 559-566.

Rao, L.G. and Mittra, B.N. 1988. Growth and yield of peanut as influenced by degree and duration of shading. J. Agronomy and Crop Science 160 : 260-265.

Rao, M.R. and Govindarajan, M. 1996. Agroforestry field experiments controlling interference among plots, Agroforestry Today 8(1): 15-18.

Rao, T. P. and Ito, O. 1998. An intercropping study of banana with annuals. *Japanese Agricultural Research Quarterly* (JARC), 32: 97-103.

Ravi, K., A.K. Agnihotri and R. Kiran, 2001. Effect of partial shading on yield and yield attributes of wheat intercropped with Sisso (*Dalbergia sissoo*) under shallow water table conditions. Dept. soil. Sci./ Agromet., G.B Pant Unik Agric. Tech. (Uttaranchal). India. Ind. Fon., 127: 799-803.

Reifsnyder, W.E. 1987. Control of solar radiation in Agroforestry practices. *Meteorology and Agroforestry.* ICRAF, WHO and UNEP.

Roy, K.C., Salam, M.A., Bari, M.S. and Hossain, M. F.2005. Perfomance of multipurpose trees and field crops under different management practices in a Agroforestry system. Srilankan J. Nat. Sci. Found. 2006. 34(1), 16-17.

Sahoo, S.C., Lenka, P.C. and Dash, D.K. 2002. A note on the performance of *in situ* green manuring crops in palm basins in littoral sandy soil of Orissa. *Orrisa Journal of Horticulture*. 30(1): 130-132.

Salina Hasan. 2007. Performance of Turmeric in the litchi based Agroforestry Systems. An MS thesis. Dept. of Agroforestry, HSTU.

Salisbury, F.B. and Ross, C.W. 1986. *Plant Physiology* Crop Botany, Pub. Bholanath Nagor, Shahdara, Delhi.

Samsuzzaman, S., Ali, M.A., Momin, Karim, M.R and Uddin, M.N. 2002. Tree crop interaction as affected by tree spacing and pruning management in Bangladesh. Indian forest. 128:11, 1204-1231.

Saneoka, H., Nagasaka, C., Hahn, D. T., Yang, W. J., Premchandra, G. S., Joly, R. J. and Rhodes, D. 1995. Salt tolerance of glycinebetaine-deficient and containing maize lines. *Plant Physiol.*, 107-: 631-638.

Satish, K., R.K., Pannle, V.S. Kadinn and S. Mumar, 2003. Effect of shade duration on wheat varieties. Ind. Ann. Biol., 19: 17-20.

Saxena, M.B.L. 1984. Improved crop variety in agroforestry. Agroforestry in Arid and Semi-Arid Zones, Central Arid Zone Research Institute, Jodhpur, India.

Schoch, P.G. 1972. Effect of shading a structural characteristics of leaf and yield of fruit in *Capsicum annum L.J. Amen. Soc .Hort.Sci. 97(4). 461-464.*

Scott, L.T. 1987. Improving the productivity of shifting cultivation in Amazon Basin of Derce through the use of leguminous vegetation. Ph.D. Dissertation, North-Carolina State Univ. Rabigh.

Shankarnarya, K.A. 1984. Agroforestry, its concept and implication for a sound land use goal. *Agroforestry in Arid and Semi-Arid Zones*. Central Arid Zone Research Institute, Jodhpur, India.

Sharda, V.N. and Ratan, S. 2003. Erosion control measures for improving productivity and farmers' profitability. Fertilizer News. 48(12): 71-78.

Sharif, M. 1993. Effect of shade on plant nutrient uptake. *Research Report*, 1994. On Farm Research Division, Gazipur.

Sharma, A.R. and Das, K.C. 1994. Effect of green manuring with dhaincha (*Sesbania aculeata*) on growth and yield of direct sown and transplanted rice under

Roy, K.C., Salam, M.A., Bari, M.S. and Hossain, M. F.2005. Perfomance of multipurpose trees and field crops under different management practices in a Agroforestry system. Srilankan J. Nat. Sci. Found. 2006. 34(1), 16-17.

Sahoo, S.C., Lenka, P.C. and Dash, D.K. 2002. A note on the performance of *in situ* green manuring crops in palm basins in littoral sandy soil of Orissa. *Orrisa Journal of Horticulture*. 30(1): 130-132.

Salina Hasan. 2007. Performance of Turmeric in the litchi based Agroforestry Systems. An MS thesis. Dept. of Agroforestry, HSTU.

Salisbury, F.B. and Ross, C.W. 1986. *Plant Physiology* Crop Botany, Pub. Bholanath Nagor, Shahdara, Delhi.

Samsuzzaman, S., Ali, M.A., Momin, Karim, M.R and Uddin, M.N. 2002. Tree crop interaction as affected by tree spacing and pruning management in Bangladesh. Indian forest. 128:11, 1204-1231.

Saneoka, H., Nagasaka, C., Hahn, D. T., Yang, W. J., Premchandra, G. S., Joly, R. J. and Rhodes, D. 1995. Salt tolerance of glycinebetaine-deficient and containing maize lines. *Plant Physiol.*, 107-: 631-638.

Satish, K., R.K., Pannle, V.S. Kadinn and S. Mumar, 2003. Effect of shade duration on wheat varieties. Ind. Ann. Biol., 19: 17-20.

Saxena, M.B.L. 1984. Improved crop variety in agroforestry. Agroforestry in Arid and Semi-Arid Zones, Central Arid Zone Research Institute, Jodhpur, India.

Schoch, P.G. 1972. Effect of shading a structural characteristics of leaf and yield of fruit in *Capsicum annum L.J. Amen. Soc .Hort.Sci. 97(4). 461-464.*

Scott, L.T. 1987. Improving the productivity of shifting cultivation in Amazon Basin of Derce through the use of leguminous vegetation. Ph.D. Dissertation, North-Carolina State Univ. Rabigh.

Shankarnarya, K.A. 1984. Agroforestry, its concept and implication for a sound land use goal. *Agroforestry in Arid and Semi-Arid Zones*. Central Arid Zone Research Institute, Jodhpur, India.

Sharda, V.N. and Ratan, S. 2003. Erosion control measures for improving productivity and farmers' profitability. Fertilizer News. 48(12): 71-78.

Sharif, M. 1993. Effect of shade on plant nutrient uptake. *Research Report*, 1994. On Farm Research Division, Gazipur.

Sharma, A.R. and Das, K.C. 1994. Effect of green manuring with dhaincha (*Sesbania aculeata*) on growth and yield of direct sown and transplanted rice under

Roy, K.C., Salam, M.A., Bari, M.S. and Hossain, M. F.2005. Perfomance of multipurpose trees and field crops under different management practices in a Agroforestry system. Srilankan J. Nat. Sci. Found. 2006. 34(1), 16-17.

Sahoo, S.C., Lenka, P.C. and Dash, D.K. 2002. A note on the performance of *in situ* green manuring crops in palm basins in littoral sandy soil of Orissa. *Orrisa Journal of Horticulture*. 30(1): 130-132.

Salina Hasan. 2007. Performance of Turmeric in the litchi based Agroforestry Systems. An MS thesis. Dept. of Agroforestry, HSTU.

Salisbury, F.B. and Ross, C.W. 1986. *Plant Physiology* Crop Botany, Pub. Bholanath Nagor, Shahdara, Delhi.

Samsuzzaman, S., Ali, M.A., Momin, Karim, M.R and Uddin, M.N. 2002. Tree crop interaction as affected by tree spacing and pruning management in Bangladesh. Indian forest. 128:11, 1204-1231.

Saneoka, H., Nagasaka, C., Hahn, D. T., Yang, W. J., Premchandra, G. S., Joly, R. J. and Rhodes, D. 1995. Salt tolerance of glycinebetaine-deficient and containing maize lines. *Plant Physiol.*, 107-: 631-638.

Satish, K., R.K., Pannle, V.S. Kadinn and S. Mumar, 2003. Effect of shade duration on wheat varieties. Ind. Ann. Biol., 19: 17-20.

Saxena, M.B.L. 1984. Improved crop variety in agroforestry. Agroforestry in Arid and Semi-Arid Zones, Central Arid Zone Research Institute, Jodhpur, India.

Schoch, P.G. 1972. Effect of shading a structural characteristics of leaf and yield of fruit in *Capsicum annum L.J. Amen. Soc .Hort.Sci. 97(4). 461-464.*

Scott, L.T. 1987. Improving the productivity of shifting cultivation in Amazon Basin of Derce through the use of leguminous vegetation. Ph.D. Dissertation, North-Carolina State Univ. Rabigh.

Shankarnarya, K.A. 1984. Agroforestry, its concept and implication for a sound land use goal. *Agroforestry in Arid and Semi-Arid Zones*. Central Arid Zone Research Institute, Jodhpur, India.

Sharda, V.N. and Ratan, S. 2003. Erosion control measures for improving productivity and farmers' profitability. Fertilizer News. 48(12): 71-78.

Sharif, M. 1993. Effect of shade on plant nutrient uptake. *Research Report*, 1994. On Farm Research Division, Gazipur.

Sharma, A.R. and Das, K.C. 1994. Effect of green manuring with dhaincha (*Sesbania aculeata*) on growth and yield of direct sown and transplanted rice under

intermediate deepwater conditions (0-50cm). *Journal of Agricultural Science*. 122(3): 359-364.

Sharma, S.N., Prasad, R. and Singh, S. 1995. The role of mungbean residues and *Sesbania aculeata* green manure in the nitrogen economy of rice-wheat cropping system. *Plant and Soil*. 1995; 172: 1, 123-129; 13 ref.

Sharma, N.K. and Tiware, R.S. 1992. Effect of shade on contributing characters and factors in relation to yield of tomato cv. Pusa Ruby. Progress Hort. (Ind). 25 (3-4); 184- 87.

Singh, R.P., Ong, C.K. and Sharma, W. 1989. Above and below ground interaction in alley cropping in semi-arid India. *Agroforestry System* 9: 259-274.

Singh, S. and Singh, T. N. 1999. Root growth of wheat in simulated vertical and lateral splits of layered salt profiles in soil. *Indian J. Plant Physiol*. 4(2): 73-78.

Solanki, K.H. 1998. Agroforestry Research in India. *India J. Agril. Sci.* 68(8): 559-566.

Teel, W.S. and Buck, L.E. 2002. Between wild crafting and monocultures: agroforestry options. pp. 199-222. In: Jones E.T., McLain R.J. and Weigand J. (eds), *Non-Timber Forest Products in the United States.* University Press of Kansas, Lawrence, KS. USA.

Thomas, B.M and S.K. Teoh. 1983. Culture of container growth *Ficus macroprylla. Influenceshading* and N. fertilizer. Royal New Zealand Ins. Hunt. Ann.j. 11.77-82.

Tilak, R.V.B.R. 2004. Response of Sesbania green manuring and mungbean residue incorporation on microbial activities for sustainability of a rice-wheat cropping system. *Journal of Agricultureand Rural Development in the Tropics and Subtropics.* 105(2): 189-196.

Turkhede, A.B., Choudhari, B.T., Chore, C.N., Kalpande, H.V., Jiotode, D.J. and Kalpande, V.V. 1998. Effect of green manuring with glyricidial leaves and fertility levels on yield and physico-chemical properties of the soil in low land paddy. *Crops Research Hisar*. 16(3):300-302.

Ullah, M. J., Karim, M. F., Bhuiyan, M. S. U. and Ali, M. H. 2002. Crop production environment and management. H.M.S press. Fakirapul, Dhaka. pp. 320-326.

Vergara, N.T. 1982. *New directions in agroforestry : the potentials of tropical legume trees.* EAPI, East-west center Honolulu, Hawaii.

intermediate deepwater conditions (0-50cm). *Journal of Agricultural Science.* 122(3): 359-364.

Sharma, S.N., Prasad, R. and Singh, S. 1995. The role of mungbean residues and *Sesbania aculeata* green manure in the nitrogen economy of rice-wheat cropping system. *Plant and Soil.* 1995; 172: 1, 123-129; 13 ref.

Sharma, N.K. and Tiware, R.S. 1992. Effect of shade on contributing characters and factors in relation to yield of tomato cv. Pusa Ruby. Progress Hort. (Ind). 25 (3-4); 184- 87.

Singh, R.P., Ong, C.K. and Sharma, W. 1989. Above and below ground interaction in alley cropping in semi-arid India. *Agroforestry System* 9: 259-274.

Singh, S. and Singh, T. N. 1999. Root growth of wheat in simulated vertical and lateral splits of layered salt profiles in soil. *Indian J. Plant Physiol.* 4(2): 73-78.

Solanki, K.H. 1998. Agroforestry Research in India. *India J. Agril. Sci.* 68(8): 559-566.

Teel, W.S. and Buck, L.E. 2002. Between wild crafting and monocultures: agroforestry options. pp. 199-222. In: Jones E.T., McLain R.J. and Weigand J. (eds), *Non-Timber Forest Products in the United States.* University Press of Kansas, Lawrence, KS. USA.

Thomas, B.M and S.K. Teoh. 1983. Culture of container growth *Ficus macroprylla. Influenceshading* and N. fertilizer. Royal New Zealand Ins. Hunt. Ann.j. 11.77-82.

Tilak, R.V.B.R. 2004. Response of Sesbania green manuring and mungbean residue incorporation on microbial activities for sustainability of a rice-wheat cropping system. *Journal of Agricultureand Rural Development in the Tropics and Subtropics.* 105(2): 189-196.

Turkhede, A.B., Choudhari, B.T., Chore, C.N., Kalpande, H.V., Jiotode, D.J. and Kalpande, V.V. 1998. Effect of green manuring with glyricidial leaves and fertility levels on yield and physico-chemical properties of the soil in low land paddy. *Crops Research Hisar.* 16(3):300-302.

Ullah, M. J., Karim, M. F., Bhuiyan, M. S. U. and Ali, M. H. 2002. Crop production environment and management. H.M.S press. Fakirapul, Dhaka. pp. 320-326.

Vergara, N.T. 1982. *New directions in agroforestry : the potentials of tropical legume trees.* EAPI, East-west center Honolulu, Hawaii.

intermediate deepwater conditions (0-50cm). *Journal of Agricultural Science.* 122(3): 359-364.

Sharma, S.N., Prasad, R. and Singh, S. 1995. The role of mungbean residues and *Sesbania aculeata* green manure in the nitrogen economy of rice-wheat cropping system. *Plant and Soil.* 1995; 172: 1, 123-129; 13 ref.

Sharma, N.K. and Tiware, R.S. 1992. Effect of shade on contributing characters and factors in relation to yield of tomato cv. Pusa Ruby. Progress Hort. (Ind). 25 (3-4); 184- 87.

Singh, R.P., Ong, C.K. and Sharma, W. 1989. Above and below ground interaction in alley cropping in semi-arid India. *Agroforestry System* 9: 259-274.

Singh, S. and Singh, T. N. 1999. Root growth of wheat in simulated vertical and lateral splits of layered salt profiles in soil. *Indian J. Plant Physiol.* 4(2): 73-78.

Solanki, K.H. 1998. Agroforestry Research in India. *India J. Agril. Sci.* 68(8): 559-566.

Teel, W.S. and Buck, L.E. 2002. Between wild crafting and monocultures: agroforestry options. pp. 199-222. In: Jones E.T., McLain R.J. and Weigand J. (eds), *Non-Timber Forest Products in the United States.* University Press of Kansas, Lawrence, KS. USA.

Thomas, B.M and S.K. Teoh. 1983. Culture of container growth *Ficus macroprylla. Influenceshading* and N. fertilizer. Royal New Zealand Ins. Hunt. Ann.j. 11.77-82.

Tilak, R.V.B.R. 2004. Response of Sesbania green manuring and mungbean residue incorporation on microbial activities for sustainability of a rice-wheat cropping system. *Journal of Agricultureand Rural Development in the Tropics and Subtropics.* 105(2): 189-196.

Turkhede, A.B., Choudhari, B.T., Chore, C.N., Kalpande, H.V., Jiotode, D.J. and Kalpande, V.V. 1998. Effect of green manuring with glyricidial leaves and fertility levels on yield and physico-chemical properties of the soil in low land paddy. *Crops Research Hisar.* 16(3):300-302.

Ullah, M. J., Karim, M. F., Bhuiyan, M. S. U. and Ali, M. H. 2002. Crop production environment and management. H.M.S press. Fakirapul, Dhaka. pp. 320-326.

Vergara, N.T. 1982. *New directions in agroforestry : the potentials of tropical legume trees.* EAPI, East-west center Honolulu, Hawaii.

Verinumbe, I. and Okali, D.U.U. 1985. The influence of coppiced teak *(Tectona grandis L.F)* regrowth and roots on intercropped maize *(Zea mays L.).* Agroforestry systems 3: 381-386.

Verma, K.P. and Warsi, A.S. 1999. Evaluation of suitable rice-based *Oryza sativa*) cropping system for central plain zone of Uttar Pradesh. *Indian Journal of Agronomy.* 44(3): 444-447.

Wallace, J.S. 1996. Evaporation and interaction by neighboring plants. *Quarterly Journal of the Royal Meteorological Society*, p.123, pp. 1885-1905.

Walt, H.R. 1989. We need agroforestry in a big way, Workshop on *agroforestry in California: planning for the twenty-first century,* Deptt. of Forestry and Resources Management University of California, Berkeley, pp. 1-3.

Weaver, J.E and F.E clements. 1973. Plant Ecology. Tata Mc Gnaw-Hill, New Delhi.

Willey, R.W, Natararyan, M. Reddy, M.S. and Rao, M.R. 1986. Cropping systems with groundnut: Resource use and productivity. In: Agroforestry meteorology of groundnut. Proceeding of an International Symposium, 21-26 August, 1986. ICRISAT, Sahelian Center, Niamey, Niger 193-205.

Xiong, Z.X. and Chen, M.H. 1993. A preliminary report on tracing the dynamics of N uptake by labelled 15N in "grain-grain-green manure" rotation. Ningxia Journal of Agro-Forestry Sciences and Technology. 2:43-46.

Yantasath, K., Buranasilpin, P., Sapatanakul, W., Tanpanich, S., Chantrasiri, S., Patanawible, S. and Jitanawasan, S. 1992. Research on acacias and their potential. In : Awang, K. and Tailor, D.A. (eds.) Tropical Acacias in East and the Pacific. *Proc. First meeting of a Consultative Group for Research and Development of Acacias,* COGREDA. June 1-3, 1992. Phuket, Thailand.

Zhou S.Q. 1993. Cultivation of *Amomum villosum* in tropical forests. *Forest Ecol. Manag.* 60: 157-162.

Zou, X. and Sanford, R.L. 1990. Agroforestry systems in China: a survey and classification. *Agroforestry system* 11: 85-94.

Verinumbe, I. and Okali, D.U.U. 1985. The influence of coppiced teak *(Tectona grandis L.F)* regrowth and roots on intercropped maize *(Zea mays L.)*. Agroforestry systems 3: 381-386.

Verma, K.P. and Warsi, A.S. 1999. Evaluation of suitable rice-based *Oryza sativa*) cropping system for central plain zone of Uttar Pradesh. *Indian Journal of Agronomy.* 44(3): 444-447.

Wallace, J.S. 1996. Evaporation and interaction by neighboring plants. *Quarterly Journal of the Royal Meteorological Society*, p.123, pp. 1885-1905.

Walt, H.R. 1989. We need agroforestry in a big way, Workshop on *agroforestry in California: planning for the twenty-first century,* Deptt. of Forestry and Resources Management University of California, Berkeley, pp. 1-3.

Weaver, J.E and F.E clements. 1973. Plant Ecology. Tata Mc Gnaw-Hill, New Delhi.

Willey, R.W, Natararyan, M. Reddy, M.S. and Rao, M.R. 1986. Cropping systems with groundnut: Resource use and productivity. In: Agroforestry meteorology of groundnut. Proceeding of an International Symposium, 21-26 August, 1986. ICRISAT, Sahelian Center, Niamey, Niger 193-205.

Xiong, Z.X. and Chen, M.H. 1993. A preliminary report on tracing the dynamics of N uptake by labelled 15N in "grain-grain-green manure" rotation. Ningxia Journal of Agro-Forestry Sciences and Technology. 2:43-46.

Yantasath, K., Buranasilpin, P., Sapatanakul, W., Tanpanich, S., Chantrasiri, S., Patanawible, S. and Jitanawasan, S. 1992. Research on acacias and their potential. In : Awang, K. and Tailor, D.A. (eds.) Tropical Acacias in East and the Pacific. *Proc. First meeting of a Consultative Group for Research and Development of Acacias,* COGREDA. June 1-3, 1992. Phuket, Thailand.

Zhou S.Q. 1993. Cultivation of *Amomum villosum* in tropical forests. *Forest Ecol. Manag.* 60: 157-162.

Zou, X. and Sanford, R.L. 1990. Agroforestry systems in China: a survey and classification. *Agroforestry system* 11: 85-94.

Verinumbe, I. and Okali, D.U.U. 1985. The influence of coppiced teak *(Tectona grandis L.F)* regrowth and roots on intercropped maize *(Zea mays L.)*. Agroforestry systems 3: 381-386.

Verma, K.P. and Warsi, A.S. 1999. Evaluation of suitable rice-based *Oryza sativa*) cropping system for central plain zone of Uttar Pradesh. *Indian Journal of Agronomy*. 44(3): 444-447.

Wallace, J.S. 1996. Evaporation and interaction by neighboring plants. *Quarterly Journal of the Royal Meteorological Society*, p.123, pp. 1885-1905.

Walt, H.R. 1989. We need agroforestry in a big way, Workshop on *agroforestry in California: planning for the twenty-first century,* Deptt. of Forestry and Resources Management University of California, Berkeley, pp. 1-3.

Weaver, J.E and F.E clements. 1973. Plant Ecology. Tata Mc Gnaw-Hill, New Delhi.

Willey, R.W, Natararyan, M. Reddy, M.S. and Rao, M.R. 1986. Cropping systems with groundnut: Resource use and productivity. In: Agroforestry meteorology of groundnut. Proceeding of an International Symposium, 21-26 August, 1986. ICRISAT, Sahelian Center, Niamey, Niger 193-205.

Xiong, Z.X. and Chen, M.H. 1993. A preliminary report on tracing the dynamics of N uptake by labelled 15N in "grain-grain-green manure" rotation. Ningxia Journal of Agro-Forestry Sciences and Technology. 2:43-46.

Yantasath, K., Buranasilpin, P., Sapatanakul, W., Tanpanich, S., Chantrasiri, S., Patanawible, S. and Jitanawasan, S. 1992. Research on acacias and their potential. In : Awang, K. and Tailor, D.A. (eds.) Tropical Acacias in East and the Pacific. *Proc. First meeting of a Consultative Group for Research and Development of Acacias,* COGREDA. June 1-3, 1992. Phuket, Thailand.

Zhou S.Q. 1993. Cultivation of *Amomum villosum* in tropical forests. *Forest Ecol. Manag.* 60: 157-162.

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Appendix I. Available light in wheat mungbean-T.aman cropping pattern under different tree canopy during the first cropping season (2006-07)

	T. Aman 06					Wheat 06-07					Mug 07		
	15 July-Aug	Aug-Sep	Sep-Oct	Oct-Nov	Average	15 Nov-Dec	Dec-Jan	Jan-Feb	Feb-March	Average	April-May	May-June	Average
T_1 (open)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
T_2 (Black siris)	75	68	60	50	63.25	70	65	68	95	74.5	90.5	60.1	75.3
T_3 (Guava)	70	68.5	60.5	60	65.25	60.1	59	61	62.5	60.6	60.5	50	58.75
T_4(Mango)	80	75	73	71.2	74.8	71.5	70	69	68	69.6	62.3	60.1	61.2

Appendix II. Available light in wheat mungbean-T.aman cropping pattern under different tree canopy during the second cropping season (2007-08)

	T. Aman 07					Wheat 07-08					Mung 08		
	15 July-Aug	Aug-Sep	Sep-Oct	Oct-Nov	Average	15 Nov-Dec	Dec-Jan	Jan-Feb	Feb-March	Average	April-May	May-June	Average
T_1 (open)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
T_2 (Black siris)	60.5	51.3	48.5	40.0	50.07	60.0	58	60.5	93	67.8	85.6	56	70.8
T_3 (Guava)	48	47	46	45	46.5	44	45	46	45	45	40	35	37.5
T_4 (Mango)	60	56	55	52	55.7	51	50	48	47.5	49.12	45	40	42.5

Appendix I. Available light in wheat mungbean-T.aman cropping pattern under different tree canopy during the first cropping season (2006-07)

	T. Aman 06					Wheat 06-07					Mug 07		
	15 July-Aug	Aug-Sep	Sep-Oct	Oct-Nov	Average	15 Nov-Dec	Dec-Jan	Jan-Feb	Feb-March	Average	April-May	May-June	Average
T_1 (open)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
T_2 (Black siris)	75	68	60	50	63.25	70	65	68	95	74.5	90.5	60.1	75.3
T_3 (Guava)	70	68.5	60.5	60	65.25	60.1	59	61	62.5	60.6	60.5	50	58.75
T_4(Mango)	80	75	73	71.2	74.8	71.5	70	69	68	69.6	62.3	60.1	61.2

Appendix II. Available light in wheat mungbean-T.aman cropping pattern under different tree canopy during the second cropping season (2007-08)

	T. Aman 07					Wheat 07-08					Mung 08		
	15 July-Aug	Aug-Sep	Sep-Oct	Oct-Nov	Average	15 Nov-Dec	Dec-Jan	Jan-Feb	Feb-March	Average	April-May	May-June	Average
T_1 (open)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
T_2 (Black siris)	60.5	51.3	48.5	40.0	50.07	60.0	58	60.5	93	67.8	85.6	56	70.8
T_3 (Guava)	48	47	46	45	46.5	44	45	46	45	45	40	35	37.5
T_4 (Mango)	60	56	55	52	55.7	51	50	48	47.5	49.12	45	40	42.5

Appendix I. Available light in wheat mungbean-T.aman cropping pattern under different tree canopy during the first cropping season (2006-07)

	T. Aman 06					Wheat 06-07					Mug 07		
	15 July-Aug	Aug-Sep	Sep-Oct	Oct-Nov	Average	15 Nov-Dec	Dec-Jan	Jan-Feb	Feb-March	Average	April-May	May-June	Average
T_1 (open)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
T_2 (Black siris)	75	68	60	50	63.25	70	65	68	95	74.5	90.5	60.1	75.3
T_3 (Guava)	70	68.5	60.5	60	65.25	60.1	59	61	62.5	60.6	60.5	50	58.75
T_4(Mango)	80	75	73	71.2	74.8	71.5	70	69	68	69.6	62.3	60.1	61.2

Appendix II. Available light in wheat mungbean-T.aman cropping pattern under different tree canopy during the second cropping season (2007-08)

	T. Aman 07					Wheat 07-08					Mung 08		
	15 July-Aug	Aug-Sep	Sep-Oct	Oct-Nov	Average	15 Nov-Dec	Dec-Jan	Jan-Feb	Feb-March	Average	April-May	May-June	Average
T_1 (open)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
T_2 (Black siris)	60.5	51.3	48.5	40.0	50.07	60.0	58	60.5	93	67.8	85.6	56	70.8
T_3 (Guava)	48	47	46	45	46.5	44	45	46	45	45	40	35	37.5
T_4 (Mango)	60	56	55	52	55.7	51	50	48	47.5	49.12	45	40	42.5

Appendix III. Available light received by banana as middle storied crop in multistoried agroforestry system during the first cropping season (2005-06)

Treatment	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sep	Mean%
Open field	100	100	100	100	100	100	100	100	100	100	100	100	100
Banana+Potato-Onion	100	100	100	100	100	100	100	100	100	100	100	100	100
Ipil-ipil+banana	50	70	75	90	90	95	80	50	70	68	65	57	71.66
G. neem+Banana	45	70	72	98	98	90	75	45	70	66	60	53	70.16
Ipil-ipil+banana+Potato-Onion	50	70	75	85	86	90	70	45	65	62	60	55	67.75
G. neem+Banana+Potato-Onion	45	70	72	97	97	87	70	42	65	60	50	40	66.25

Appendix IV. Available light received by banana as middle storied crop in multistoried agroforestry system during the first cropping season (2006-07)

Treatment	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sep	Mean%
Open field	100	100	100	100	100	100	100	100	100	100	100	100	100
Banana+Potato-Onion	100	100	100	100	100	100	100	100	100	100	100	100	100
Ipil-ipil+banana	47	70	74	90	90	92	75	43	70	65	60	56	69.33
G. neem+Banana	40	70	73	95	98	97	68	40	70	65	55	50	67.58
Ipil-ipil+banana+Potato-Onion	45	60	68	82	85	90	70	40	60	62	55	50	63.92
G. neem+Banana+Potato-Onion	25	60	62	94	97	84	70	40	60	58	50	40	61.66

Appendix III. Available light received by banana as middle storied crop in multistoried agroforestry system during the first cropping season (2005-06)

Treatment	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sep	Mean%
Open field	100	100	100	100	100	100	100	100	100	100	100	100	100
Banana+Potato-Onion	100	100	100	100	100	100	100	100	100	100	100	100	100
Ipil-ipil+banana	50	70	75	90	90	95	80	50	70	68	65	57	71.66
G. neem+Banana	45	70	72	98	98	90	75	45	70	66	60	53	70.16
Ipil-ipil+banana+Potato-Onion	50	70	75	85	86	90	70	45	65	62	60	55	67.75
G. neem+Banana+Potato-Onion	45	70	72	97	97	87	70	42	65	60	50	40	66.25

Appendix IV. Available light received by banana as middle storied crop in multistoried agroforestry system during the first cropping season (2006-07)

Treatment	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sep	Mean%
Open field	100	100	100	100	100	100	100	100	100	100	100	100	100
Banana+Potato-Onion	100	100	100	100	100	100	100	100	100	100	100	100	100
Ipil-ipil+banana	47	70	74	90	90	92	75	43	70	65	60	56	69.33
G. neem+Banana	40	70	73	95	98	97	68	40	70	65	55	50	67.58
Ipil-ipil+banana+Potato-Onion	45	60	68	82	85	90	70	40	60	62	55	50	63.92
G. neem+Banana+Potato-Onion	25	60	62	94	97	84	70	40	60	58	50	40	61.66

Appendix III. Available light received by banana as middle storied crop in multistoried agroforestry system during the first cropping season (2005-06)

Treatment	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sep	Mean%
Open field	100	100	100	100	100	100	100	100	100	100	100	100	100
Banana+Potato-Onion	100	100	100	100	100	100	100	100	100	100	100	100	100
Ipil-ipil+banana	50	70	75	90	90	95	80	50	70	68	65	57	71.66
G. neem+Banana	45	70	72	98	98	90	75	45	70	66	60	53	70.16
Ipil-ipil+banana+Potato-Onion	50	70	75	85	86	90	70	45	65	62	60	55	67.75
G. neem+Banana+Potato-Onion	45	70	72	97	97	87	70	42	65	60	50	40	66.25

Appendix IV. Available light received by banana as middle storied crop in multistoried agroforestry system during the first cropping season (2006-07)

Treatment	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sep	Mean%
Open field	100	100	100	100	100	100	100	100	100	100	100	100	100
Banana+Potato-Onion	100	100	100	100	100	100	100	100	100	100	100	100	100
Ipil-ipil+banana	47	70	74	90	90	92	75	43	70	65	60	56	69.33
G. neem+Banana	40	70	73	95	98	97	68	40	70	65	55	50	67.58
Ipil-ipil+banana+Potato-Onion	45	60	68	82	85	90	70	40	60	62	55	50	63.92
G. neem+Banana+Potato-Onion	25	60	62	94	97	84	70	40	60	58	50	40	61.66

Appendix V. Available light received by potato as lower storied crop in multistoried agroforestry system during the first cropping season

Treatment	% Light received by potato	
	2005-06	2006-07
Open field	100	100
Banana+Potato-Onion	100	98
Ipil-ipil+banana	78.3	78
G. neem+Banana	80	79.3
Ipil-ipil+banana+Potato-Onion	76.6	70
G. neem+Banana+Potato-Onion	79.6	72

Appendix VI. Available light received by onion as lower storied crop in multistoried agroforestry system during the first cropping season

Treatment	% Light received by onion	
	2006	2007
Open field	100	100
Banana+Potato-Onion	97	96.5
Ipil-ipil+banana	88.33	85.66
G. neem+Banana	87.66	84.33
Ipil-ipil+banana+Potato-Onion	85.00	82.16
G. neem+Banana+Potato-Onion	84.66	80.83

Appendix V. Available light received by potato as lower storied crop in multistoried agroforestry system during the first cropping season

Treatment	**% Light received by potato**	
	2005-06	**2006-07**
Open field	100	100
Banana+Potato-Onion	100	98
Ipil-ipil+banana	78.3	78
G. neem+Banana	80	79.3
Ipil-ipil+banana+Potato-Onion	76.6	70
G. neem+Banana+Potato-Onion	79.6	72

Appendix VI. Available light received by onion as lower storied crop in multistoried agroforestry system during the first cropping season

Treatment	**% Light received by onion**	
	2006	**2007**
Open field	100	100
Banana+Potato-Onion	97	96.5
Ipil-ipil+banana	88.33	85.66
G. neem+Banana	87.66	84.33
Ipil-ipil+banana+Potato-Onion	85.00	82.16
G. neem+Banana+Potato-Onion	84.66	80.83

Appendix V. Available light received by potato as lower storied crop in multistoried agroforestry system during the first cropping season

Treatment	% Light received by potato	
	2005-06	2006-07
Open field	100	100
Banana+Potato-Onion	100	98
Ipil-ipil+banana	78.3	78
G. neem+Banana	80	79.3
Ipil-ipil+banana+Potato-Onion	76.6	70
G. neem+Banana+Potato-Onion	79.6	72

Appendix VI. Available light received by onion as lower storied crop in multistoried agroforestry system during the first cropping season

Treatment	% Light received by onion	
	2006	2007
Open field	100	100
Banana+Potato-Onion	97	96.5
Ipil-ipil+banana	88.33	85.66
G. neem+Banana	87.66	84.33
Ipil-ipil+banana+Potato-Onion	85.00	82.16
G. neem+Banana+Potato-Onion	84.66	80.83

Appendix VII. Effect of tree on plant height of T.aman at 2006 and 2007

Treatment	Plant height (cm) 2006				Plant height (cm) 2007			
	30 DAT	45DAT	60DAT	75DAT	30 DAT	45DAT	60DAT	75DAT
T_1	60.81	78.26	89.50	102.0	59.12 bc	76.66 c	87.92 b	102.40 b
T_2	62.13	79.82	90.71	103.80	60.40 ab	78.98 b	88.96 b	102.10 b
T_3	68.46	80.47	93.71	106.5	56.81 c	78.32 b	87.85 b	100.90 c
T_4	65.02	78.61	89.58	103.2	62.90 a	80.30 a	92.39 a	104.60 a
Level of Significance	NS	NS	NS	NS	**	*	*	*
CV%	1.18	2.10	0.66	1.30	3.99	3.90	5.18	4.19

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

T_1= Control (open field), T_2= Black siris, T_3= Guava, T_4= Mango trees ** = Significant at 1% level of probability, * = significant at 5% level of probability, NS= Not significant.

Appendix VII. Effect of tree on plant height of T.aman at 2006 and 2007

Treatment	Plant height (cm) 2006				Plant height (cm) 2007			
	30 DAT	45DAT	60DAT	75DAT	30 DAT	45DAT	60DAT	75DAT
T_1	60.81	78.26	89.50	102.0	59.12 bc	76.66 c	87.92 b	102.40 b
T_2	62.13	79.82	90.71	103.80	60.40 ab	78.98 b	88.96 b	102.10 b
T_3	68.46	80.47	93.71	106.5	56.81 c	78.32 b	87.85 b	100.90 c
T_4	65.02	78.61	89.58	103.2	62.90 a	80.30 a	92.39 a	104.60 a
Level of Significance	NS	NS	NS	NS	**	*	*	*
CV%	1.18	2.10	0.66	1.30	3.99	3.90	5.18	4.19

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

T_1= Control (open field), T_2= Black siris, T_3= Guava, T_4= Mango trees ** = Significant at 1% level of probability, * = significant at 5% level of probability, NS= Not significant.

Appendix VII. Effect of tree on plant height of T.aman at 2006 and 2007

Treatment	Plant height (cm) 2006				Plant height (cm) 2007			
	30 DAT	45DAT	60DAT	75DAT	30 DAT	45DAT	60DAT	75DAT
T_1	60.81	78.26	89.50	102.0	59.12 bc	76.66 c	87.92 b	102.40 b
T_2	62.13	79.82	90.71	103.80	60.40 ab	78.98 b	88.96 b	102.10 b
T_3	68.46	80.47	93.71	106.5	56.81 c	78.32 b	87.85 b	100.90 c
T_4	65.02	78.61	89.58	103.2	62.90 a	80.30 a	92.39 a	104.60 a
Level of Significance	NS	NS	NS	NS	**	*	*	*
CV%	1.18	2.10	0.66	1.30	3.99	3.90	5.18	4.19

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

T_1= Control (open field), T_2= Black siris, T_3= Guava, T_4= Mango trees ** = Significant at 1% level of probability, * = significant at 5% level of probability, NS= Not significant.

Appendix VIII. Effect of variety on plant height of T.aman at 2006 and 2007

Variety	Plant height (cm) 2006				Plant height (cm) 2007			
	30 DAT	45DAT	60DAT	75DAT	30 DAT	45DAT	60DAT	75DAT
V_1	70.04 a	88.28 a	99.97 a	113.9 a	68.29a	86.57a	98.32a	112.2a
V_2	69.26 a	88.88 a	100.7 a	114.5 a	68.58a	87.11a	99.0a	112.8a
V_3	59.52 b	74.76 ab	85.78 b	97.53 bc	57.57b	72.66c	84.54c	96.22c
V_4	60.94 b	79.82 ab	90.53 b	104.4 ab	59.23b	78.18b	88.86b	102.8b
V_5	48.26 c	69.71 b	77.43 c	89.07 c	46.36c	68.31d	75.68d	89.74d
Level of Significance	**	*	**	**	**	**	**	**
CV%	1.18	2.10	0.66	1.30	3.99	3.90	5.18	4.19

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

V_1= BR10, V_2= BR11, V_3= BRRI dhan 33, V_4= BRRI dhan 39, V_5= Sorna

Appendix VIII. Effect of variety on plant height of T.aman at 2006 and 2007

Variety	Plant height (cm) 2006				Plant height (cm) 2007			
	30 DAT	45DAT	60DAT	75DAT	30 DAT	45DAT	60DAT	75DAT
V_1	70.04 a	88.28 a	99.97 a	113.9 a	68.29a	86.57a	98.32a	112.2a
V_2	69.26 a	88.88 a	100.7 a	114.5 a	68.58a	87.11a	99.0a	112.8a
V_3	59.52 b	74.76 ab	85.78 b	97.53 bc	57.57b	72.66c	84.54c	96.22c
V_4	60.94 b	79.82 ab	90.53 b	104.4 ab	59.23b	78.18b	88.86b	102.8b
V_5	48.26 c	69.71 b	77.43 c	89.07 c	46.36c	68.31d	75.68d	89.74d
Level of Significance	**	*	**	**	**	**	**	**
CV%	1.18	2.10	0.66	1.30	3.99	3.90	5.18	4.19

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

V_1= BR10, V_2= BR11, V_3= BRRI dhan 33, V_4= BRRI dhan 39, V_5= Sorna

Appendix VIII. Effect of variety on plant height of T.aman at 2006 and 2007

Variety	Plant height (cm) 2006				Plant height (cm) 2007			
	30 DAT	45DAT	60DAT	75DAT	30 DAT	45DAT	60DAT	75DAT
V_1	70.04 a	88.28 a	99.97 a	113.9 a	68.29a	86.57a	98.32a	112.2a
V_2	69.26 a	88.88 a	100.7 a	114.5 a	68.58a	87.11a	99.0a	112.8a
V_3	59.52 b	74.76 ab	85.78 b	97.53 bc	57.57b	72.66c	84.54c	96.22c
V_4	60.94 b	79.82 ab	90.53 b	104.4 ab	59.23b	78.18b	88.86b	102.8b
V_5	48.26 c	69.71 b	77.43 c	89.07 c	46.36c	68.31d	75.68d	89.74d
Level of Significance	**	*	**	**	**	**	**	**
CV%	1.18	2.10	0.66	1.30	3.99	3.90	5.18	4.19

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

V_1= BR10, V_2= BR11, V_3= BRRI dhan 33, V_4= BRRI dhan 39, V_5= Sorna

Appendix IX. Effect of tree on number of tiller/hill of T.aman at 2006 and 2007

Treatment	Number of tiller/hill, 2006			Number of tiller/hill, 2007		
	30 DAT	**45DAT**	**60DAT**	**30 DAT**	**45DAT**	**60DAT**
T_1	6.880	12.72	14.12	6.55	12.35 a	13.73 a
T_2	6.533	11.48	13.03	6.29	11.10 b	12.71 b
T_3	6.520	10.94	12.43	6.22	10.60 c	12.06 c
T_4	6.473	11.68	12.11	6.19	11.26 b	11.74 b
Level of significance	NS	NS	NS	NS	*	*
CV%	1.59	1.25	2.26	7.74	10.16	10.87

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix X. Effect of variety on number of tiller/hill of T.aman at 2006 and 2007

Variety	Number of tiller/hill at 2006			Number of tiller/hill at 2007		
	30 DAT	**45DAT**	**60DAT**	**30 DAT**	**45DAT**	**60DAT**
V_1	6.842 ab	12.03 ab	13.58 A	6.531ab	11.6b	13.18a
V_2	7.358 a	13.04 a	14.07 A	7.013a	12.68a	13.67a
V_3	6.267 b	11.13 b	12.31 A	5.994bc	10.76bc	11.93b
V_4	6.692 ab	11.35 b	12.39 A	6.36abc	11.01bc	12.11b
V_5	5.850 b	10.98 b	11.27 AB	5.65c	10.57c	11.91b
Level of Significance	*	*	NS	*	**	**
CV%	1.59	1.25	2.26	7.74	10.16	10.87

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix IX. Effect of tree on number of tiller/hill of T.aman at 2006 and 2007

Treatment	Number of tiller/hill, 2006			Number of tiller/hill, 2007		
	30 DAT	**45DAT**	**60DAT**	**30 DAT**	**45DAT**	**60DAT**
T_1	6.880	12.72	14.12	6.55	12.35 a	13.73 a
T_2	6.533	11.48	13.03	6.29	11.10 b	12.71 b
T_3	6.520	10.94	12.43	6.22	10.60 c	12.06 c
T_4	6.473	11.68	12.11	6.19	11.26 b	11.74 b
Level of significance	NS	NS	NS	NS	*	*
CV%	1.59	1.25	2.26	7.74	10.16	10.87

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix X. Effect of variety on number of tiller/hill of T.aman at 2006 and 2007

Variety	Number of tiller/hill at 2006			Number of tiller/hill at 2007		
	30 DAT	**45DAT**	**60DAT**	**30 DAT**	**45DAT**	**60DAT**
V_1	6.842 ab	12.03 ab	13.58 A	6.531ab	11.6b	13.18a
V_2	7.358 a	13.04 a	14.07 A	7.013a	12.68a	13.67a
V_3	6.267 b	11.13 b	12.31 A	5.994bc	10.76bc	11.93b
V_4	6.692 ab	11.35 b	12.39 A	6.36abc	11.01bc	12.11b
V_5	5.850 b	10.98 b	11.27 AB	5.65c	10.57c	11.91b
Level of Significance	*	*	NS	*	**	**
CV%	1.59	1.25	2.26	7.74	10.16	10.87

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix IX. Effect of tree on number of tiller/hill of T.aman at 2006 and 2007

Treatment	Number of tiller/hill, 2006			Number of tiller/hill, 2007		
	30 DAT	45DAT	60DAT	30 DAT	45DAT	60DAT
T_1	6.880	12.72	14.12	6.55	12.35 a	13.73 a
T_2	6.533	11.48	13.03	6.29	11.10 b	12.71 b
T_3	6.520	10.94	12.43	6.22	10.60 c	12.06 c
T_4	6.473	11.68	12.11	6.19	11.26 b	11.74 b
Level of significance	NS	NS	NS	NS	*	*
CV%	1.59	1.25	2.26	7.74	10.16	10.87

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix X. Effect of variety on number of tiller/hill of T.aman at 2006 and 2007

Variety	Number of tiller/hill at 2006			Number of tiller/hill at 2007		
	30 DAT	45DAT	60DAT	30 DAT	45DAT	60DAT
V_1	6.842 ab	12.03 ab	13.58 A	6.531ab	11.6b	13.18a
V_2	7.358 a	13.04 a	14.07 A	7.013a	12.68a	13.67a
V_3	6.267 b	11.13 b	12.31 A	5.994bc	10.76bc	11.93b
V_4	6.692 ab	11.35 b	12.39 A	6.36abc	11.01bc	12.11b
V_5	5.850 b	10.98 b	11.27 AB	5.65c	10.57c	11.91b
Level of Significance	*	*	NS	*	**	**
CV%	1.59	1.25	2.26	7.74	10.16	10.87

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix XI. Effect of tree on straw fresh weight and root fresh weight of T.aman at 2006 and 2007

Treatment	Straw fresh weight (gm)		Straw dry weight (gm)	
	2006	2007	2006	2007
T_1	80.82 a	78.57a	29.19 a	28.68a
T_2	64.51 c	62.03c	22.51 b	22.08c
T_3	53.12 d	50.62d	16.69 c	15.35d
T_4	70.52 b	68.03b	25.78 b	25.70b
Level of Significance	**	**	*	**
CV%	0.19	6.92	2.56	3.49

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix XII. Effect of variety on plant fresh weight, straw fresh weight and root fresh weight of T.aman at 2006 and 2007

Varieties	Straw fresh weight (gm)		Straw dry weight (gm	
	2006	2007	2006	2007
V_1	72.82 a	70.32a	28.33a	27.86a
V_2	70.78 b	68.28a	27.78 a	27.34a
V_3	63.47 d	61.04bc	22.89 b	22.54c
V_4	66.64 c	64.22b	23.62 b	23.48b
V_5	62.50 d	60.19c	22.59 b	22.29c
Level of Significance	**	**	*	**
CV%	0.19	6.92	2.56	3.49

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix XI. Effect of tree on straw fresh weight and root fresh weight of T.aman at 2006 and 2007

Treatment	Straw fresh weight (gm)		Straw dry weight (gm)	
	2006	2007	2006	2007
T_1	80.82 a	78.57a	29.19 a	28.68a
T_2	64.51 c	62.03c	22.51 b	22.08c
T_3	53.12 d	50.62d	16.69 c	15.35d
T_4	70.52 b	68.03b	25.78 b	25.70b
Level of Significance	**	**	*	**
CV%	0.19	6.92	2.56	3.49

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix XII. Effect of variety on plant fresh weight, straw fresh weight and root fresh weight of T.aman at 2006 and 2007

Varieties	Straw fresh weight (gm)		Straw dry weight (gm	
	2006	2007	2006	2007
V_1	72.82 a	70.32a	28.33a	27.86a
V_2	70.78 b	68.28a	27.78 a	27.34a
V_3	63.47 d	61.04bc	22.89 b	22.54c
V_4	66.64 c	64.22b	23.62 b	23.48b
V_5	62.50 d	60.19c	22.59 b	22.29c
Level of Significance	**	**	*	**
CV%	0.19	6.92	2.56	3.49

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix XI. Effect of tree on straw fresh weight and root fresh weight of T.aman at 2006 and 2007

Treatment	Straw fresh weight (gm)		Straw dry weight (gm)	
	2006	2007	2006	2007
T_1	80.82 a	78.57a	29.19 a	28.68a
T_2	64.51 c	62.03c	22.51 b	22.08c
T_3	53.12 d	50.62d	16.69 c	15.35d
T_4	70.52 b	68.03b	25.78 b	25.70b
Level of Significance	**	**	*	**
CV%	0.19	6.92	2.56	3.49

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix XII. Effect of variety on plant fresh weight, straw fresh weight and root fresh weight of T.aman at 2006 and 2007

Varieties	Straw fresh weight (gm)		Straw dry weight (gm	
	2006	2007	2006	2007
V_1	72.82 a	70.32a	28.33a	27.86a
V_2	70.78 b	68.28a	27.78 a	27.34a
V_3	63.47 d	61.04bc	22.89 b	22.54c
V_4	66.64 c	64.22b	23.62 b	23.48b
V_5	62.50 d	60.19c	22.59 b	22.29c
Level of Significance	**	**	*	**
CV%	0.19	6.92	2.56	3.49

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Appendix XIII. Effect of tree on yield and yield contributing characters of of T.aman in 2006 and 2007

Treatment	Panicle length (cm)		No of grain/ Panicle		Unfilled grain/ Panicle		1000 grain weight (g)		Yield (t ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1	24.93a	24.62 a	158.5	157.40 a	12.49c	12.10c	20.47	20.40 a	3.927	3.855a
T_2	24.25ab	23.97 ab	152.6	150.90 b	14.82a b	14.42b	20.46	20.18 b	3.840	3.27 b
T_3	23.17b	20.35 c	148.3	136.40 c	16.59a	20.16a	20.35	20.12 c	3.553	2.50 c
T_4	23.04b	22.80 b	149.6	147.50 b	13.17b c	12.79c	20.45	20.22 b	3.613	3.26 b
Level of Significance	*	*	NS	*	*	*	NS	NS	NS	*
CV%	O.73	9.72	O.78	6.27	1.38	8.33	5.33	11.29	1.57	8.85

Appendix XIII. Effect of tree on yield and yield contributing characters of of T.aman in 2006 and 2007

Treatment	Panicle length (cm)		No of grain/ Panicle		Unfilled grain/ Panicle		1000 grain weight (g)		Yield (t ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1	24.93a	24.62 a	158.5	157.40 a	12.49c	12.10c	20.47	20.40 a	3.927	3.855a
T_2	24.25ab	23.97 ab	152.6	150.90 b	14.82a b	14.42b	20.46	20.18 b	3.840	3.27 b
T_3	23.17b	20.35 c	148.3	136.40 c	16.59a	20.16a	20.35	20.12 c	3.553	2.50 c
T_4	23.04b	22.80 b	149.6	147.50 b	13.17b c	12.79c	20.45	20.22 b	3.613	3.26 b
Level of Significance	*	*	NS	*	*	*	NS	NS	NS	*
CV%	O.73	9.72	O.78	6.27	1.38	8.33	5.33	11.29	1.57	8.85

Appendix XIII. Effect of tree on yield and yield contributing characters of of T.aman in 2006 and 2007

Treatment	Panicle length (cm)		No of grain/ Panicle		Unfilled grain/ Panicle		1000 grain weight (g)		Yield (t ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
T_1	24.93a	24.62 a	158.5	157.40 a	12.49c	12.10c	20.47	20.40 a	3.927	3.855a
T_2	24.25ab	23.97 ab	152.6	150.90 b	14.82a b	14.42b	20.46	20.18 b	3.840	3.27 b
T_3	23.17b	20.35 c	148.3	136.40 c	16.59a	20.16a	20.35	20.12 c	3.553	2.50 c
T_4	23.04b	22.80 b	149.6	147.50 b	13.17b c	12.79c	20.45	20.22 b	3.613	3.26 b
Level of Significance	*	*	NS	*	*	*	NS	NS	NS	*
CV%	O.73	9.72	O.78	6.27	1.38	8.33	5.33	11.29	1.57	8.85

Appendix XIV. Effect of variety on yield and yield contributing characters of of T.aman in 2006 and 2007

Variety	Panicle length (cm)		No of grain Panicle^{-1}		Sterile spikelets Panicle^{-1}		1000 grain weight (g)		Yield (t ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
V_1	24.88ab	24.57ab	154.9ab	151.10b	12.60 c	11.36 c	20.54 b	20.31 b	4.575a	4.506a
V_2	25.66 a	25.38a	165.1a	162.60a	10.51 d	9.57 d	21.85 a	21.63 a	4.817a	4.744a
V_3	23.81 bc	23.58bc	149.9b	151.10b	17.89 a	16.90 a	21.72 ab	21.22 ab	3.23b	3.181b
V_4	22.77 c	22.77c	148.4b	146.40bc	18.45 a	17.47 a	20.51 c	20.31 c	3.158b	3.106b
V_5	22.11 c	22.13c	143.0b	141.60c	15.14 b	14.04 b	17.83 d	17.43 d	2.883b	2.831c
Level of Significance	**	**	*	**	*	**	**	**	*	**
CV%	0.73	9.72	0.78	6.27	1.38	8.33	5.33	11.29	1.57	8.85

Appendix XIV. Effect of variety on yield and yield contributing characters of of T.aman in 2006 and 2007

Variety	Panicle length (cm)		No of grain Panicle^{-1}		Sterile spikelets Panicle^{-1}		1000 grain weight (g)		Yield (t ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
V_1	24.88ab	24.57ab	154.9ab	151.10b	12.60 c	11.36 c	20.54 b	20.31 b	4.575a	4.506a
V_2	25.66 a	25.38a	165.1a	162.60a	10.51 d	9.57 d	21.85 a	21.63 a	4.817a	4.744a
V_3	23.81 bc	23.58bc	149.9b	151.10b	17.89 a	16.90 a	21.72 ab	21.22 ab	3.23b	3.181b
V_4	22.77 c	22.77c	148.4b	146.40bc	18.45 a	17.47 a	20.51 c	20.31 c	3.158b	3.106b
V_5	22.11 c	22.13c	143.0b	141.60c	15.14 b	14.04 b	17.83 d	17.43 d	2.883b	2.831c
Level of Significance	**	**	*	**	*	**	**	**	*	**
CV%	0.73	9.72	0.78	6.27	1.38	8.33	5.33	11.29	1.57	8.85

Appendix XIV. Effect of variety on yield and yield contributing characters of of T.aman in 2006 and 2007

Variety	Panicle length (cm)		No of grain Panicle^{-1}		Sterile spikelets Panicle^{-1}		1000 grain weight (g)		Yield (t ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
V_1	24.88ab	24.57ab	154.9ab	151.10b	12.60 c	11.36 c	20.54 b	20.31 b	4.575a	4.506a
V_2	25.66 a	25.38a	165.1a	162.60a	10.51 d	9.57 d	21.85 a	21.63 a	4.817a	4.744a
V_3	23.81 bc	23.58bc	149.9b	151.10b	17.89 a	16.90 a	21.72 ab	21.22 ab	3.23b	3.181b
V_4	22.77 c	22.77c	148.4b	146.40bc	18.45 a	17.47 a	20.51 c	20.31 c	3.158b	3.106b
V_5	22.11 c	22.13c	143.0b	141.60c	15.14 b	14.04 b	17.83 d	17.43 d	2.883b	2.831c
Level of Significance	**	**	*	**	*	**	**	**	*	**
CV%	0.73	9.72	0.78	6.27	1.38	8.33	5.33	11.29	1.57	8.85

Appendix XV. Effect of tree on plant height of wheat in 2006-07and 2007-08

Treatment	Plant height (cm) 2006-07			Plant height (cm) 2007-08		
	40DAS	80DAS	120DAS	40DAS	80DAS	120DAS
T_1	42.74 b	86.38 ab	92.18 ab	43.61 a	88.89 a	95.17 a
T_2	43.39 a	87.63 a	93.12 ab	41.36 bc	85.13 ab	90.75 ab
T_3	41.47 bc	84.34 b	90.67 b	36.43 d	77.93 d	84.53 bc
T_4	43.83 a	88.52 a	94.14 a	40.21 c	83.73 bc	88.27 b
Level of significance	**	*	*	*	*	*
CV%	7.5	9.8	5.3	3.25	9.13	10.4

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where, T_1= Control (open field), T_2= Black siris, T_3= Guava, T_4= Mango trees ** = Significant at 1% level of probability, * = significant at 5% level of probability, NS= Not significant.

Appendix XVI. Effect of variety on plant height of wheat in 2006-07and 2007-08

Variety	Plant height (cm) 2006-07			Plant height (cm) 2007-08		
	40DAS	80DAS	120DAS	40DAS	80DAS	120DAS
V_1	42.63 b	87.28	93.47	43.23 ab	87.16	93.71
V_2	41.78 b	86.65	92.12	42.28 bc	87.28	94.33
V_3	47.95 a	88.51	93.50	43.43 a	89.66	95.41
V_4	42.13 b	87.56	92.32	42.34 bc	87.73	93.93
V_5	41.58 b	86.09	91.22	43.13 ab	87.78	94.78
Level of significance	**	NS	NS	*	NS	NS
CV%	7.5	9.8	5.3	3.25	9.13	10.4

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

* =Significant at 5% level of probability, **=Significant at 1% level of probability.

Where, V_1=Gourove, V_2= Sourave, V_3= Shatabdi , V_4= Kanchan, V_5= Protiva DAS = Days after sowing.

Appendix XV. Effect of tree on plant height of wheat in 2006-07and 2007-08

Treatment	Plant height (cm) 2006-07			Plant height (cm) 2007-08		
	40DAS	80DAS	120DAS	40DAS	80DAS	120DAS
T_1	42.74 b	86.38 ab	92.18 ab	43.61 a	88.89 a	95.17 a
T_2	43.39 a	87.63 a	93.12 ab	41.36 bc	85.13 ab	90.75 ab
T_3	41.47 bc	84.34 b	90.67 b	36.43 d	77.93 d	84.53 bc
T_4	43.83 a	88.52 a	94.14 a	40.21 c	83.73 bc	88.27 b
Level of significance	**	*	*	*	*	*
CV%	7.5	9.8	5.3	3.25	9.13	10.4

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where, T_1= Control (open field), T_2= Black siris, T_3= Guava, T_4= Mango trees ** = Significant at 1% level of probability, * = significant at 5% level of probability, NS= Not significant.

Appendix XVI. Effect of variety on plant height of wheat in 2006-07and 2007-08

Variety	Plant height (cm) 2006-07			Plant height (cm) 2007-08		
	40DAS	80DAS	120DAS	40DAS	80DAS	120DAS
V_1	42.63 b	87.28	93.47	43.23 ab	87.16	93.71
V_2	41.78 b	86.65	92.12	42.28 bc	87.28	94.33
V_3	47.95 a	88.51	93.50	43.43 a	89.66	95.41
V_4	42.13 b	87.56	92.32	42.34 bc	87.73	93.93
V_5	41.58 b	86.09	91.22	43.13 ab	87.78	94.78
Level of significance	**	NS	NS	*	NS	NS
CV%	7.5	9.8	5.3	3.25	9.13	10.4

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

* =Significant at 5% level of probability, **=Significant at 1% level of probability.

Where, V_1=Gourove, V_2= Sourave, V_3= Shatabdi , V_4= Kanchan, V_5= Protiva DAS = Days after sowing.

Appendix XV. Effect of tree on plant height of wheat in 2006-07and 2007-08

Treatment	Plant height (cm) 2006-07			Plant height (cm) 2007-08		
	40DAS	80DAS	120DAS	40DAS	80DAS	120DAS
T_1	42.74 b	86.38 ab	92.18 ab	43.61 a	88.89 a	95.17 a
T_2	43.39 a	87.63 a	93.12 ab	41.36 bc	85.13 ab	90.75 ab
T_3	41.47 bc	84.34 b	90.67 b	36.43 d	77.93 d	84.53 bc
T_4	43.83 a	88.52 a	94.14 a	40.21 c	83.73 bc	88.27 b
Level of significance	**	*	*	*	*	*
CV%	7.5	9.8	5.3	3.25	9.13	10.4

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where, T_1= Control (open field), T_2= Black siris, T_3= Guava, T_4= Mango trees ** = Significant at 1% level of probability, * = significant at 5% level of probability, NS= Not significant.

Appendix XVI. Effect of variety on plant height of wheat in 2006-07and 2007-08

Variety	Plant height (cm) 2006-07			Plant height (cm) 2007-08		
	40DAS	80DAS	120DAS	40DAS	80DAS	120DAS
V_1	42.63 b	87.28	93.47	43.23 ab	87.16	93.71
V_2	41.78 b	86.65	92.12	42.28 bc	87.28	94.33
V_3	47.95 a	88.51	93.50	43.43 a	89.66	95.41
V_4	42.13 b	87.56	92.32	42.34 bc	87.73	93.93
V_5	41.58 b	86.09	91.22	43.13 ab	87.78	94.78
Level of significance	**	NS	NS	*	NS	NS
CV%	7.5	9.8	5.3	3.25	9.13	10.4

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

* =Significant at 5% level of probability, **=Significant at 1% level of probability.

Where, V_1=Gourove, V_2= Sourave, V_3= Shatabdi , V_4= Kanchan, V_5= Protiva DAS = Days after sowing.

Appendix XVII. Effect of trees on number of tiller/hill in wheat at different days after sowing in 2006-07 and 2007-08

Treatment	Number of tiller hill^{-1}, 2006-07			Number of tiller hill^{-1}, 2007-08		
	30 DAS	45DAS	60DAS	30 DAS	45DAS	60DAS
T_1	2.6	3.90 a	4.19 a	2.7 a	3.85 a	4.22 a
T_2	2.5	3.22 b	3.65 b	2.3 ab	3.12 b	3.48 b
T_3	2.4	3.09 b	3.40 b	1.4 b	2.0 c	2.22 c
T_4	2.6	3.20 b	3.57 b	2.0 b	2.5 c	2.96 c
Level of significance	NS	*	*	*	**	**
CV%	8.28	6.28	9.70	7.93	4.5	5.28

Appendix XVIII. Effect of varieties on number of tiller/hill in wheat at different days after sowing in 2006-07 and 2007-08

	Number of tiller hill^{-1}, 2006-07			Number of tiller hill^{-1}, 2007-08		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
V_1	2.6	3.32 b	3.50 c	2.20	3.08 b	3.34 b
V_2	2.4	3.19 b	3.30 d	2.15	3.03 b	3.18 b
V_3	3.0	3.55 a	4.53 a	2.80	3.30 a	3.64 a
V_4	2.7	3.48 a	3.98 b	2.50	3.20 a	3.50 a
V_5	2.5	3.22 b	3.41 c	2.18	3.08 b	3.28 b
Level of significance	NS	**	**	NS	*	*
CV%	8.28	6.28	9.70	7.93	4.5	5.28

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

* = Significant at 5% level of probability, **= Significant at 1% level of probability.
Where, V_1= Gourove, V_2= Sourave, V_3 = Shatabdi , V_4 = Kanchan, V_5 = Protiva
DAS = Days after sowing.

Appendix XVII. Effect of trees on number of tiller/hill in wheat at different days after sowing in 2006-07 and 2007-08

Treatment	Number of tiller hill^{-1}, 2006-07			Number of tiller hill^{-1}, 2007-08		
	30 DAS	45DAS	60DAS	30 DAS	45DAS	60DAS
T_1	2.6	3.90 a	4.19 a	2.7 a	3.85 a	4.22 a
T_2	2.5	3.22 b	3.65 b	2.3 ab	3.12 b	3.48 b
T_3	2.4	3.09 b	3.40 b	1.4 b	2.0 c	2.22 c
T_4	2.6	3.20 b	3.57 b	2.0 b	2.5 c	2.96 c
Level of significance	NS	*	*	*	**	**
CV%	8.28	6.28	9.70	7.93	4.5	5.28

Appendix XVIII. Effect of varieties on number of tiller/hill in wheat at different days after sowing in 2006-07 and 2007-08

	Number of tiller hill^{-1}, 2006-07			Number of tiller hill^{-1}, 2007-08		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
V_1	2.6	3.32 b	3.50 c	2.20	3.08 b	3.34 b
V_2	2.4	3.19 b	3.30 d	2.15	3.03 b	3.18 b
V_3	3.0	3.55 a	4.53 a	2.80	3.30 a	3.64 a
V_4	2.7	3.48 a	3.98 b	2.50	3.20 a	3.50 a
V_5	2.5	3.22 b	3.41 c	2.18	3.08 b	3.28 b
Level of significance	NS	**	**	NS	*	*
CV%	8.28	6.28	9.70	7.93	4.5	5.28

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

* = Significant at 5% level of probability, **= Significant at 1% level of probability.
Where, V_1= Gourove, V_2= Sourave, V_3 = Shatabdi , V_4 = Kanchan, V_5 = Protiva
DAS = Days after sowing.

Appendix XVII. Effect of trees on number of tiller/hill in wheat at different days after sowing in 2006-07 and 2007-08

Treatment	Number of tiller hill^{-1}, 2006-07			Number of tiller hill^{-1}, 2007-08		
	30 DAS	45DAS	60DAS	30 DAS	45DAS	60DAS
T_1	2.6	3.90 a	4.19 a	2.7 a	3.85 a	4.22 a
T_2	2.5	3.22 b	3.65 b	2.3 ab	3.12 b	3.48 b
T_3	2.4	3.09 b	3.40 b	1.4 b	2.0 c	2.22 c
T_4	2.6	3.20 b	3.57 b	2.0 b	2.5 c	2.96 c
Level of significance	NS	*	*	*	**	**
CV%	8.28	6.28	9.70	7.93	4.5	5.28

Appendix XVIII. Effect of varieties on number of tiller/hill in wheat at different days after sowing in 2006-07 and 2007-08

	Number of tiller hill^{-1}, 2006-07			Number of tiller hill^{-1}, 2007-08		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
V_1	2.6	3.32 b	3.50 c	2.20	3.08 b	3.34 b
V_2	2.4	3.19 b	3.30 d	2.15	3.03 b	3.18 b
V_3	3.0	3.55 a	4.53 a	2.80	3.30 a	3.64 a
V_4	2.7	3.48 a	3.98 b	2.50	3.20 a	3.50 a
V_5	2.5	3.22 b	3.41 c	2.18	3.08 b	3.28 b
Level of significance	NS	**	**	NS	*	*
CV%	8.28	6.28	9.70	7.93	4.5	5.28

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

* = Significant at 5% level of probability, **= Significant at 1% level of probability.
Where, V_1= Gourove, V_2= Sourave, V_3 = Shatabdi , V_4 = Kanchan, V_5 = Protiva
DAS = Days after sowing.

Appendix XIX. Effect of trees on yield and yield contributing characters of wheat varieties in 2006-07 and 2007-08

Trees	No. of spikes hill		Length of spike hill^{-1}		No. of grains hill $^{-1}$		Grain wt.(g hill^{-1})		1000grain-weight(g)		Grain yield (t ha^{-1})	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
T_1	3.34	3.35a	10.35	10.22 a	124.62a	128.90 a	5.61 a	5.65 a	45.07 a	43.83 a	2.92a	2.94 a
T_2	3.24	3.11a	10.00	9.90 b	110.99b	105.70 b	4.69 b	4.50 b	42.27 b	42.50 a	2.45b	2.34b
T_3	3.21	1.81c	9. 78	9.74 b	108.01c	77.90 c	4.47 b	2.94 c	41.46 b	37.70 b	2.32b	1.52 c
T_4	3.30	2.74b	10.17	9.75 b	111.43b	90.90 b	4.77 b	3.94 b	42.85 b	42.30 a	2.48b	2.05bc
Level of significance	NS	*	NS	*	*	*	*	*	*	*	*	**
CV%	10.25	5.20	7.80	6.8	5.40	3.57	9.89	6.77	8.50	9.20	4.30	5.50

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

T_1= Control (open field), T_2= Black siris, T_3= Guava, T_4= Mango trees

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Appendix XIX. Effect of trees on yield and yield contributing characters of wheat varieties in 2006-07 and 2007-08

Trees	No. of spikes hill		Length of spike hill^{-1}		No. of grains hill $^{-1}$		Grain wt.(g hill^{-1})		1000grain-weight(g)		Grain yield (t ha^{-1})	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
T_1	3.34	3.35a	10.35	10.22 a	124.62a	128.90 a	5.61 a	5.65 a	45.07 a	43.83 a	2.92a	2.94 a
T_2	3.24	3.11a	10.00	9.90 b	110.99b	105.70 b	4.69 b	4.50 b	42.27 b	42.50 a	2.45b	2.34b
T_3	3.21	1.81c	9. 78	9.74 b	108.01c	77.90 c	4.47 b	2.94 c	41.46 b	37.70 b	2.32b	1.52 c
T_4	3.30	2.74b	10.17	9.75 b	111.43b	90.90 b	4.77 b	3.94 b	42.85 b	42.30 a	2.48b	2.05bc
Level of significance	NS	*	NS	*	*	*	*	*	*	*	*	**
CV%	10.25	5.20	7.80	6.8	5.40	3.57	9.89	6.77	8.50	9.20	4.30	5.50

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

T_1= Control (open field), T_2= Black siris, T_3= Guava, T_4= Mango trees

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Appendix XIX. Effect of trees on yield and yield contributing characters of wheat varieties in 2006-07 and 2007-08

Trees	No. of spikes hill		Length of spike hill^{-1}		No. of grains hill $^{-1}$		Grain wt.(g hill^{-1})		1000grain-weight(g)		Grain yield (t ha^{-1})	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
T_1	3.34	3.35a	10.35	10.22 a	124.62a	128.90 a	5.61 a	5.65 a	45.07 a	43.83 a	2.92a	2.94 a
T_2	3.24	3.11a	10.00	9.90 b	110.99b	105.70 b	4.69 b	4.50 b	42.27 b	42.50 a	2.45b	2.34b
T_3	3.21	1.81c	9. 78	9.74 b	108.01c	77.90 c	4.47 b	2.94 c	41.46 b	37.70 b	2.32b	1.52 c
T_4	3.30	2.74b	10.17	9.75 b	111.43b	90.90 b	4.77 b	3.94 b	42.85 b	42.30 a	2.48b	2.05bc
Level of significance	NS	*	NS	*	*	*	*	*	*	*	*	**
CV%	10.25	5.20	7.80	6.8	5.40	3.57	9.89	6.77	8.50	9.20	4.30	5.50

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

T_1= Control (open field), T_2= Black siris, T_3= Guava, T_4= Mango trees

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Appendix XX. Effect of varieties on yield and yield contributing characters of wheat varieties in 2006-07 and 2007-08

Varieties	No. of spikes $^{-1}$hill		Length of spike hill^{-1}		No. of grain/hill		Grain wt. (g) hill^{-1}		1000 grain- weight(g)		Grain yield (t ha^{-1})	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
V_1	3.29ab	2.25b	10.35a	10.33a	113.30b	98. 27 b	4.46b	4.10 ab	44.19b	44.15 b	2.76ab	2.66
V_2	3.04b	1.93c	10.02b	10.32a	115.19b	101.02 b	3.38c	3.00b	42.11c	42.00 c	2.67b	2.32
V_3	3.47a	2.86a	10.60ab	10.54a	125.86a	110.23 a	4.788a	4.42 a	46.09a	45.89 a	2.88a	2..80
V_4	3.27ab	2.24b	9.64c	9.42b	111.20b	98.77 b	3.76cb	3.15b	41.94c	41.43 c	2.53c	2.23
V_5	3.28ab	1.61d	9.60c	9.41b	103.25c	87.38 c	3.61d	3.21b	40.22d	40.00 d	2.44c	2.33
Level of significance	*	**	**	**	**	**	**	*	**		**	NS
CV%	10.25	5.20	7.80	6.8	5.40	3.57	9.89	6.77	8.50	9.20	4.30	5.50

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

V_1=Gourove, V_2= Sourave, V_3= Shatabdi , V_4= Kanchan, V_5= Protiva

* =Significant at 5% level of probability,

**=Significant at 1% level of probability.

Appendix XX. Effect of varieties on yield and yield contributing characters of wheat varieties in 2006-07 and 2007-08

Varieties	No. of spikes $^{-1}$hill		Length of spike hill^{-1}		No. of grain/hill		Grain wt. (g) hill^{-1}		1000 grain- weight(g)		Grain yield (t ha^{-1})	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
V_1	3.29ab	2.25b	10.35a	10.33a	113.30b	98. 27 b	4.46b	4.10 ab	44.19b	44.15 b	2.76ab	2.66
V_2	3.04b	1.93c	10.02b	10.32a	115.19b	101.02 b	3.38c	3.00b	42.11c	42.00 c	2.67b	2.32
V_3	3.47a	2.86a	10.60ab	10.54a	125.86a	110.23 a	4.788a	4.42 a	46.09a	45.89 a	2.88a	2..80
V_4	3.27ab	2.24b	9.64c	9.42b	111.20b	98.77 b	3.76cb	3.15b	41.94c	41.43 c	2.53c	2.23
V_5	3.28ab	1.61d	9.60c	9.41b	103.25c	87.38 c	3.61d	3.21b	40.22d	40.00 d	2.44c	2.33
Level of significance	*	**	**	**	**	**	**	*	**		**	NS
CV%	10.25	5.20	7.80	6.8	5.40	3.57	9.89	6.77	8.50	9.20	4.30	5.50

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

V_1=Gourove, V_2= Sourave, V_3= Shatabdi , V_4= Kanchan, V_5= Protiva

* =Significant at 5% level of probability,

**=Significant at 1% level of probability.

Appendix XX. Effect of varieties on yield and yield contributing characters of wheat varieties in 2006-07 and 2007-08

Varieties	No. of spikes $^{-1}$hill		Length of spike hill^{-1}		No. of grain/hill		Grain wt. (g) hill^{-1}		1000 grain- weight(g)		Grain yield (t ha^{-1})	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
V_1	3.29ab	2.25b	10.35a	10.33a	113.30b	98. 27 b	4.46b	4.10 ab	44.19b	44.15 b	2.76ab	2.66
V_2	3.04b	1.93c	10.02b	10.32a	115.19b	101.02 b	3.38c	3.00b	42.11c	42.00 c	2.67b	2.32
V_3	3.47a	2.86a	10.60ab	10.54a	125.86a	110.23 a	4.788a	4.42 a	46.09a	45.89 a	2.88a	2..80
V_4	3.27ab	2.24b	9.64c	9.42b	111.20b	98.77 b	3.76cb	3.15b	41.94c	41.43 c	2.53c	2.23
V_5	3.28ab	1.61d	9.60c	9.41b	103.25c	87.38 c	3.61d	3.21b	40.22d	40.00 d	2.44c	2.33
Level of significance	*	**	**	**	**	**	**	*	**		**	NS
CV%	10.25	5.20	7.80	6.8	5.40	3.57	9.89	6.77	8.50	9.20	4.30	5.50

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per DMRT.

Where,

V_1=Gourove, V_2= Sourave, V_3= Shatabdi , V_4= Kanchan, V_5= Protiva

* =Significant at 5% level of probability,

**=Significant at 1% level of probability.

Appendix XXI. Effect of trees on grain yield, biological yield & harvest index in 2006-07 and 2007-08

Trees	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest Index (%)	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
T_1	2.92	2.94	4.67 a	4.75 a	7.59	7.69 a	38.47	38.23 a
T_2	2.45	2.34	4.04 b	3.86 b	6.49	6.20 b	37.75	37.74 b
T_3	2.32	1.52	3.95 b	2.76 c	6.27	4.28 bc	37.00	35.50 c
T_4	2.48	2.05	4.10 b	3.41 bc	6.58	5.46 bc	37.68	37.54 b
Level of significance	*	**	*	**	NS	*	NS	*
CV%	4.30	5.50	6.89	5.52	9.34	5.56	8.37	5.34

Appendix XXI. Effect of trees on grain yield, biological yield & harvest index in 2006-07 and 2007-08

Trees	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest Index (%)	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
T_1	2.92	2.94	4.67 a	4.75 a	7.59	7.69 a	38.47	38.23 a
T_2	2.45	2.34	4.04 b	3.86 b	6.49	6.20 b	37.75	37.74 b
T_3	2.32	1.52	3.95 b	2.76 c	6.27	4.28 bc	37.00	35.50 c
T_4	2.48	2.05	4.10 b	3.41 bc	6.58	5.46 bc	37.68	37.54 b
Level of significance	*	**	*	**	NS	*	NS	*
CV%	4.30	5.50	6.89	5.52	9.34	5.56	8.37	5.34

Appendix XXI. Effect of trees on grain yield, biological yield & harvest index in 2006-07 and 2007-08

Trees	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest Index (%)	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
T_1	2.92	2.94	4.67 a	4.75 a	7.59	7.69 a	38.47	38.23 a
T_2	2.45	2.34	4.04 b	3.86 b	6.49	6.20 b	37.75	37.74 b
T_3	2.32	1.52	3.95 b	2.76 c	6.27	4.28 bc	37.00	35.50 c
T_4	2.48	2.05	4.10 b	3.41 bc	6.58	5.46 bc	37.68	37.54 b
Level of significance	*	**	*	**	NS	*	NS	*
CV%	4.30	5.50	6.89	5.52	9.34	5.56	8.37	5.34

Appendix XXII. Effect of tree on plant height, number of pod/plant, pod length, seed/pod and 1000 seed weight of mungbean in 2007 and 2008

Treatment	Plant height (cm)		Number of pod plant^{-1}		Pod length (cm)		Seed pod^{-1}		1000 seed wt (g)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1	63.48 d	69.74 a	8.841 a	6.24 a	6.321 b	6.13 a	11.43 a	10.85 a	32.99 a	32.63 a
T_2	64.98 c	71.49 a	8.33 b	6.26 a	6.38 ab	6.24 a	10.74 b	10.10 b	31.71 b	31.77 ab
T_3	66.79 a	60.4 b	7.31 c	5.74 b	6.27 b	5.74 b	9.23 c	8.71 c	29.34 c	28.27 c
T_4	66.01 b	68.94 a	8.31 b	6.13 a	6.48 a	6.26 a	10.58 b	10.05 b	32.01 b	31.52 b
level of significance	**	*	**	**	*	**	**	**	**	**
CV%	0.42	0.30	7.32	7.50	2.83	4.60	4.48	5.14	2.95	3.57

Appendix XXII. Effect of tree on plant height, number of pod/plant, pod length, seed/pod and 1000 seed weight of mungbean in 2007 and 2008

Treatment	Plant height (cm)		Number of pod plant^{-1}		Pod length (cm)		Seed pod^{-1}		1000 seed wt (g)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1	63.48 d	69.74 a	8.841 a	6.24 a	6.321 b	6.13 a	11.43 a	10.85 a	32.99 a	32.63 a
T_2	64.98 c	71.49 a	8.33 b	6.26 a	6.38 ab	6.24 a	10.74 b	10.10 b	31.71 b	31.77 ab
T_3	66.79 a	60.4 b	7.31 c	5.74 b	6.27 b	5.74 b	9.23 c	8.71 c	29.34 c	28.27 c
T_4	66.01 b	68.94 a	8.31 b	6.13 a	6.48 a	6.26 a	10.58 b	10.05 b	32.01 b	31.52 b
level of significance	**	*	**	**	*	**	**	**	**	**
CV%	0.42	0.30	7.32	7.50	2.83	4.60	4.48	5.14	2.95	3.57

Appendix XXII. Effect of tree on plant height, number of pod/plant, pod length, seed/pod and 1000 seed weight of mungbean in 2007 and 2008

Treatment	Plant height (cm)		Number of pod plant^{-1}		Pod length (cm)		Seed pod^{-1}		1000 seed wt (g)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
T_1	63.48 d	69.74 a	8.841 a	6.24 a	6.321 b	6.13 a	11.43 a	10.85 a	32.99 a	32.63 a
T_2	64.98 c	71.49 a	8.33 b	6.26 a	6.38 ab	6.24 a	10.74 b	10.10 b	31.71 b	31.77 ab
T_3	66.79 a	60.4 b	7.31 c	5.74 b	6.27 b	5.74 b	9.23 c	8.71 c	29.34 c	28.27 c
T_4	66.01 b	68.94 a	8.31 b	6.13 a	6.48 a	6.26 a	10.58 b	10.05 b	32.01 b	31.52 b
level of significance	**	*	**	**	*	**	**	**	**	**
CV%	0.42	0.30	7.32	7.50	2.83	4.60	4.48	5.14	2.95	3.57

Appendix XXIII. Effect of variety on plant height, number of pod/plant, pod length, seed/pod and 1000 seed weight of mungbean in 2007 and 2008

Variety	Plant height (cm)		Number of pod plant^{-1}		Pod length (cm)		Seed pod^{-1}		1000 seed wt (g)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
V_1	62.91 d	67.19 d	7.02 c	6.47 c	6.39 c	6.18 c	10.04 c	9.59 d	24.35 d	24.02 d
V_2	69.68 a	72.82 a	9.02 b	8.53 b	6.59 b	6.32 bc	10.77 bc	10.30 c	28.01 c	27.58 c
V_3	65.40 c	69.96 c	10.32 a	9.83 a	6.82 a	6.53 ab	11.52 ab	10.79 b	37.88 b	37.58 b
V_4	67.28 b	70.89 b	10.51 a	9.67 a	6.913 a	6.58 a	12.18 a	11.46 a	48.24 a	47.49 a
V_5	61.29 e	66.09 e	4.11 d	3.42 d	5.10 d	4.85 d	7.958 d	7.50 e	19.08 e	18.58 e
level of significance	**	**	**	**	*	**	**	**	**	**
CV%	0.42	0.30	7.32	7.50	2.83	4.60	4.48	5.14	2.95	3.57

Appendix XXIII. Effect of variety on plant height, number of pod/plant, pod length, seed/pod and 1000 seed weight of mungbean in 2007 and 2008

Variety	Plant height (cm)		Number of pod plant^{-1}		Pod length (cm)		Seed pod^{-1}		1000 seed wt (g)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
V_1	62.91 d	67.19 d	7.02 c	6.47 c	6.39 c	6.18 c	10.04 c	9.59 d	24.35 d	24.02 d
V_2	69.68 a	72.82 a	9.02 b	8.53 b	6.59 b	6.32 bc	10.77 bc	10.30 c	28.01 c	27.58 c
V_3	65.40 c	69.96 c	10.32 a	9.83 a	6.82 a	6.53 ab	11.52 ab	10.79 b	37.88 b	37.58 b
V_4	67.28 b	70.89 b	10.51 a	9.67 a	6.913 a	6.58 a	12.18 a	11.46 a	48.24 a	47.49 a
V_5	61.29 e	66.09 e	4.11 d	3.42 d	5.10 d	4.85 d	7.958 d	7.50 e	19.08 e	18.58 e
level of significance	**	**	**	**	*	**	**	**	**	**
CV%	0.42	0.30	7.32	7.50	2.83	4.60	4.48	5.14	2.95	3.57

Appendix XXIII. Effect of variety on plant height, number of pod/plant, pod length, seed/pod and 1000 seed weight of mungbean in 2007 and 2008

Variety	Plant height (cm)		Number of pod plant^{-1}		Pod length (cm)		Seed pod^{-1}		1000 seed wt (g)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
V_1	62.91 d	67.19 d	7.02 c	6.47 c	6.39 c	6.18 c	10.04 c	9.59 d	24.35 d	24.02 d
V_2	69.68 a	72.82 a	9.02 b	8.53 b	6.59 b	6.32 bc	10.77 bc	10.30 c	28.01 c	27.58 c
V_3	65.40 c	69.96 c	10.32 a	9.83 a	6.82 a	6.53 ab	11.52 ab	10.79 b	37.88 b	37.58 b
V_4	67.28 b	70.89 b	10.51 a	9.67 a	6.913 a	6.58 a	12.18 a	11.46 a	48.24 a	47.49 a
V_5	61.29 e	66.09 e	4.11 d	3.42 d	5.10 d	4.85 d	7.958 d	7.50 e	19.08 e	18.58 e
level of significance	**	**	**	**	*	**	**	**	**	**
CV%	0.42	0.30	7.32	7.50	2.83	4.60	4.48	5.14	2.95	3.57

Appendix XXIV. Effect of tree on grain yield, incorporated fresh weight, biological yield and harvest index of mungbean in 2007 and 2008

Treatment	**Grain yield (t/ha)**		**Incorporated fresh weight ($t\ ha^{-1}$)**		**Biological yield ($t\ ha^{-1}$)**		**Harvest index %**	
	2007	2008	2007	2008	2007	2008	2007	2008
T_1	1.08	1.20	6.24	7.2	7.33	8.4	14.8	14.28
T_2	1.04	1.02	6.13	6.5	7.17	7.52	14.5	13.56
T_3	0.8	0.52	5.90	5.5	6.7	6.02	11.94	8.63
T_4	1.02	0.71	6.0	6.0	7.02	6.71	14.52	10.58
level of significance	*	**	*	*				
CV%	6.56	4.28	8.90	7.26				

Appendix XXIV. Effect of tree on grain yield, incorporated fresh weight, biological yield and harvest index of mungbean in 2007 and 2008

Treatment	**Grain yield (t/ha)**		**Incorporated fresh weight ($t\ ha^{-1}$)**		**Biological yield ($t\ ha^{-1}$)**		**Harvest index %**	
	2007	2008	2007	2008	2007	2008	2007	2008
T_1	1.08	1.20	6.24	7.2	7.33	8.4	14.8	14.28
T_2	1.04	1.02	6.13	6.5	7.17	7.52	14.5	13.56
T_3	0.8	0.52	5.90	5.5	6.7	6.02	11.94	8.63
T_4	1.02	0.71	6.0	6.0	7.02	6.71	14.52	10.58
level of significance	*	**	*	*				
CV%	6.56	4.28	8.90	7.26				

Appendix XXIV. Effect of tree on grain yield, incorporated fresh weight, biological yield and harvest index of mungbean in 2007 and 2008

Treatment	**Grain yield (t/ha)**		**Incorporated fresh weight ($t\ ha^{-1}$)**		**Biological yield ($t\ ha^{-1}$)**		**Harvest index %**	
	2007	2008	2007	2008	2007	2008	2007	2008
T_1	1.08	1.20	6.24	7.2	7.33	8.4	14.8	14.28
T_2	1.04	1.02	6.13	6.5	7.17	7.52	14.5	13.56
T_3	0.8	0.52	5.90	5.5	6.7	6.02	11.94	8.63
T_4	1.02	0.71	6.0	6.0	7.02	6.71	14.52	10.58
level of significance	*	**	*	*				
CV%	6.56	4.28	8.90	7.26				

Appendix XXV. Effect of tree on grain yield, incorporated fresh weight, biological yield and harvest index of mungbean in 2007 and 2008

Variety	**Grain yield (t/ha)**		**Incorporated fresh weight ($t\ ha^{-1}$)**		**Biological yield ($t\ ha^{-1}$)**		**Harvest index %**	
	2007	2008	2007	2008	2007	2008	2007	2008
V_1	0.85	0.90	6.11	7.56	6.96	8.46	12.21	10.65
V_2	0.91	1.02	8.2	8.45	9.11	9.47	9.98	10.77
V_3	1.25	1.36	6.24	6.90	7.49	8.26	16.68	16.46
V_4	1.34	1.45	6.91	7.22	8.25	8.67	16.24	16.72
V_5	0.52	0.56	4.2	4.33	4.72	4.98	11.06	11.24
level of significance	*	**	*	*				
CV%	6.56	4.28	8.90	7.26				

Appendix XXV. Effect of tree on grain yield, incorporated fresh weight, biological yield and harvest index of mungbean in 2007 and 2008

Variety	**Grain yield (t/ha)**		**Incorporated fresh weight ($t\ ha^{-1}$)**		**Biological yield ($t\ ha^{-1}$)**		**Harvest index %**	
	2007	2008	2007	2008	2007	2008	2007	2008
V_1	0.85	0.90	6.11	7.56	6.96	8.46	12.21	10.65
V_2	0.91	1.02	8.2	8.45	9.11	9.47	9.98	10.77
V_3	1.25	1.36	6.24	6.90	7.49	8.26	16.68	16.46
V_4	1.34	1.45	6.91	7.22	8.25	8.67	16.24	16.72
V_5	0.52	0.56	4.2	4.33	4.72	4.98	11.06	11.24
level of significance	*	**	*	*				
CV%	6.56	4.28	8.90	7.26				

Appendix XXV. Effect of tree on grain yield, incorporated fresh weight, biological yield and harvest index of mungbean in 2007 and 2008

Variety	Grain yield (t/ha)		Incorporated fresh weight (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index %	
	2007	2008	2007	2008	2007	2008	2007	2008
V_1	0.85	0.90	6.11	7.56	6.96	8.46	12.21	10.65
V_2	0.91	1.02	8.2	8.45	9.11	9.47	9.98	10.77
V_3	1.25	1.36	6.24	6.90	7.49	8.26	16.68	16.46
V_4	1.34	1.45	6.91	7.22	8.25	8.67	16.24	16.72
V_5	0.52	0.56	4.2	4.33	4.72	4.98	11.06	11.24
level of significance	*	**	*	*				
CV%	6.56	4.28	8.90	7.26				

Appendix XXVI. Periodic increment, mean annual increment and current annual increment of black siris, guava and mango as sole tree

Tree	Growth parameter	Increment during T. aman' 2005	Increment during wheat 2005-06	Increment during mung bean 2006	Increment during T. aman 2005	Increment during wheat 2006-07	Increment during mung bean 2007	MAI	CAI
Black siris	Plant hei	1.19	0.2	0.85	0.25	1.25	0.6	2.03	2.1
	Base girt	7.5	3	6.5	13.7	5.9	4.9	15	24.5
	Canopy diam	20	0	20	140	0	20	95	160
	Volume (cm^3)	1958.7	1220.14	4396.02	12392.48	13256.14	11722.35	15113.85	37370.97
Guava	Plant hei	0.25	0.1	0.2	1	0.5	0.4	0.967	1.9
	Base girt	3.9	1.5	4	7	2	3	8.53	12
	Canopy diam	20	11	64	60	60	50	114	170
	Volume (cm^3)	421.54	233	789.87	3259.98	1802.18	2525.4	3088.62	7587.56
Mango	Plant he	0.3	0.2	0.2	0.5	0.5	0	0.67	1
	Base	8.2	2	1.3	6	7	1	9.63	14
	Canopy dia	20	7.5	3.5	114	50	5	86.67	169
	Volume (cm^3)	856.7	453	424.99	2230.12	4115.37	408.72	2879.28	6754.21

Appendix XXVI. Periodic increment, mean annual increment and current annual increment of black siris, guava and mango as sole tree

Tree	Growth parameter	Increment during T. aman' 2005	Increment during wheat 2005-06	Increment during mung bean 2006	Increment during T. aman 2005	Increment during wheat 2006-07	Increment during mung bean 2007	MAI	CAI
Black siris	Plant hei	1.19	0.2	0.85	0.25	1.25	0.6	2.03	2.1
	Base girt	7.5	3	6.5	13.7	5.9	4.9	15	24.5
	Canopy diam	20	0	20	140	0	20	95	160
	Volume (cm^3)	1958.7	1220.14	4396.02	12392.48	13256.14	11722.35	15113.85	37370.97
Guava	Plant hei	0.25	0.1	0.2	1	0.5	0.4	0.967	1.9
	Base girt	3.9	1.5	4	7	2	3	8.53	12
	Canopy diam	20	11	64	60	60	50	114	170
	Volume (cm^3)	421.54	233	789.87	3259.98	1802.18	2525.4	3088.62	7587.56
Mango	Plant he	0.3	0.2	0.2	0.5	0.5	0	0.67	1
	Base	8.2	2	1.3	6	7	1	9.63	14
	Canopy dia	20	7.5	3.5	114	50	5	86.67	169
	Volume (cm^3)	856.7	453	424.99	2230.12	4115.37	408.72	2879.28	6754.21

Appendix XXVI. Periodic increment, mean annual increment and current annual increment of black siris, guava and mango as sole tree

Tree	Growth parameter	Increment during T. aman' 2005	Increment during wheat 2005-06	Increment during mung bean 2006	Increment during T. aman 2005	Increment during wheat 2006-07	Increment during mung bean 2007	MAI	CAI
Black siris	Plant hei	1.19	0.2	0.85	0.25	1.25	0.6	2.03	2.1
	Base girt	7.5	3	6.5	13.7	5.9	4.9	15	24.5
	Canopy diam	20	0	20	140	0	20	95	160
	Volume (cm^3)	1958.7	1220.14	4396.02	12392.48	13256.14	11722.35	15113.85	37370.97
Guava	Plant hei	0.25	0.1	0.2	1	0.5	0.4	0.967	1.9
	Base girt	3.9	1.5	4	7	2	3	8.53	12
	Canopy diam	20	11	64	60	60	50	114	170
	Volume (cm^3)	421.54	233	789.87	3259.98	1802.18	2525.4	3088.62	7587.56
Mango	Plant he	0.3	0.2	0.2	0.5	0.5	0	0.67	1
	Base	8.2	2	1.3	6	7	1	9.63	14
	Canopy dia	20	7.5	3.5	114	50	5	86.67	169
	Volume (cm^3)	856.7	453	424.99	2230.12	4115.37	408.72	2879.28	6754.21

Appendix XXVII. Growth of the black siris, guava and mango over time for sole cultivation during the study period

		Growth of trees							
Tree	Growth parameter	Initial	Before planting t-aman	Before sowing wheat	Before sowing mung bean	Before planting t-aman	Before sowing wheat	Before sowing mung bean	Before planting t-aman
		10/7/2005	15/7/2006	15/11/2006	25/3/2007	15/7/2007	15/11/2007	25/3/2008	15/7/2008
Black siris	Plant height (m)	1.0	2.76	3.95	4.15	5.00	5.25	6.50	7.10
	Base girth (cm)	4.0	7.5	15.0	18.0	24.5	38.2	44.1	49.0
	Canopy dia. (cm)	15	100	120	120	140	280	280	300
	Volume (cm^3)	14.67	410.39	2369.09	3589.23	7985.25	20377.73	33633.87	45356.22
Guava	Plant height (m)	1.0	1.45	1.70	1.8	2.0	3.0	3.50	3.90
	Base girth (cm)	4.4	8.6	12.5	14.0	18.0	25.0	27.0	30.0
	Canopy dia. (cm)	18	95.0	115	126	190.	250	310.0	360.0
	Volume (cm^3)	51.45	285.34	706.88	939.88	1729.75	4989.73	6791.91	9317.31
Mango	Plant height (m)	1.0	1.30	1.6	1.8	2.0	2.50	3.0	3.0
	Base girth (cm)	4.1	7.5	15.7	17.7	19.0	25.0	32.0	33.0
	Canopy dia. (cm)	20.0	80.0	100.0	107.5	111.0	225.0	275.0	280.0
	Volume (cm^3)	44.36	578.4	1050	1503	1927.99	4158.11	8273.48	8682.2

Appendix XXVII. Growth of the black siris, guava and mango over time for sole cultivation during the study period

		Growth of trees							
Tree	Growth parameter	Initial	Before planting t-aman	Before sowing wheat	Before sowing mung bean	Before planting t-aman	Before sowing wheat	Before sowing mung bean	Before planting t-aman
		10/7/2005	15/7/2006	15/11/2006	25/3/2007	15/7/2007	15/11/2007	25/3/2008	15/7/2008
Black siris	Plant height (m)	1.0	2.76	3.95	4.15	5.00	5.25	6.50	7.10
	Base girth (cm)	4.0	7.5	15.0	18.0	24.5	38.2	44.1	49.0
	Canopy dia. (cm)	15	100	120	120	140	280	280	300
	Volume (cm^3)	14.67	410.39	2369.09	3589.23	7985.25	20377.73	33633.87	45356.22
Guava	Plant height (m)	1.0	1.45	1.70	1.8	2.0	3.0	3.50	3.90
	Base girth (cm)	4.4	8.6	12.5	14.0	18.0	25.0	27.0	30.0
	Canopy dia. (cm)	18	95.0	115	126	190.	250	310.0	360.0
	Volume (cm^3)	51.45	285.34	706.88	939.88	1729.75	4989.73	6791.91	9317.31
Mango	Plant height (m)	1.0	1.30	1.6	1.8	2.0	2.50	3.0	3.0
	Base girth (cm)	4.1	7.5	15.7	17.7	19.0	25.0	32.0	33.0
	Canopy dia. (cm)	20.0	80.0	100.0	107.5	111.0	225.0	275.0	280.0
	Volume (cm^3)	44.36	578.4	1050	1503	1927.99	4158.11	8273.48	8682.2

Appendix XXVII. Growth of the black siris, guava and mango over time for sole cultivation during the study period

		Growth of trees							
Tree	**Growth parameter**	**Initial**	**Before planting t-aman**	**Before sowing wheat**	**Before sowing mung bean**	**Before planting t-aman**	**Before sowing wheat**	**Before sowing mung bean**	**Before planting t-aman**
		10/7/2005	15/7/2006	15/11/2006	25/3/2007	15/7/2007	15/11/2007	25/3/2008	15/7/2008
Black siris	Plant height (m)	1.0	2.76	3.95	4.15	5.00	5.25	6.50	7.10
	Base girth (cm)	4.0	7.5	15.0	18.0	24.5	38.2	44.1	49.0
	Canopy dia. (cm)	15	100	120	120	140	280	280	300
	Volume (cm^3)	14.67	410.39	2369.09	3589.23	7985.25	20377.73	33633.87	45356.22
Guava	Plant height (m)	1.0	1.45	1.70	1.8	2.0	3.0	3.50	3.90
	Base girth (cm)	4.4	8.6	12.5	14.0	18.0	25.0	27.0	30.0
	Canopy dia. (cm)	18	95.0	115	126	190.	250	310.0	360.0
	Volume (cm^3)	51.45	285.34	706.88	939.88	1729.75	4989.73	6791.91	9317.31
Mango	Plant height (m)	1.0	1.30	1.6	1.8	2.0	2.50	3.0	3.0
	Base girth (cm)	4.1	7.5	15.7	17.7	19.0	25.0	32.0	33.0
	Canopy dia. (cm)	20.0	80.0	100.0	107.5	111.0	225.0	275.0	280.0
	Volume (cm^3)	44.36	578.4	1050	1503	1927.99	4158.11	8273.48	8682.2

Appendix XXIX. Cost of Production of T. aman per ha of land

A. Input cost:

a. Non material cost

Sl No.	Operation	Animal mechanical[-1] power	Man power @ 70 Tk/day	Total Tk
1.	Seedbed preparation for raising seedlings	200 Tk	5	550
2.	Seed sowing and care of seedbed		5	350
3.	Seedling uprooting & carrying		10	700
4.	Land (main field) preparation, plowing, cross plowing, leveling etc	2000 Tk	30	4100
5.	Ail dressing, plastering, weed uprooting, cleaning, spading of corner & fert. Application (basal)		15	1050
6.	Transplanting		30	2100
7.	Pesticide application (spraying)		2	140
8.	Weeding		30	2100
9.	Rouging		1	70
10.	Harvesting & carrying		40	2800
11.	Threshing & cleaning, drying		20	1400
12.	Straw drying & heaping		10	700
	Total		198	16060

Appendix XXIX. Cost of Production of T. aman per ha of land

A. Input cost:

a. Non material cost

Sl No.	Operation	Animal mechanical[-1] power	Man power @ 70 Tk/day	Total Tk
1.	Seedbed preparation for raising seedlings	200 Tk	5	550
2.	Seed sowing and care of seedbed		5	350
3.	Seedling uprooting & carrying		10	700
4.	Land (main field) preparation, plowing, cross plowing, leveling etc	2000 Tk	30	4100
5.	Ail dressing, plastering, weed uprooting, cleaning, spading of corner & fert. Application (basal)		15	1050
6.	Transplanting		30	2100
7.	Pesticide application (spraying)		2	140
8.	Weeding		30	2100
9.	Rouging		1	70
10.	Harvesting & carrying		40	2800
11.	Threshing & cleaning, drying		20	1400
12.	Straw drying & heaping		10	700
	Total		198	16060

Appendix XXIX. Cost of Production of T. aman per ha of land

A. Input cost:

a. Non material cost

Sl No.	Operation	Animal mechanical[-1] power	Man power @ 70 Tk/day	Total Tk
1.	Seedbed preparation for raising seedlings	200 Tk	5	550
2.	Seed sowing and care of seedbed		5	350
3.	Seedling uprooting & carrying		10	700
4.	Land (main field) preparation, plowing, cross plowing, leveling etc	2000 Tk	30	4100
5.	Ail dressing, plastering, weed uprooting, cleaning, spading of corner & fert. Application (basal)		15	1050
6.	Transplanting		30	2100
7.	Pesticide application (spraying)		2	140
8.	Weeding		30	2100
9.	Rouging		1	70
10.	Harvesting & carrying		40	2800
11.	Threshing & cleaning, drying		20	1400
12.	Straw drying & heaping		10	700
	Total		198	16060

b. Material cost

Sl no.	Expenditure	Amount (kg)	Price Tk/kg	Total cost Tk
1.	Seed	30	18	540
2.	Fertilizer			
	Urea	225	6	1350
	TSP	15	18	270
	MP	70	14	980
	Gypsum	20	6	120
	Dollochone	500	5	2500
3.	Pesticide			500
4.	Unforseen cost			500
			Total	6760

Input cost = 16060 +6760 = 22820 Tk

B. Fixed cost:

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 6 months @ 10 Tk	1141
2.	If the land given lease for 6 months @ 1000 Tk/bigha	7450
3.	Miscellaneous cost (5% of input cost)	1231.5
	Total	9822.5

Total cost of production of T. aman = 22820+9822.5= 32642.5 Tk

b. Material cost

Sl no.	Expenditure	Amount (kg)	Price Tk/kg	Total cost Tk
1.	Seed	30	18	540
2.	Fertilizer			
	Urea	225	6	1350
	TSP	15	18	270
	MP	70	14	980
	Gypsum	20	6	120
	Dollochone	500	5	2500
3.	Pesticide			500
4.	Unforseen cost			500
			Total	6760

Input cost = 16060 +6760 = 22820 Tk

B. Fixed cost:

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 6 months @ 10 Tk	1141
2.	If the land given lease for 6 months @ 1000 Tk/bigha	7450
3.	Miscellaneous cost (5% of input cost)	1231.5
	Total	9822.5

Total cost of production of T. aman = 22820+9822.5= 32642.5 Tk

b. Material cost

Sl no.	Expenditure	Amount (kg)	Price Tk/kg	Total cost Tk
1.	Seed	30	18	540
2.	Fertilizer			
	Urea	225	6	1350
	TSP	15	18	270
	MP	70	14	980
	Gypsum	20	6	120
	Dollochone	500	5	2500
3.	Pesticide			500
4.	Unforseen cost			500
			Total	6760

Input cost = 16060 +6760 = 22820 Tk

B. Fixed cost:

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 6 months @ 10 Tk	1141
2.	If the land given lease for 6 months @ 1000 Tk/bigha	7450
3.	Miscellaneous cost (5% of input cost)	1231.5
	Total	9822.5

Total cost of production of T. aman = 22820+9822.5= 32642.5 Tk

Appendix XXX. Cost of Production of Wheat per ha of land

A. Input cost

1. Non material cost

Sl no.	Name of the operation	Power tiller	Man power @ 70 Tk day^{-1}	Total cost Tk
1.	Land preparation	2000 Tk	40	4800
2.	Carrying & application of fertilizer and manures (basal application)		4	280
3.	Seed treatment & sowing of seed in line		8	560
4.	Drive away of birds/ birds flying (5 days)		5	350
5.	Weeding (2 times)		16	1120
6.	Top dressing of urea & pesticide application		3	210
7.	Irrigation (2 times)		4	280
8.	Crop harvesting 7 carrying		35	2450
9.	Threshing, Drying, cleaning		35	2450
10.	Dying of straw & prepared of pala		10	700
	Total		160	13200

2. Material cost

Sl no.	Input	Amount kg/ha	Price Tk/kg	Value Tk
1.	Seed (If grain 80%)	125	20	2500
2.	Urea	300	6	1800
	TSP	30	18	5400
	MP	140	14	1960
	Gypsum	35	6	210
	Pesticide			800
	Irrigation water (2 times)	15 lt/ha @ 60Tk/lt		1800
			Total	14470

Appendix XXX. Cost of Production of Wheat per ha of land

A. Input cost

1. Non material cost

Sl no.	Name of the operation	Power tiller	Man power @ 70 Tk day^{-1}	Total cost Tk
1.	Land preparation	2000 Tk	40	4800
2.	Carrying & application of fertilizer and manures (basal application)		4	280
3.	Seed treatment & sowing of seed in line		8	560
4.	Drive away of birds/ birds flying (5 days)		5	350
5.	Weeding (2 times)		16	1120
6.	Top dressing of urea & pesticide application		3	210
7.	Irrigation (2 times)		4	280
8.	Crop harvesting 7 carrying		35	2450
9.	Threshing, Drying, cleaning		35	2450
10.	Dying of straw & prepared of pala		10	700
	Total		160	13200

2. Material cost

Sl no.	Input	Amount kg/ha	Price Tk/kg	Value Tk
1.	Seed (If grain 80%)	125	20	2500
2.	Urea	300	6	1800
	TSP	30	18	5400
	MP	140	14	1960
	Gypsum	35	6	210
	Pesticide			800
	Irrigation water (2 times)	15 lt/ha @ 60Tk/lt		1800
			Total	14470

Appendix XXX. Cost of Production of Wheat per ha of land

A. Input cost

1. Non material cost

Sl no.	Name of the operation	Power tiller	Man power @ 70 Tk day^{-1}	Total cost Tk
1.	Land preparation	2000 Tk	40	4800
2.	Carrying & application of fertilizer and manures (basal application)		4	280
3.	Seed treatment & sowing of seed in line		8	560
4.	Drive away of birds/ birds flying (5 days)		5	350
5.	Weeding (2 times)		16	1120
6.	Top dressing of urea & pesticide application		3	210
7.	Irrigation (2 times)		4	280
8.	Crop harvesting 7 carrying		35	2450
9.	Threshing, Drying, cleaning		35	2450
10.	Dying of straw & prepared of pala		10	700
	Total		160	13200

2. Material cost

Sl no.	Input	Amount kg/ha	Price Tk/kg	Value Tk
1.	Seed (If grain 80%)	125	20	2500
2.	Urea	300	6	1800
	TSP	30	18	5400
	MP	140	14	1960
	Gypsum	35	6	210
	Pesticide			800
	Irrigation water (2 times)	15 lt/ha @ 60Tk/lt		1800
			Total	14470

Total input cost = 13200+ 14470 = 27670 Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 4 months @ Tk 10	922.33
2.	Interest on land value (Tk 1000000) @ Tk 10 for 4 months/ lease value	3333.33
3.	Miscellaneous cost 5% of total input cost)	1383.5
	Total	5639.13

Total cost of production of wheat = 27670 + 5639= 33309 Tk

Appendix XXXI. Cost of Production of Mungbean per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Seed	30	100	3000
2.	Fertilizer			
	Urea	45	6	270
	TSP	28	18	504
	MP	56	14	784
	Gypsum	44	6	264
3.	Unforseen cost			1000
			Total	5822

Total input cost = 13200+ 14470 = 27670 Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 4 months @ Tk 10	922.33
2.	Interest on land value (Tk 1000000) @ Tk 10 for 4 months/ lease value	3333.33
3.	Miscellaneous cost 5% of total input cost)	1383.5
	Total	5639.13

Total cost of production of wheat = 27670 + 5639= 33309 Tk

Appendix XXXI. Cost of Production of Mungbean per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Seed	30	100	3000
2.	Fertilizer			
	Urea	45	6	270
	TSP	28	18	504
	MP	56	14	784
	Gypsum	44	6	264
3.	Unforseen cost			1000
			Total	5822

Total input cost = 13200+ 14470 = 27670 Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 4 months @ Tk 10	922.33
2.	Interest on land value (Tk 1000000) @ Tk 10 for 4 months/ lease value	3333.33
3.	Miscellaneous cost 5% of total input cost)	1383.5
	Total	5639.13

Total cost of production of wheat = 27670 + 5639= 33309 Tk

Appendix XXXI. Cost of Production of Mungbean per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Seed	30	100	3000
2.	Fertilizer			
	Urea	45	6	270
	TSP	28	18	504
	MP	56	14	784
	Gypsum	44	6	264
3.	Unforseen cost			1000
			Total	5822

b. Non material cost

Sl no.	Operation	Power tiller	Man power @ 70 Tk/ha	Total cost Tk
1.	Land preparation	2000 Tk	40	4800
2.	Ail dressing, removal of uprooted weeds and debris and fertilizer application		15	1050
3.	Sowing of seed in line		15	1050
4.	Weeding (2 times)		40	2800
5.	Harvesting & carrying		30	2100
6.	Threshing, cleaning, drying, weighing		30	2100
	Total		173	13900

Total input cost = 5822 + 13900 = 19722 Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 2 months @ Tk 10	328.7
	Interest on land value (Tk 1000000) @ Tk 10 for 2 months/ lease value	1666.67
	Miscellanious cost (5% on input cost)	986.1
	Total	2981.47

Total cost of production of mungbean = 19722 + 2981= 22703Tk

b. Non material cost

Sl no.	Operation	Power tiller	Man power @ 70 Tk/ha	Total cost Tk
1.	Land preparation	2000 Tk	40	4800
2.	Ail dressing, removal of uprooted weeds and debris and fertilizer application		15	1050
3.	Sowing of seed in line		15	1050
4.	Weeding (2 times)		40	2800
5.	Harvesting & carrying		30	2100
6.	Threshing, cleaning, drying, weighing		30	2100
	Total		173	13900

Total input cost = 5822 + 13900 = 19722 Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 2 months @ Tk 10	328.7
	Interest on land value (Tk 1000000) @ Tk 10 for 2 months/ lease value	1666.67
	Miscellanious cost (5% on input cost)	986.1
	Total	2981.47

Total cost of production of mungbean = 19722 + 2981= 22703Tk

b. Non material cost

Sl no.	Operation	Power tiller	Man power @ 70 Tk/ha	Total cost Tk
1.	Land preparation	2000 Tk	40	4800
2.	Ail dressing, removal of uprooted weeds and debris and fertilizer application		15	1050
3.	Sowing of seed in line		15	1050
4.	Weeding (2 times)		40	2800
5.	Harvesting & carrying		30	2100
6.	Threshing, cleaning, drying, weighing		30	2100
	Total		173	13900

Total input cost = 5822 + 13900 = 19722 Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 2 months @ Tk 10	328.7
	Interest on land value (Tk 1000000) @ Tk 10 for 2 months/ lease value	1666.67
	Miscellanious cost (5% on input cost)	986.1
	Total	2981.47

Total cost of production of mungbean = 19722 + 2981= 22703Tk

Appendix XXXII.Cost of Production of Banana per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Sucker	1111	5	5555
2.	Fertilizer			
	Urea	555.5 kg	6	3333
	TSP	555.5 kg	18	9999
	MP	111.1 kg	14	1555.4
	Cowdung	5555 kg	0.5	2777.5
3.	Unforseen cost			2222
			Total	25441.9

b. Non material cost

Sl no.	Operation	Man power @ 70 Tk/ha	Total cost Tk
1.	Pit preparation	40	4800
2.	Soil preparation with basal dose of fertilizer and refilling the pit	20	1400
3.	Planting of sucker	10	700
4.	Weeding and fertilizing (2 times)	40	2800
5.	Harvesting & carrying	30	2100
		Total	11800

Total input cost = 25442 + 11800 = 37242Tk

Appendix XXXII.Cost of Production of Banana per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Sucker	1111	5	5555
2.	Fertilizer			
	Urea	555.5 kg	6	3333
	TSP	555.5 kg	18	9999
	MP	111.1 kg	14	1555.4
	Cowdung	5555 kg	0.5	2777.5
3.	Unforseen cost			2222
			Total	25441.9

b. Non material cost

Sl no.	Operation	Man power @ 70 Tk/ha	Total cost Tk
1.	Pit preparation	40	4800
2.	Soil preparation with basal dose of fertilizer and refilling the pit	20	1400
3.	Planting of sucker	10	700
4.	Weeding and fertilizing (2 times)	40	2800
5.	Harvesting & carrying	30	2100
		Total	11800

Total input cost = 25442 + 11800 = 37242Tk

Appendix XXXII.Cost of Production of Banana per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Sucker	1111	5	5555
2.	Fertilizer			
	Urea	555.5 kg	6	3333
	TSP	555.5 kg	18	9999
	MP	111.1 kg	14	1555.4
	Cowdung	5555 kg	0.5	2777.5
3.	Unforseen cost			2222
			Total	25441.9

b. Non material cost

Sl no.	Operation	Man power @ 70 Tk/ha	Total cost Tk
1.	Pit preparation	40	4800
2.	Soil preparation with basal dose of fertilizer and refilling the pit	20	1400
3.	Planting of sucker	10	700
4.	Weeding and fertilizing (2 times)	40	2800
5.	Harvesting & carrying	30	2100
		Total	11800

Total input cost = 25442 + 11800 = 37242Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 12 months @ Tk 10	3724.2
	Interest on land value (Tk 1000000) @ Tk 10 for 12 months/ lease value	10000
	Miscellaneous cost (5% on input cost)	1862.1
	Total	15586.3

Total cost of production of banana = 37242 + 15586= 52828Tk

Appendix XXXIII. Cost of Production of potato per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Seed potato	1500 kg	15	22500
2.	Fertilizer			
	Urea	330 kg	6	1980
	TSP	28 kg	18	504
	MP	45 kg	14	630
	Gypsum	70 kg	6	420
	Cowdung	8000kg	0.5	4000
3.	Pesticide cost			2000
			Total	32034

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 12 months @ Tk 10	3724.2
	Interest on land value (Tk 1000000) @ Tk 10 for 12 months/ lease value	10000
	Miscellaneous cost (5% on input cost)	1862.1
	Total	15586.3

Total cost of production of banana = 37242 + 15586= 52828Tk

Appendix XXXIII. Cost of Production of potato per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Seed potato	1500 kg	15	22500
2.	Fertilizer			
	Urea	330 kg	6	1980
	TSP	28 kg	18	504
	MP	45 kg	14	630
	Gypsum	70 kg	6	420
	Cowdung	8000kg	0.5	4000
3.	Pesticide cost			2000
			Total	32034

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 12 months @ Tk 10	3724.2
	Interest on land value (Tk 1000000) @ Tk 10 for 12 months/ lease value	10000
	Miscellaneous cost (5% on input cost)	1862.1
	Total	15586.3

Total cost of production of banana = 37242 + 15586= 52828Tk

Appendix XXXIII. Cost of Production of potato per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Seed potato	1500 kg	15	22500
2.	Fertilizer			
	Urea	330 kg	6	1980
	TSP	28 kg	18	504
	MP	45 kg	14	630
	Gypsum	70 kg	6	420
	Cowdung	8000kg	0.5	4000
3.	Pesticide cost			2000
			Total	32034

b. Non material cost

Sl no.	Operation	Power tiller	Man power @ 70 Tk ha^{-1}	Total cost Tk
1.	Land preparation	2000 Tk	40	4800
2.	Ail dressing, removal of uprooted weeds and debris and fertilizer application		15	1050
3.	Sowing of seed in line		15	1050
4.	Weeding (2 times)		40	2800
5.	Harvesting & carrying		30	2100
	Total			11800

Total input cost = 32034 + 11800 = 43834Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 4 months @ Tk 10	1461.13
2.	Interest on land value (Tk 1000000) @ Tk 10 for 4 months/ lease value	3333.33
3.	Miscellaneous cost(5% of total input cost)	2191.7
	Total	6986.16

Total cost of production of potato = 43834 + 6986= 50820Tk

b. Non material cost

Sl no.	Operation	Power tiller	Man power @ 70 Tk ha^{-1}	Total cost Tk
1.	Land preparation	2000 Tk	40	4800
2.	Ail dressing, removal of uprooted weeds and debris and fertilizer application		15	1050
3.	Sowing of seed in line		15	1050
4.	Weeding (2 times)		40	2800
5.	Harvesting & carrying		30	2100
	Total			11800

Total input cost = 32034 + 11800 = 43834Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 4 months @ Tk 10	1461.13
2.	Interest on land value (Tk 1000000) @ Tk 10 for 4 months/ lease value	3333.33
3.	Miscellaneous cost(5% of total input cost)	2191.7
	Total	6986.16

Total cost of production of potato = 43834 + 6986= 50820Tk

b. Non material cost

Sl no.	Operation	Power tiller	Man power @ 70 Tk ha^{-1}	Total cost Tk
1.	Land preparation	2000 Tk	40	4800
2.	Ail dressing, removal of uprooted weeds and debris and fertilizer application		15	1050
3.	Sowing of seed in line		15	1050
4.	Weeding (2 times)		40	2800
5.	Harvesting & carrying		30	2100
	Total			11800

Total input cost = 32034 + 11800 = 43834Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 4 months @ Tk 10	1461.13
2.	Interest on land value (Tk 1000000) @ Tk 10 for 4 months/ lease value	3333.33
3.	Miscellaneous cost(5% of total input cost)	2191.7
	Total	6986.16

Total cost of production of potato = 43834 + 6986= 50820Tk

Appendix XXXIV. Cost of Production of Onion per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Seed	7.5 kg	1200	9000
2.	Fertilizer			
	Urea	220 kg	6	1320
	TSP	40 kg	18	720
	MP	40 kg	14	560
	Gypsum	150 kg	6	900
	Cowdung	7000kg	0.5	3500
3.	Pesticide cost			1000
			Total	17000

b. Non material cost

Sl no.	Operation	Man power @ 70 Tk/ha	Total cost Tk
1.	Land preparation	30	2100
2.	Removal of uprooted weeds and fertilizer application	10	700
3.	Sowing of seed in line	15	1050
4.	Weeding (2 times)	30	2100
5.	Harvesting & carrying	30	2100
	Total		8050

Total input cost = 17000 + 8050 = 25050Tk

Appendix XXXIV. Cost of Production of Onion per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Seed	7.5 kg	1200	9000
2.	Fertilizer			
	Urea	220 kg	6	1320
	TSP	40 kg	18	720
	MP	40 kg	14	560
	Gypsum	150 kg	6	900
	Cowdung	7000kg	0.5	3500
3.	Pesticide cost			1000
			Total	17000

b. Non material cost

Sl no.	Operation	Man power @ 70 Tk/ha	Total cost Tk
1.	Land preparation	30	2100
2.	Removal of uprooted weeds and fertilizer application	10	700
3.	Sowing of seed in line	15	1050
4.	Weeding (2 times)	30	2100
5.	Harvesting & carrying	30	2100
	Total		8050

Total input cost = 17000 + 8050 = 25050Tk

Appendix XXXIV. Cost of Production of Onion per ha of land

A. Input cost

a. Material cost

Sl no.	Inputs	Amount of inputs	Price Tk	Total cost Tk
1.	Seed	7.5 kg	1200	9000
2.	Fertilizer			
	Urea	220 kg	6	1320
	TSP	40 kg	18	720
	MP	40 kg	14	560
	Gypsum	150 kg	6	900
	Cowdung	7000kg	0.5	3500
3.	Pesticide cost			1000
			Total	17000

b. Non material cost

Sl no.	Operation	Man power @ 70 Tk/ha	Total cost Tk
1.	Land preparation	30	2100
2.	Removal of uprooted weeds and fertilizer application	10	700
3.	Sowing of seed in line	15	1050
4.	Weeding (2 times)	30	2100
5.	Harvesting & carrying	30	2100
	Total		8050

Total input cost = 17000 + 8050 = 25050Tk

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 3 months @ Tk 10	626.25
2.	Interest on land value (Tk 1000000) @ Tk 10 for 3 months/ lease value	2500
3.	Miscellaneous cost (5% of total input cost)	1252.5
	Total	4378.75

Total cost of production of onion = 25050 +4379 = 29429Tk

Appendix XXV. Cost of Production for establishment of MPTS per ha of land

a. Material cost

Sl no.	Sapling	No. of sapling	Price Tk	Sapling cost Tk	Fertilizer cost	Pit preparation and planting cost	Total cost
1.	Black siris	1111	10	11110	11110	6900	30241
2.	Guava	1111	20	22220	11110	6900	41361
3.	Mango	1111	50	55550	11110	6900	74721
4.	Gora neem	1111	10	11110	11110	6900	30241
5.	Ipil-ipil	1111	10	11110	11110	6900	30241

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 3 months @ Tk 10	626.25
2.	Interest on land value (Tk 1000000) @ Tk 10 for 3 months/ lease value	2500
3.	Miscellaneous cost (5% of total input cost)	1252.5
	Total	4378.75

Total cost of production of onion = 25050 +4379 = 29429Tk

Appendix XXV. Cost of Production for establishment of MPTS per ha of land

a. Material cost

Sl no.	Sapling	No. of sapling	Price Tk	Sapling cost Tk	Fertilizer cost	Pit preparation and planting cost	Total cost
1.	Black siris	1111	10	11110	11110	6900	30241
2.	Guava	1111	20	22220	11110	6900	41361
3.	Mango	1111	50	55550	11110	6900	74721
4.	Gora neem	1111	10	11110	11110	6900	30241
5.	Ipil-ipil	1111	10	11110	11110	6900	30241

B. Over head cost

Sl no.	Expenditure	Cost Tk
1.	Interest on input cost for 3 months @ Tk 10	626.25
2.	Interest on land value (Tk 1000000) @ Tk 10 for 3 months/ lease value	2500
3.	Miscellaneous cost (5% of total input cost)	1252.5
	Total	4378.75

Total cost of production of onion = 25050 +4379 = 29429Tk

Appendix XXV. Cost of Production for establishment of MPTS per ha of land

a. Material cost

Sl no.	Sapling	No. of sapling	Price Tk	Sapling cost Tk	Fertilizer cost	Pit preparation and planting cost	Total cost
1.	Black siris	1111	10	11110	11110	6900	30241
2.	Guava	1111	20	22220	11110	6900	41361
3.	Mango	1111	50	55550	11110	6900	74721
4.	Gora neem	1111	10	11110	11110	6900	30241
5.	Ipil-ipil	1111	10	11110	11110	6900	30241

Appendix XXXVI. Yield table of wheat- mung bean- T. aman crop in agro-forestry (second year)

Wheat (Variety- Sotabdi)					Mung bean (Variety- BARI Mug-5)				T.Aman (Variety- BR-33)			
Sowing date-15 Nov 2005 (1st Agrahaon) Harvesting date-15 March 2006 (3rd Chaitra)					25 March- 2006 (13 Chaitra) 30 May-2006 (18 Chaitra)				15 July-2006 (2nd Srabon) 7 Oct- 2006 (24 Ashin)			
	Open field	Under Mango	Under Guava	Under Koroi	Open field	Under Mango	Under Guava	Under Koroi	Open field	Under Mango	Under Guava	Under Koroi
Yield Kg/Plot	1.8	1.75	1.65	1.6	0.68	0.65	0.5	0.64	1.7	1.5	1.45	1.3
Yield t/ha	2.88	2.8	2.64	2.56	1.088	1.04	0.8	1.02	2.72	2.4	2.25	2.08
Kg/Tree	2.5											

Appendix XXXVI. Yield table of wheat- mung bean- T. aman crop in agro-forestry (second year)

Wheat (Variety- Sotabdi)					Mung bean (Variety- BARI Mug-5)				T.Aman (Variety- BR-33)			
Sowing date-15 Nov 2005 (1st Agrahaon) Harvesting date-15 March 2006 (3rd Chaitra)					25 March- 2006 (13 Chaitra) 30 May-2006 (18 Chaitra)				15 July-2006 (2nd Srabon) 7 Oct- 2006 (24 Ashin)			
	Open field	Under Mango	Under Guava	Under Koroi	Open field	Under Mango	Under Guava	Under Koroi	Open field	Under Mango	Under Guava	Under Koroi
Yield Kg/Plot	1.8	1.75	1.65	1.6	0.68	0.65	0.5	0.64	1.7	1.5	1.45	1.3
Yield t/ha	2.88	2.8	2.64	2.56	1.088	1.04	0.8	1.02	2.72	2.4	2.25	2.08
Kg/Tree	2.5											

Appendix XXXVI. Yield table of wheat- mung bean- T. aman crop in agro-forestry (second year)

	Wheat (Variety- Sotabdi) Sowing date-15 Nov 2005 (1st Agrahaon) Harvesting date-15 March 2006 (3rd Chaitra)				Mung bean (Variety- BARI Mug-5) 25 March- 2006 (13 Chaitra) 30 May-2006 (18 Chaitra)				T.Aman (Variety- BR-33) 15 July-2006 (2nd Srabon) 7 Oct- 2006 (24 Ashin)			
	Open field	Under Mango	Under Guava	Under Koroi	Open field	Under Mango	Under Guava	Under Koroi	Open field	Under Mango	Under Guava	Under Koroi
Yield Kg/Plot	1.8	1.75	1.65	1.6	0.68	0.65	0.5	0.64	1.7	1.5	1.45	1.3
Yield t/ha	2.88	2.8	2.64	2.56	1.088	1.04	0.8	1.02	2.72	2.4	2.25	2.08
Kg/Tree	2.5											

Appendix XXXVII. Time schedule of wheat- mungbean- T. aman cropping pattern in agro-forestry

Name of crop	Name of month											
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
	Kartic/Agrahaon	Agrahaon/Poush	Poush/Magh	Magh/Falgun	Falgun/Chaita	Chaita/Baisakh	Baisakh/Jaistha	Jaistha/Ashar	Ashar/Shrabon	Shrabon/Bhadra	Bhadra/Ashin	Ashin/Kartic
	1	2	3	4	5	6	7	8	9	10	11	12
Wheat (Sotabdi)	Wheat (15 Nov- 15 March)											
Mung bean (BARI -6)						Mung bean (25 March- 31 May						
T.Aman(BR-33/39)									T.Aman (15 July- 5 Oct)			
Tree (Amrapali)	Tree (year round)											

Appendix XXXVII. Time schedule of wheat- mungbean- T. aman cropping pattern in agro-forestry

Name of crop	Name of month											
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
	Kartic/Agrahaon	Agrahaon/Poush	Poush/Magh	Magh/Falgun	Falgun/Chaita	Chaita/Baisakh	Baisakh/Jaistha	Jaistha/Ashar	Ashar/Shrabon	Shrabon/Bhadra	Bhadra/Ashin	Ashin/Kartic
	1	2	3	4	5	6	7	8	9	10	11	12
Wheat (Sotabdi)	Wheat (15 Nov- 15 March)											
Mung bean (BARI -6)						Mung bean (25 March- 31 May						
T.Aman(BR-33/39)									T.Aman (15 July- 5 Oct)			
Tree (Amrapali)	Tree (year round)											

Appendix XXXVII. Time schedule of wheat- mungbean- T. aman cropping pattern in agro-forestry

Name of crop	Name of month											
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
	Kartic/Agrahaon	Agrahaon/Poush	Poush/Magh	Magh/Falgun	Falgun/Chaita	Chaita/Baisakh	Baisakh/Jaistha	Jaistha/Ashar	Ashar/Shrabon	Shrabon/Bhadra	Bhadra/Ashin	Ashin/Kartic
	1	2	3	4	5	6	7	8	9	10	11	12
Wheat (Sotabdi)	Wheat (15 Nov- 15 March)											
Mung bean (BARI -6)						Mung bean (25 March- 31 May						
T.Aman(BR-33/39)									T.Aman (15 July- 5 Oct)			
Tree (Amrapali)	Tree (year round)											