

**PERFORMANCE OF TRANSPLANTED AMAN RICE UNDER
DIFFERENT MULTIPURPOSE TREE SPECIES AS
AGROFORESTRY SYSTEM**

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**A THESIS
BY**

**MD. HAFIZ ALL AMIN
Student No. 0605006
Session: 2006-07
Thesis Semester: January-June, 2007**

**MASTER OF SCIENCE (M.S.)
IN
AGROFORESTRY**



**DEPARTMENT OF AGROFORESTRY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
UNIVERSITY DINAJPUR**

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*Submitted to the Department of Agroforestry, Hajee Mohammad
Danesh Science and Technology University, Dinajpur in partial
fulfillment of the requirements for the degree of*

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June 2007

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DEDICATED

TO

MY BELOVED PARENTS

AND

YOUNGER BROTHER & SISTER

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At first the author expresses his gratefulness to almighty Allah, Who has helped Him in pursuit of his education in Agriculture and for giving the strength to complete of this research work,

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The author

ABSTRACT

A field experiment was conducted at the Agroforestry Farm, Department of Agroforestry, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during June 2006 to November 2006 to evaluate the performance of transplanted Aman rice grown under different multipurpose tree species at various shading condition. Five variety cv. BR10, BR11, BRRI dhan 33, BRRI dhan 39 and Sorna were cultivated under three different tree species namely, Black siris, Guava and Mango. The experiment was laid out in split plot design with four replications where tree species were in main plot and rice variety was in sub plots. The data were collected at 30, 45, 60 and 75 DAT (days after transplanting) and finally after harvesting. The significant effect of partial shade was found in number of effective tiller / hill, length of leaf blade, breadth of leaf blade and plant height at 30 DAT, plant fresh weight, straw- root fresh & dry weight, unfilled grain / panicle, 1000 grain weight and grain yield. The varietal effect was significantly observed on number of leaf / hill, length of leaf blade, breadth of leaf blade at 30 DAT, plant height & number of effective tiller / hill at 30, 45, 60 & 75 DAT, plant fresh weight, straw root fresh and dry weight, days to maturity, panicle length, number of grain / panicle, unfilled grain / panicle, 1000 grain weight and grain yield. The interaction effect was significantly found in number of leaf / hill, length of leaf blade, breadth of leaf blade at 30 DAT, plant height at 30, 45 & 75 DAT, number of effective tiller / hill at 45 DAT, plant fresh weight straw root fresh & dry weight, unfilled grain / panicle and grain yield. It was recorded that in partial shade condition the highest grain yield (3.78 t / ha) was found under Black siris which was statistically similar to that of Mango and the lowest grain yield was found (3.50 t / ha) under Guava. The highest plant height was recorded (62.90 cm) at 30 DAT under Mango which was statistically similar to that of Black siris and the lowest plant height was found under Guava at 30 DAT. The highest

unfilled grain / panicle (16.16) was found under Guava and lowest (12.79) under Mango. The highest plant fresh weight (82.43 gm) was found under Black siris which was statistically similar to that of Mango and the lowest (63.40 gm) under Guava. Regarding the varietal effect, the results showed that the highest panicle length (25.38 cm), number of grain / panicle (162.60), 1000 grain weight (21.63 gm) and grain yield (4.744 t / ha) was found in BR11, and the lowest panicle length (22.13 cm), number of grain / panicle (141.60), 1000 grain weight (17.43 gm) and grain yield (2.83 t / ha) was found in Sorna. From the interaction effect of tree-rice association the highest grain yield (4.82 t / ha) was found in Black siris & BR11 combination and the lowest grain yield (2.65 t / ha) in both Guava & Sorna and Mango & Sorna combination. Finally, it appeared that BR11 performed best in both partial shade condition and varietal effect in association with Black siris except open field.

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CHAPTER 1

INTRODUCTION

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INTRODUCTION

Agroforestry has been a collective term for land-use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land-management unit, either in a spatial mixture or a temporal sequence. The trees in agroforestry practices generally fulfill multiple purposes, involving the protection of the soil or improvement of its fertility, as well as the production of one or more products (Cooper *et al.*, 1996). The domestication of these agroforestry trees should enhance their capacity to fulfill either or both of these service or production functions. Domestication should also aim at increasing the social and economic benefits of agroforestry, through improved profitability, reduced risks and diversified sources of income to buffer against crop failure (Sanchez, 1995). This will act as an incentive for adoption by farmers.

Rice (*Oryza sativa*, L.) is the principle food of Bangladesh and it is the world's second important food grain. It belongs to the family Gramineae. It is grown worldwide on 150 million hectares (ha) with the total production of about 563 million tons of unmilled rough rice (FAO, 1999). Nearly half of the total population of the world use rice as their staple food and it is main source of calories for about 40% of the world population (Hoffman, 1991). Bangladesh is not only a rice growing country but also a rice-eating people. It is the forth-largest country in the world with respect to rice area coverage and production (IRRI, 2000). Rice is cultivated in more than 10% of the earth arable land of the world (FAO, 1999).

Rice is cultivated in Bangladesh throughout the year as Aush, Aman and Boro. Among these cropping, transplanted Aman is most important crop and it occupies about 46.30% of the rice cultivated land. Modern transplanted Aman rice are grown in upland area. Now a day, these lands are used for fruits and vegetables production as there are great shortage of vitamin and minerals.

Bangladesh is one of the most densely populated country of the world having agro based economy which situated in the North-Eastern port of south Asia with a tropical to sub-tropical climate. Now the population of Bangladesh is 14 billion in an area of 147570 sq. Kilometers. This excessive population creates pressure on the cultivated land. The available percapita land is decreasing to an alarming rate of 0.005 ha crop⁻¹ yr⁻¹. (Hossain and Bari, 1996). Each year, nearly 1.94 million peoples are added to its population of about 122 millions (FAO, 1999). Due to rapid growth of population, people migrate to forest area and are encroaching and cultivation food crops. The total forest land area of the country covers about 13.36% of the land area (BBS, 2003). However according to forest master plan and surveys by multilateral donor agencies a total of 76900 ha or 6% of the country land mass has actual tree coverage (Bangladesh state of Environmental Report 1999). But to enjoy benefit of nature, we should have at least 25% of our land covered with forest.

Crop land Agroforestry is a production technique or method that combines agricultural crops and forestry / fruit trees on a piece of land to maximize the utilization of natural resources (land, sunlight, water etc) (Chowdhary and Mahat, 1993).

In order to meet the food deficit of Bangladesh and to cope with the demand of food for the increasing population rice production need to increase. On the other hand fruit, fodder, foil, timber, timber constriction materials and raw materials requirement is a crying need. There is no scope to increase

monoculture crop command area horizontally. So combined production of rice and forest species / fruit trees (agroforestry) is the best alternative to meet the entire requirement. Before large scale production of transplanted rice under multipurpose tree species by farmer, tree- crop interaction effect must be studied from scientific point of view.

Keeping this view in mind the research has been under taken to assess the following objectives-

- i) To find out transplanted Aman rice variety suitable in the partial shading conditions under Black siris, Guava and Mango.
- ii) To characterize the growth and yield behavior of transplanted Aman rice varieties grown under Black siris, Guava and Mango.
- iii) To determine the interaction effect of trees and transplanted Aman rice varieties.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

The research was carried out to observe the performance of rice varieties under different multipurpose tree species in the different shading conditions. In recent times, the modern practices of Agroforestry are extended in the crop field in Bangladesh. The farmers are growing tree in the crop field to get maximum benefit. But tree directly influence crop's yield. Literatures directly related to this aspect are meager. Therefore, literatures some way linking to the subject of interest from home and abroad are reviewed and outlined below under the following sections.

2.1 Concepts of Agroforestry

Agroforestry is an age-old and ancient practice. It is an integral part of the traditional farming systems of Bangladesh. The concept of agroforestry probably originate from the realization that trees play an important role in protecting the long range interests of agriculture and in making agriculture economically viable. 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 areas but these practices are now considered as complementary. 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 of animal in some form of spatial arrangement or temporal sequence.

Saxena (1984) pointed out that agroforestry utilizes the inter spaces 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 use of fuel and timber from trees.

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

From a 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.

Ong (1988) reported that by 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 when mixed canopy intercepts more solar energy.

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

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 the farmers take up combination of 10-15 species of fruit, ornamental and multipurpose trees along with vegetables to meet their own or aesthetic own or aesthetic value (Rang *et al.*, 1990).

Trees are grown in the crop land, homestead, orchard not only produce food, fruits, fodder, fuel wood or to generate cash for various purpose (Chowdhury and Satter, 1993) but also gives better living environment (Haque, 1996).

The other potential benefit of agroforestry is that of the diversification of species grown on farm. Through this, and the domestication of an increasing number of tree species, it should be possible to make small-holder farming both more biologically diverse and more rewarding economically. Through the incorporation of a range of domesticated trees into different agroforestry practices within the same landscape, agroforestry can become, as recently defined (Leakey 1996).

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 has high potential to simultaneously satisfy 3 important objectives: (i) protecting and stabilizing the ecosystems (ii) producing a high level output of economic goods (fuel, fodder, small timber, organic fertilizer etc) (ii) providing stable employment, improved income and basic material to rural populations.

2.2 Tree-crop interaction

Khan and Aslam (1974) studied the effect of single sissoo (*Dalbergia sissoo*) tree on the yield of wheat crop. Yield was from plots within a quadrat of 1m². The quadrates were taken at a distance of 3m, 4.5m and 6m from the base of tree. One quadrat 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, 4.3 and 6m, respectively as compared to the open field. Both the tree and the crops were raised under irrigated condition.

Scott (1987) investigated the *Inga edulis* rows reduced rice yield 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* has a pronounced effect reducing rice yields by 50% up to 2.5m away; beyond that, yield were similar to those in rows 6m away (Palm *et al.*, 1992).

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* followed by oats. The yields decreased less than 4 years old trees compared with those under 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. Cv. 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 azadirachta* (*Azadirachta indica*), compared with the open plot yields. The PAR received under the 4 trees canopies was 90, 87, 80 and 63%, respectively of suitable for cultivation in Agroforestry system especially under *A. lebbeck*.

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

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 affected much. Results of three-year trial indicated that *Geliricida sepium* exhibited the lowest yield depression on upland rice in rows near the hedges.

Studies at ICRAF's research filed with *Leucaena lucocephala* and maize showed that total maize yields 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. 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 distances. In all the tree species, the wheat yield was reduced to a maximum on the north side of trees and had almost no effect in the southern direction.

Khan and Ehrenreich (1994) determined the influence of boundary planting of *Acacia nilotica* on the growth and yield of associated rice (*oryza sativa*) crops under irrigated condition. The results indicated that close proximity to trees adversely affected tillers m^{-2} , grains panicle⁻¹ or 1000-grain weight, but grain yield were slightly lowest near largest trees.

Shading effect can 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 (Rao and Govindarajan, 1996).

Reports of trees that are deliberately maintained in upland rice (*Oryza sativa*) fields are rare. Hocking and Islam (1995) reported the growing of trees like *Acacia nilotica*, *Acacia catechu*, and *Borassus flabellifer* in rice paddy fields

in Bangladesh. Jambulingam and Fernandes (1988) have documented the cultivation of *Acacia nilotica* trees on rice bunds (raised risers) in Tanjavur reports on the practice of maintaining *Acacia nilotica* trees in upland rice fields in the Chhattisgarh region are also available (Jena, 1991; Puri *et al.*, 1994; Viswanath *et al.*, 1998).

2.3 Importance of Light in Agroforestry

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.

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

One of the major constraints of microclimate and growth in agroforestry practice is solar radiation. Interaction among the trees and solar geometry produce the particular solar climate of a tree/corn system. These interaction and effects include interception of radiation by tree stands of various densities, effect of canopy structure, effect spacing, effect of latitude and time of year on solar paths, shade from single crowns and spectral quality of sunlight under partial shade (Reifsnyder, 1987).

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

Limiting light (Shade) is obviously the most important factor that cause 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).

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

Essentially the underlying processes involved in the partitioning of resources (e.g. light water and nutrients) are not well understood. A better mechanistic understanding of resource capture and utilization in agroforestry system is required to facilitate the development of improved systems in terms of species combinations, planting arrangement and management (Howard *et al.*, 1995).

Agroforestry system that incorporate a range of tree and crop species offer much more scope for useful management of light interception and distribution than do monoculture forests and agricultural crops (Miah, 1996).

2.4 Characteristics of Tree Species in Agroforestry Systems

Selection of Suitable tree species is vital factor in an agroforestry system. Nair (1980) considered the most choice of suitable plants species that can grown together as important factor in ensuring the sources of agroforestry. The most appropriate species for this system remains an open question for research. King (1979) listed the characteristics at tree species that should be grown with agricultural crops :

- a) They should tolerate relatively high incidence of pruning.
- b) They should have a low crown diameter to bole diameter ratio.
- c) They should be light branching in their habit.
- d) They should be tolerant of side shade.
- e) Their phylotaxie should permit penetration of the light of the ground.

- f) Their phenology, particularly with reference to leaf flushing and leaf fall, should be advantageous to growth of the annual crop in conjunction with which their being raised.
- g) The rate litter fall and litter decomposition should have positive effect on the soil.
- h) The above ground changes over time in structure and morphology should be such that retain or improve those characteristics which reduce competition for solar energy, nutrient and water.
- i) Their root systems and root growth characteristics should ideally result in exploration of soil layers that are different to those being tapped by agricultural crops.

Rachie (1983) pointed out the following factors to be considered during the selection of woody legumes for intercropping with annuals in the low land tropics:

- i) Ease of establishment from seeds or seedlings.
- ii) Rapid growth and high productivity of foliage and wood.
- iii) Limited maximum size (may be optimum in small trees).
- iv) Good coppicing ability (regrowth following topping).
- v) Effective nutrient recycling abilities especially di-nitrogenfixation.
- vi) Multiple uses: food, feed, fire wood, construction materials and other products and service (shade, shelter etc.).
- vii) Minimum competition with shallow rooted annual crops.
- viii) Small leaflets readily detached when dried and quickly decomposed when used as fertilizer.
- ix) A high proportion of leaves to secondary branches.
- x) Free from pests and diseases and
- xi) Ease of control of eventual elimination.

Purohit (1984) suggested to selecting those species which would (i) not compete for moisture, space and air (ii) supply nitrogen in the soil (iii)

provide food, fodder, fuel and timber (iv) maintain proper ecosystems (v) have no toxic effects to the crops; and (vi) have thin and erect leaves. Singh (1984) opined that suitable species should be multipurpose, well-adapted to different sites, easy to establish: have nitrogen-fixing ability, rapid growth and ability to coppice.

Hegde and MacDicken (1990) pointed out some criteria for planting trees under the agroforestry system : (i) Non-Interference with arable crops. (ii) Easy establishment (iii) Fast growth and short gestation period (iv) Non-Allelopathic effects on arable crops, (v) Ability to Atmospheric nitrogen (vi) Easy decomposition of litter (Ability to litter, (vii) Ability to withstand frequent lopping (viii) Multiple uses and high returns, and (ix) Ability to generate employment.

However, It is not possible to select having all the above mentioned criteria. Therefore, researchers should select which have most of the points and which are adapted to local soil and environmental conditions.

2.5 Performance of Crop in Agroforestry Systems

The response of different crops to the agroforestry systems was different. The performance of field crops in agroforestry systems is influenced by the tree and crop species and their compatibility, spacing between tree lines, management practices, soil and climatic factors.

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

Fifty per cent shading during ear formation and milking stage of rice decreased yield by 48% and 18%, respectively (Park and Kwon, 1975). Nayak and Murty (1980) reported that yield reduction of rice occur by 47, 57 and 74 per cent in 75, 50 and 25 per cent of normal light.

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

Yamoah *et al.* (1986) reported that maize height, stover and cob weights were reduced (though insignificantly) in maize rows close to the shrub hedgerows compared with those in the middle of the alley.

Jadhav (1987) reported that partial shading (45-50% of normal light) at 15 days after transplanting reduced grain yield of rice by 73 percent because of reduction in number of panicles per plant (51.5%), number of grain per panicle (16.7%) and increase in number of unfilled spiklets (42.1%) in 25 rice cultivars.

Chaturvedi and Ingram (1989) mentioned that pre-flowering shade (50% shade) resulted in reduced leaf area, tiller number, spiklets per panicle, whereas post-flowering shade reduced filled spiklets fraction and grain weight in rice.

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

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

Rabarimandimby (1992) observed that hedgerows significantly competed for nutrients and light with upland rice and mungbean in the alley. He found that competition was severe in the 2-3 rows closest to the hedgerows, while yields

were reduced by 47-95 percent and 11-37 percent for rice and mungbean, respectively.

Nazir *et al.* (1993) conducted a trial in Pakistan, rice was sown parallel to *Dalbergia sissoo* trees at distance which gave 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, 1000-grain weight, grain protein concentration and percentage DM and grain yield. Yield was 2.99, 2.96, 2.11, 2.57, 2.4, 2.12, 1.64 and 1.32 t /ha with 0.2, 3, 4, 5, 6, 7 and 8 hr. shade /day respectively.

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

Miah *et al.* (1995) reported that the mean light availability on crop rows decreased as they approached the trees rows across the alleys. The rate of decrease was greater in unpruned than in pruned alleys. Rice and mungbean yield decreased linearly with the reduced percent light incidence, rice yields decreased 47 kg/ha and mungbean yields decreased 10 kg/ha. In pruning regimes, mungbean yields decreased more in pruned conditions (13 kg/h) than in unpruned condition (9 kg/ha).

Growth of trees and seasonal yields of understorey crops were measured by Hicking *et al.* (1998) over a five year period for 4 crops grown under 17 tree species at 8 x 8 m spacing in wetland rice field. All tree species grew well in rice fields, at rates comparable to their growth in forest plantations. Top and rood pruning reduced average tree girths by up to 19% and average tree volume b up to 41% depending on intensity of pruning. The crops monitored were *Oryza sativa*, *Triticum aestivum*, *Corchorus oletorius*, and *lens culinaris*. Crop yields under the trees average 93% of the corresponding yield outside the tree canopy.

Solanki (1998) stated that fruit trees and crops are grown together in various ways. Depending on the pattern and configuration, these companion crops are known as intercropping, under planting, hedgerow planting or alley cropping. In an agroforestry system where agricultural crops are normally grown between rows of fruit trees, the agricultural crops provide seasonal revenue, whereas fruit trees managed for 30-35 years giving regular returns of fruit and in some cases fuel wood from pruned wood and fodder. Several kinds of crops are also under planted to take the advantage of shade provide by the canopy of fruit trees.

Nandal *et al.* (1999) had grown 5 rice cultivars under the *Sissoo* tree. 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 with crops growing in the open place.

Pandey *et al.* (1999) reported that rice yield was positively related to distance from the tree. Impact of the trees was maximum at 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 increase relationship between the percentage decrease in the parameters and the distance indicating that the greater the distance the smaller the effect of the tree.

Time tested, indigenous land use systems can provide valuable information for the design of ecologically sustainable and socially acceptable agro forestry systems. One such traditional system is the growing of *Acacia nilotica* (L.) Willd. Ex Delile trees, locally known as babul, in rice fields of smallholder farmers in Madhya Pradesh State of central India, an area with subhumid monsoon climate and hot summer. The functional characteristics of the system were collected through participatory rural appraisal involving intensive interactions with farmers in the region during six years, and through a structured-questionnaire survey in 25 villages, involving a total of 200 farm families. The farms had an average of 20 babul trees, ranging in age from <1

to 12 years, per hectare in upland rice fields, the tree-stand density being greater on smaller than of larger farms (>8 ha). Over a ten year rotation period, the trees provide a variety of products such as fuel wood (30 kg/tree), brushwood for fencing (4 kg/tree), small timber for farm implements and furniture (0.2 cu.m), and non-timber products such as gum and seeds. The babul + rice system was estimated to have a benefit/cost (B/C) ratio of 1.47 and an internal rate of return (IRR) of 33% at 12% annual discount rate during a ten-year period, though at a low level of income. Babul trees account for nearly 10% of the annual farm income of smallholder farmers (<2 ha). By practicing the agroforestry (rice+babul) system, farmers get higher cash returns on a short-term (10 year) harvest cycle of trees, and the labour input (both family-and hired) on farms was distributed more uniformly throughout the year than in rice monoculture.

Purchased inputs are seldom used in the system. The ease of management of the system, the self-generating and robust nature of the tree and the multiple products and services it provides, and easy marketability of the products are the major factors that encourage farmers to adopt the system. Furthermore, the farmers have secure ownership rights to their farms. In spite of its long history and tradition as a sustainable approach to land use, the system has not attracted the attention of development agencies. More detailed investigations on its social, economic, and cultural attributes are warranted to not only improve this system, but provide insights into farmer adoption of agroforestry innovations (Viswanath *et al.*, 2000).

Samsuzzaman *et al.* (2002) carried out three studies in Bangladesh to find out the effect of tree species on crops and alternative management practices for better system productivity. The first experiment revealed that the highest yield of mustard (0.788 t/ha) and rice (2.89 t /ha) was obtained under *Albizia lebbeck* trees and *Acacia nilotica*, respectively. The result of the second experiment indicated that the lower reduction in yield of adjacent crop with wider the tree spacing the result of 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* two and three times a year respectively. Pruning of *Albizia lebbek* three times a year contributed to the highest increase in rice (50%) and radish (35%) yields.

2.6 Yield and associated components of rice variety

Alim *et al.* (1962) tested five fine rice cultivars namely, Badshabhog, Basmati, Hatisail and Radhunipagal for five years and found that Basmati showed the best performance followed by Gobindhabhog and badshabhog. The also reported that Badshabhog yielded 2.6 t ha^{-1} and each of Daudkhani (other fine rice cultivars) and Hatsail yielded 2.69 t ha^{-1} . and each of The authors further reported about a cross between Daudkhani and Indrasail which resulted and average yield of 2.87 t ha^{-1} .

BRRI (1991) reported that the number of effective tillers produced by some transplant aman rice ranged from 7 to 14 and it significantly differed from variety to variety. In local varieties, namely, Haloi, Tilockachari, Nizersail and latishail, the number of effective tillers hill⁻¹ were 9.7, 9.3, 10.8 and 9.0, respectively.

Chowdhury *et al.* (1993) stated that cultivar BR23 showed superior performance over Pajam in respect of yield and yield contributing characters i.e. number of productive tillers hill⁻¹. Length of panicle, 1000-graub weight, grain and straw yields. On the other hand, Pajam produce significantly taller plants, higher number of total spikelets panicle⁻¹, and unfilled spikelets panicle⁻¹. BRRI (1994) reported that Tulsimala produced the highest number of spikelets panicle⁻¹ and BRI produced the lowest number of spikelets panicle⁻¹.

BRRI (1994) studied the performance of BR14, Pajam, and BR5. BR14 (3.75 t ha^{-1}) produced the highest yield while BR5 (2.61 t ha^{-1}) produced the lowest one. BINA (1993) evaluated the performance of four varieties/advanced lines

differed significantly for plant height, number of non-bearing tillers, panicle length and sterile spikelets panicle⁻¹. Results showed that grain yield did not differ significantly.

BRRI (1995) studied varietal performances of BR4, BR10, BR22, BR23 and BR25 varieties including two local checks Challish and Nizersail transplanted at 20 cm x 20 cm spacing with 2-3 seedling hill⁻¹. The results indicated that BR4, BR10, BR11, Challish and Nizersail produced yields of 4.38, 3.12, 3.12, 3.12 and 2.7 t ha⁻¹, respectively. Challish variety earlier than all other varieties.

Dwivedi (1997) reported that Kamini, RP615, Harbans, Basmati, Kasturi and Sugandha varieties of fine rice produced 2.43, 1.94, 1.92, 20.1 and 2.65 t ha⁻¹ respectively.

BRRI (1999) reported that three proposed fine grain aromatic rice varieties viz., Khaskani, Basmati-D and Katarbhog were tested along with two check varieties at four locations each in the project and out reach area. BR5 was used as a standard check and Kalizira Khirkon and Khirshapati as local checks. Khaskani gave the highest mean yield of 2.81 and 2.75 t ha⁻¹ in the 144 and 148 days, respectively, whereas the mean yield of Basmati-D (2.34 t ha⁻¹) and 148 days, respectively, whereas the mean yield of Basmati-D (2.34 t ha⁻¹) and Katarbhog (2.04 t ha⁻¹) could not exceed of standard check BR5 (2.66 t ha⁻¹) in the Project areas. But in the out reach area, the mean yield of Basmati-D (2.32 t ha⁻¹) and Katarbhog (2.32 t ha⁻¹) was similar to BR5 (2.4 t ha⁻¹).

BRRI (2000) reported that the performance of three proposed varieties BR 4384-2b-2-2-4, BR 4384-2B-2-6 and BR 4384-2B-2-2-HR3 was tested along with two standard checks and one local check in 11 locations in T. Aman. Katarbhog and Khaskani were used as standard check and Chinking, Basmati,

Kalizira, Phlippine Katrai, Chinigura. Chiniatop and Bashful as local checks. In Sonagazi and Bogra Sadar, the yield performance of the proposed varieties was excellent with more than 4.0 t ha⁻¹ yield. Hence, about 30% higher yield was obtained from the proposed varieties over the checks.

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during T. Aman season, 2002 to study the effect of different level of nitrogen on growth and yield of transplant aman rice. The experiment included four treatments viz. 0, 60, 80 and 100 kg N ha⁻¹. Nitrogen level significantly influenced growth and yield components. The highest number of effective tillers hill⁻¹ (9.20), maximum grains panicle⁻¹ (100.80) and highest grain yield (5.34 t ha⁻¹) were obtained with 80 kg N ha⁻¹. The highest straw yield (6.98 t ha⁻¹) was obtained at the highest nitrogen level (100 kg N ha⁻¹). The highest harvest index (44.50%) was observed at 80 kg N ha⁻¹. Results showed that 80 kg N ha⁻¹ was optimum to produce maximum yield of transplant aman rice cv. BRRI dhan32. (Rahman *et al.*, 2007)

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

In this section, the materials and methods have been presented which include brief description of location of the experimental site, soil, climate, materials used and methodology followed in the experiment. The details of these sections are described below.

3.1 Location of the Experimental Plot

The site of the experiment is situated between 25°13' Latitude and 88°23' longitude at the elevation of 37m above the sea level. The experimental plots were laid out at the Agroforestry Farm, Department of Agroforestry Hajee Mohammad Danesh Science and Technology University, Dinajpur.

3.2 Experimental Period

Duration of the experiential period was from June 2006 to November 2006.

3.3 Soil Characteristics

The experiment was laid out in a medium high land belonging to the AEZ old Himalayan piedmont plain area. The soil texture was sandy loam with p^H 5.1. The structural class of the soil was fine and the organic matter content was around 1.06%. The characteristics of the soil were previously tested in the Soil Resource Development Institute (SRDI), Dinajpur (Appendix-I).

3.4 Climate and Weather

The climate of the study area is characterized by plenty rainfall during kharif season (April to October) and scanty rainfall during the rest period of the year i.e. during Rabi season (October to March). The mean of maximum temperature in summer (April to September) was 28.98°C and the mean of

minimum temperature in winter 14.9°C. The mean humidity during July to November was 89.83%. The mean annual rainfall was 175mm, most of which occurs in short spells during the period from May to September (Appendix-II).

3.5 Experimental Design and Treatment

The experiment was laid out following a split plot design with four replications. Tree species were arranged in main plots and rice variety were in sub plots. Total number of experimental plot was 80. The size of each unit plot was 2.5 m x 2.5 m = 6.25 m². Sixty plots were laid under the trees and 20 plots were laid in control (open field). Tree species used in main plots were as follows:

T₁ = Open field

T₂ = Black siris (*Albizia lebbbeck*)

T₃ = Guava (*Psidium guajava*)

T₄ = Mango (*Mangifera indica*)

The five sub-plots having different rice variety were as follows:

V₁ = BR10

V₂ = BR11

V₃ = BRRI dhan 33

V₄ = BRRI dhan 39

V₅ = Sorna

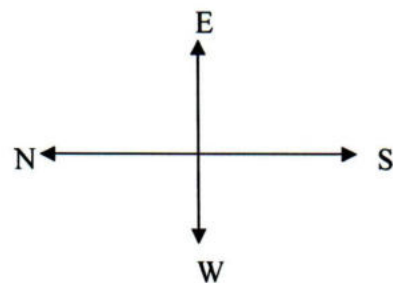
3.6 Land Preparation

The experimental field was opened with a spread on 4 July 2006. Thereafter, the land was spaded several times followed by laddering to obtain 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 seedling transplanting.

Layout of the Experimental plot:Plot size: $2.25 \times 2.25 \text{ m}^2$

No. of replication: 4

Total number of plot: 80

**Mango species**

R ₁	BR11	BRRIdhan 33	BR10	Sorna	BRRIdhan 39	R ₃	Sorna	BRRIdhan 39	BR11	BRRIdhan 33	BR10
R ₂	Sorna	BRRIdhan 39	BR11	BR10	BRRIdhan 33	R ₄	BR10	BR11	BRRIdhan 33	Sorna	BRRIdhan 39

Guava species

R ₁	BRRIdhan 39	BR11	BRRIdhan 33	Sorna	BR10	R ₃	BRRIdhan 39	Sorna	BR10	BRRIdhan 33	BR11
R ₂	BRRIdhan 33	Sorna	BR10	BR11	BRRIdhan 39	R ₄	BR11	BRRIdhan 33	BRRIdhan 39	Sorna	BR10

Black siris species

R ₁	BR10	BRRIdhan 33	Sorna	BR11	BRRIdhan 39	R ₃	BR11	BR10	Sorna	BRRIdhan 33	BRRIdhan 39
R ₂	BR11	BRRIdhan 39	Sorna	BR10	BRRIdhan 33	R ₄	Sorna	BRRIdhan 39	BR10	BR11	BRRIdhan 33

Open field

R ₁	BR10	BRRIdhan 33	BR11	BRRIdhan 39	Sorna	R ₃	BRRIdhan 33	BR10	BR11	Sorna	BRRIdhan 39
R ₂	BRRIdhan 33	BR11	BRRIdhan 39	Sorna	BR10	R ₄	BR11	BRRIdhan 33	BRRIdhan 39	BR10	Sorna

3.7 Fertilizer Application

The following fertilizer and manure doses were applied in the field according to Razzaque *et al.* (2000).

Types of Fertilizer	Recommended dose kg/ha
Urea	180kg
TSP	100 kg
MP	70kg
Gypsum	60kg
Cow dung	7-10 ton/ha

Sulphur 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 seedling transplanting. 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.

3.8 Experiential materials

3.8.1 Crop species and varieties

Rice (*Oryza sativa* L.) was used in this study. Five transplanted Aman rice variety i.e. BR10, BR11, BRRI dhan 33, BRRI dhan 39 and Sorna were used as experimental crops. This is briefly described below.

BR10 (Pragoti): Bangladesh Rice research Institute (BRRI) invents BR10 making hybridization between IR20 and IR5-114-3-1. The breeding line number of this rice is BR51-46-6-HR65. The popular name of this rice is Pragoti. This variety is easily recognized because the ears are stayed under flag leaf during flowering and end edge of flag leaf suddenly become sharp. It is late variety. Pragoti has achieved goodwill in the world as its being

included in the list of optimum yielding in the international competition. The yield potential of this variety is 6.5 t / ha and days of maturity 150.

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 and days of maturity 145.

BRRI dhan 33: 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 and days of maturity 118.

BRR dhan 39: This rice has been invented by making hybridization among BR1185-2B-56-2-1-1, R1674-28-3-1-1 and 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 and days of maturity 122.

Sorna: It is an Indian variety but 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 and days of maturity 150.

3.8.2 Structural Description of the Trees during the Study Period

Black siris (*Albizia lebbeck*): A handsome tree, deciduous, having umbrella foliage, reaching some 30 meter in height and 1 meter in diameter. It produces white flowers in heads. The long dry straw coloured pods are

characteristics and rustle in a breeze. It is nearly leafless in part of the year (R.K. Gupta, 1993).

The existing plant growth status is given below-

- i. Average plant height 3.80 m
- ii. Average basal diameter 5.01 cm
- iii. Average canopy diameter 100 cm

Guava trees (*Psidium guajava*): This is a popular fruits cultivar in Bangladesh. Tree vigorous, medium tall, 5.8-6.2 m, branching, heavy with dense foliage, tendency to produce long shoots, crown and compact. Leaves medium, elliptical to oblong in shaped. Fruits medium, roundest in shaped (Bose, *et. al.* 2004).

The existing plant growth status is given below-

- i. Average plant height 2.2 m
- ii. Average basal diameter 3.92 cm
- iii. Average canopy diameter 112.5 cm

Mango trees (*Mangifera indica*): This is one of the finest (Amropaly) 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).

The existing plant growth status is given below-

- i. Average plant height 1.95 m
- ii. Average basal diameter 5.06 cm
- iii. Average canopy diameter 102.6 cm

(This data was collected at the time of data collection on rice at 30 DAT)

3.9 Sowing of seeds in seed bed

Seeds were sown on 4 June 2006 in seed bed. Sowing was done at the rate of 20-30 kg seeds ha⁻¹.

3.10 Seedling transplanted in main field

35 days aged seedling was transplanted in the main plot by using plant to plant distant 15 cm and line to line distance 25 cm.

3.11 Intercultural operation

Intercultural operations such as weeding and irrigation were given uniformly in each plot. Weeding was done two times on 15 and 45 days after transplanting (DAT). The field was irrigated as per needed. Plant protection measure such as insecticide or fungicide spray was required, at the panicle ignition stage as different types of pest and insects were found in the field.

3.12 Harvesting, threshing and weighting

The crop was harvested on different time of maturity in November, 2006. The grain and straw were separated by hand threshing and plot-wise, weight of grain was recorded in kg/plot. The grain yield was later expressed in ton/ha.

3.13 Sampling and data collection

For collecting data on several plant characters, 8 (2 from each orientation) randomly selected plants were uprooted from each plot before harvesting. The harvested crops were then threshed plot-wise and grain yield was recorded plot-wise on 14% moisture basis as ton /ha. From the 8 selected plants per plot the following parameters were recorded.

- Number of leaf hill⁻¹
- Length of leaf blade (cm)

- Breadth of leaf blade (cm)
- Plant height (cm)
- Number of tiller hill⁻¹
- Number of effective tiller hill⁻¹
- Plant fresh weight (g)
- Straw fresh weight (g) plant⁻¹
- Root fresh weight (g) plant⁻¹
- Straw dry weight (g) plant⁻¹
- Root dry weight (g) plant⁻¹
- Total dry matter (TDM) (g)
- Length of panicle (cm)
- Number of grain panicle⁻¹
- Number of unfilled grain panicle⁻¹
- 1000 grain weight (g)
- Grain yield
- Time of maturity (days)
- Light measurement (lx)

3.14 Procedure of data recording

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

3.14.1 Number of leaf hill⁻¹

Number of leaf was counted from the selected hills at 30 DAT (Days after transplanting).

3.14.2 Length of leaf blade

Length of leaf blade was measured by measuring scale in cm.

3.14.3 Breadth of leaf blade

Breadth of leaf blade was measured by measuring scale in cm.

A handwritten calculation is enclosed in a circle. It shows the number 33 above a horizontal line, and the number 7,10.07 below the line, representing a division operation.

3.14.4 Plant height

The plant height was measured from the ground level to the top of flag leaf. From each plot 8 hills were measured and averaged at 30, 45, 60 and 75 days after transplanting (DAT).

3.14.5 Number of tiller hill⁻¹

Number of tiller was counted from the selected hills at 30 days after transplanting (DAT).

3.14.6 Number of effective tiller hill⁻¹

Number of effective tiller was counted from the selected hills at 45, 60 and 75 days after transplanting (DAT).

3.14.7 Plant fresh weight

Plant fresh weight (g) was measured at harvesting stage with measuring balance.

3.14.8 Straw fresh weight plant⁻¹

After threshing of grain, straw fresh weight was measured from rice plant.

3.14.9 Root fresh weight plant⁻¹

The root fresh weight was taken at the initial stage of crop cutting avoiding soil attach with roots.

3.14.10 Straw dry weight plant⁻¹

The threshed straw of plant was sun dried and kept into oven for 24 hours. The oven-dried straw was then weighted by a digital electric balance and expressed in (g).

3.14.11 Root dry weight hill⁻¹

Clean root of plant was sun dried and kept into oven for 24 hours. The oven-dried root was then weighted by a digital electric balance and expressed in (g).

3.14.12 Total dry matter

Total dry matter was measured from the sum of straw dry wt and root dry wt.

3.14.13 Length of panicle

Panicle length was recorded from the basal node of the rachis to the apex of each panicle.

3.14.14 Number of grain panicle⁻¹

Ten panicles were randomly collected from each sample and grains were counted. Then average of 5 samples was taken.

3.14.15 Number of unfilled grain panicle⁻¹

The grain would not able for further use then it was rejected for better counting and weight. Sampling method was using here.

**3.14.16 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.

3.14.17 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. The grain yield was later expressed in ton/ha.

3.14.18 Days to maturity

Proper time of maturity of transplanted aman variety is an important factor for the further use of land. So, the crop was harvested when it physiologically matured.

3.14.19 Light measurement

It is very important in Agroforestry research to measure light intensity. Month and day wise light measurement were collected (Appendix iii).

3.15 Statistical analysis

Data were statistically analyzed using the "Analysis of variance" (ANOVA) technique with the help of computer package MSTAT. The mean differences were adjudged by Duncan's Multiple Range Test (DMRT) Gomez and Gomez, 1984.

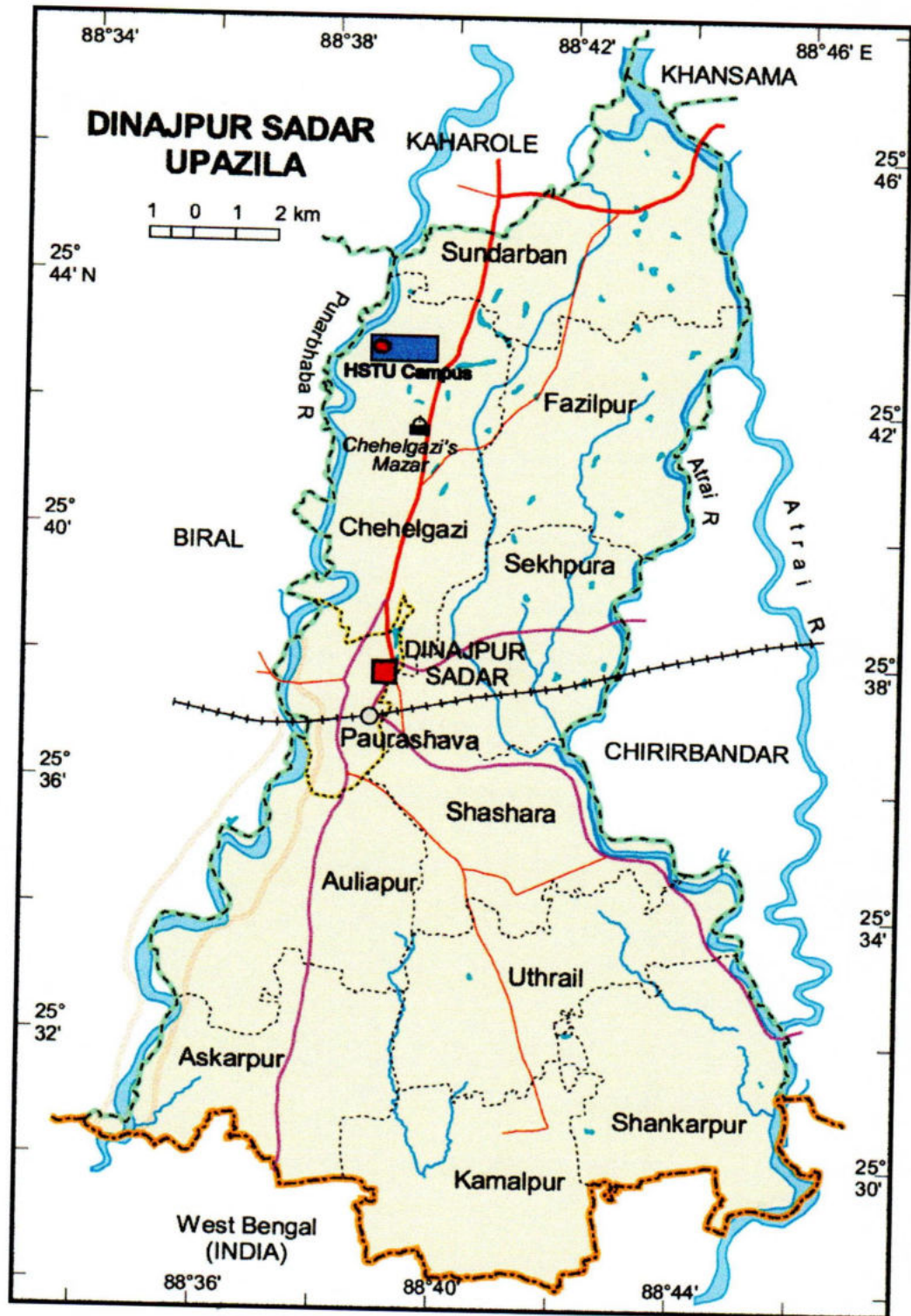


Fig.1. Map of Dinajpur Sadar Upazila showing the research working area.

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

The results obtained from the present study along with statistical analysis of data have been presented and discussed in this chapter. The present study regarding shading effect of some selected tree species on performance of vegetative, yield and yield contributing characters of 5 transplanted aman rice varieties cv. BR10, BR11, BRR1 dhan 33, BRR1 dhan 39 and Sorna has been shown in Table 1-12 & Fig 2 to 8 and plate 1 to 3. The summary of analysis of variance for all yield contributing characters and growth parameters studied have been presented in Appendix IV- IX.

4.1.1 Number of leaf

Main effect of tree

The number of leaf per hill of rice was significantly influenced by the different tree species at 30 DAT (Table 1). The results showed that the highest number of leaf per hill (32.47) was found in open field (T_1) and the lowest number of leaf per hill (29.00) was found under Guava (T_3). The second highest number of leaf per hill (30.80) was found under Black siris (T_2) which was statistically similar to that of Mango (T_4). Crookston *et al.* (1975) also reported similar results. The lower number of leaf per hill under tree species might be due to lower production of photosynthates under shading conditions.

Effect of rice variety

Varietal effects at 30 DAT significantly influenced the number of leaf per hill (Table 2). Significantly the highest number of leaf per hill (32.33) was found in BR11 (V_2) followed by V_1 (32.03). The lowest number of leaf per hill

(28.00) was found in Sorna (V_5), which was statistically similar to BRRI dhan 33 (V_3). This might be happened due to their genetic variation.

Interaction effect of tree and rice variety

The interaction effect of tree and rice variety was significantly different at 30 DAT (Table 3). The results showed that the highest number of leaf per hill (38.33) was found in T_4V_2 combination followed by T_4V_1 & T_2V_2 combination (37.50). The lowest number of leaf per hill (24.67) was found in T_1V_4 combination.

4.1.2 Length of leaf blade

Main effect of tree

Length of leaf blade of rice was significantly varied by tree species at 30 DAT (Table 1). The results showed that the highest length of leaf blade (51.40 cm) was found under T_2 , followed by under T_3 (50.47 cm) and the lowest length of leaf blade (41.3 cm) was found in T_1 . This might be attributing due to the stimulation of cellular expansion and cell division of leaf sheath under shading condition. This might be attributing due to the stimulation of cellular expansion and cell division of leaf sheath under shading condition. Garrity *et al.* (1992) observed length of leaf blade affected minimum due to shading condition in alley cropping of upland rice.

Effect of rice variety

Varietal effects at 30 DAT significantly influenced the length of leaf blade of rice (Table 2). The results showed that the highest length of leaf blade (51.33 cm) was observed in V_3 (BRRI Dhan33) followed by V_1 (50.17 cm) and significantly the lowest length of leaf blade (41.08 cm) was found in V_5 .

Interaction effect of tree and rice variety

The interaction effect of tree and rice variety was significantly different at 30 DAT (Table 3). The highest length of leaf blade (55.67 cm) was recorded in T_2V_1 , followed by T_3V_3 combination (55.60 cm). Although T_2V_3 , T_3V_3 & T_2V_1 identical. Significantly the lowest length of leaf blade (33.67 cm) was found in T_1V_5 combination.

4.1.3 Breadth of leaf blade

Main effect of tree

Breadth of leaf blade of rice was significantly influenced by the effect of tree species at 30 DAT (Table 1). The results showed that highest breadth of leaf blade (1.41 cm) was recorded under T_4 , which was statistically similar to that of T_3 (1.39 cm) and T_2 (1.38 cm). Significantly the lowest breadth of leaf blade (1.25 cm) was recorded in T_1 .

Effect of rice variety

Varietal effects at 30 DAT significantly influenced the breadth of leaf blade of rice (Table 2). The highest breadth (1.46 cm) was observed in V_3 (BRRI dhan 33) and lowest breadth (1.23 cm) was found in V_5 (Sorna). The second highest (1.40 cm) was found in V_1 which was statistically similar to that of V_2 (1.38 cm) & V_4 (1.34 cm).

Interaction effect of tree and rice variety

The interaction effect of tree and rice variety on breadth of leaf blade was significantly different at 30 DAT (Table 3). The highest breadth of leaf blade (1.53 cm) was found in both T_3V_3 & T_4V_3 combination. Significantly the lowest breadth of leaf blade (1.13 cm) was found in T_1V_5 combination.

4.1.4 Plant height

Main effect of tree

The shading effect of tree on plant height of rice was found significantly different at 30, DAT (Table 1) but at 45, 60, and 75 DAT was not significantly different (Table 4). The highest plant height was (62.90 cm), (80.30 cm), (92.39 cm) and (104.6 cm) at 30, 45, 60 and 75 DAT was found in T₄ and the lowest plant height was obtained (56.81 cm), (76.66 cm), (87.85 cm), and (101.9 cm) at 30, 45, 60 and 75 DAT in T₁ (Open field). This might be attributing due to the stimulation of cellular expansion and cell division of leaf sheath under shading condition. Garrity *et al.* (1992) observed plant height affected minimum due to shading condition in alley cropping of upland rice.

Table 1. Effect of tree on number of leaf/ hill, length & breadth of leaf blade, plant height and number of tiller/hill of transplanted aman rice

30 Days after transplanting					
Tree	Number of leaf / hill	Length of Leaf blade(cm)	Breadth of leaf blade (cm)	Plant height (cm)	Number of tiller / hill
T ₁	29.00 c	41.13 d	1.25 b	56.81c	6.55
T ₂	30.80 b	51.40 a	1.38 a	60.40ab	6.29
T ₃	30.60 b	50.47 b	1.39 a	59.12bc	6.19
T ₄	32.47 a	48.93 c	1.41 a	62.90a	6.22
Level of Significance	*	**	*	**	NS
CV%	5.07	1.28	6.49	3.99	7.74

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

Where,

T₁= Control (open field), T₂= Black siris, T₃= Guava, T₄= Mango trees

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Table 2. Effect of variety on number of leaf /hill, length & breadth of leaf blade, plant height and number of tiller/hill of transplanted aman rice

30 Days after transplanting					
Variety	Number of leaf / hill	Length of Leaf blade(cm)	Breadth of leaf blade (cm)	Plant height (cm)	Number of tiller / hill
V ₁	32.03 ab	50.17 a	1.40 ab	68.29a	6.53ab
V ₂	32.33 a	49.58 b	1.38 b	68.58a	7.01a
V ₃	28.83 c	51.33 a	1.46 a	57.57b	5.99bc
V ₄	31.08 b	46.75 c	1.34 b	59.23b	6.36abc
V ₅	28.00 c	41.08 d	1.23 c	46.36c	5.65c
Level of Significance	**	**	**	**	*
CV%	5.07	1.28	6.49	3.99	7.74

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

Where,

V₁= BR10, V₂= BR11, V₃= BRRI dhan 33, V₄= BRRI dhan 39, V₅= Sorna

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Effect of rice variety

The plant height of rice variety recorded at 30, 45, 60 and 75 DAT was significant. At 30 DAT the highest plant height (68.29 cm) in V₁ and (87.11 cm), (99.00 cm) and (112.8 cm) at 45, 60, and 75 DAT in V₂ was observed. The lowest plant height (46.36 cm), (68.31 cm), (75.68 cm) and (89.7 cm) was found at 30, 45, 60 and 75 DAT in V₅. This might be occurred due to their genetic character.

Table 3. Interaction effect of tree and rice variety on number of leaf/hill, length & breadth of leaf blade, plant height and number of tiller/hill

30 Days after transplanting						
Interaction		Number of leaf / hill	Length of Leaf blade(cm)	Breadth of leaf blade(cm)	Plant height (cm)	Number of tiller / hill
T ₁	V ₁	28.33 h	43.67 i	1.20 h	64.65cde	7.12
	V ₂	32.00 de	41.00 j	1.30 fg	61.80ef	6.90
	V ₃	28.67 h	47.00 h	1.36 de	56.13gh	6.20
	V ₄	24.67 j	40.33 k	1.27 fg	55.05h	7.10
	V ₅	31.33 ef	33.67 l	1.13 i	46.42i	5.50
T ₂	V ₁	35.67 b	55.67 a	1.43 bc	71.27a	6.35
	V ₂	37.50 ab	48.67 ef	1.30 efg	71.70a	6.90
	V ₃	30.00 g	55.33 a	1.50 ab	55.90gh	6.375
	V ₄	31.33 ef	50.33 d	1.47 abc	56.70gh	5.82
	V ₅	27.00 i	49.00 e	1.33 ef	46.42i	5.82
T ₃	V ₁	35.11 b	53.67 c	1.47 abc	65.78bcd	6.37
	V ₂	35.70 b	54.00 c	1.43 bc	68.30abc	6.85
	V ₃	28.00 hi	55.60 a	1.53 a	55.80gh	5.62
	V ₄	35.67 b	48.33 fg	1.33 ef	59.07fg	6.37
	V ₅	25.00 j	40.67 jk	1.20 h	46.00i	5.60
T ₄	V ₁	37.50 ab	53.67 c	1.50 ab	71.47a	6.35
	V ₂	38.33 a	54.67 b	1.47 bc	68.53ab	6.97
	V ₃	28.67 h	47.33 h	1.53 a	62.45def	5.77
	V ₄	32.67 d	48.00 g	1.30 efg	66.10bcd	6.15
	V ₅	28.67 h	41.00 j	1.23 gh	46.17i	5.67
Level of Significance		**	**	*	**	NS
CV%		5.07	1.28	6.49	3.99	7.74

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

Where,

T₁= Control (open field), T₂= Black siris, T₃= Guava, T₄= Mango trees

V₁= BR10, V₂= BR11, V₃= BRRI dhan 33, V₄= BRRI dhan 39, V₅= Sorna

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Interaction effect of tree and rice variety

From the interaction effect, the plant height of rice at different DAT was shown significantly different except 60 DAT. The highest plant height of rice (71.70 cm), (90.03 cm), (101.60 cm) at 30, 45, & 60 DAT was found in T₂V₂ combination and (116.40 cm) at 75 DAT in T₄V₁ combination. The lowest plant height of rice (46.17 cm), (65.95 cm) and (86.5 cm) at 30, 45 and 75 DAT in T₄V₅ combination.

4.1.5 Effective tiller**Main effect of tree**

The shading effect of tree on number of effective tiller hill⁻¹ of rice was not significant at 45, 60 and 75 DAT (Table 4). Numerically the highest number of effective tiller (12.35), (13.73) and (12.18) at 45, 60 and 75 DAT was observed in T₁ and the lowest number of effective tiller were (10.60), (11.74) and (11.28) at 45, 60, and 75 DAT respectively in T₃.

Effect of rice variety

Number of effective tiller hill⁻¹ of rice variety was significantly observed in (Table 5). Variation in number of effective tiller hill⁻¹ was more distinct from variety wise. Results showed that the highest number of tiller hill⁻¹ (12.68), (13.67) and (12.57) at 45, 60 and 75 DAT was found in V₂ respectively. The lowest number of effective tiller hill⁻¹ (10.57), (11.91) and (10.94) at 45, 60 and 75 DAT in V₅ which was statistically similar to that of V₃ and V₄.

Interaction effect of tree and rice variety

Effective number of tiller hill⁻¹ of rice variety was significantly affected by the interaction of tree and rice variety at 45 DAT and 60, (Table 6). The highest number of effective tiller hill⁻¹ (13.73), (14.9) and (12.98) at 45, 60 and 75 DAT was observed in T₁V₂ combination. The lowest number of effective tiller hill⁻¹ (9.85) was observed in T₃V₃ combination at 45 DAT, (11.00) in T₄V₅ combination at 60 DAT.

Table 4. Effect of tree on plant height and number of effective tiller/hill

Tree	Plant height (cm)			Number of effective tiller/hill		
	45DAT	60DAT	75DAT	45DAT	60DAT	75DAT
T ₁	76.66	87.92	101.9	12.35	13.73	12.18
T ₂	78.98	88.96	102.1	11.26	12.71	11.69
T ₃	78.32	87.85	102.4	10.6	11.74	11.28
T ₄	80.30	92.39	104.6	11.10	12.06	11.41
Level of Significance	NS	NS	NS	NS	NS	NS
CV%	3.90	5.18	4.19	10.16	10.87	11.55

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

Where,

T₁= Control (open field), T₂= Black siris, T₃= Guava, T₄= Mango trees

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Table 05. Effect of variety on plant height and number of effective tiller/hill.

Variety	Plant height (cm)			Number of effective tiller/hill		
	45DAT	60DAT	75DAT	45DAT	60DAT	75DAT
V ₁	86.57a	98.32a	112.2a	11.6b	13.18a	12.01ab
V ₂	87.11a	99.0a	112.8a	12.68a	13.67a	12.57a
V ₃	72.66c	84.54c	96.22c	10.76bc	11.93b	11.16bc
V ₄	78.18b	88.86b	102.8b	11.01bc	12.11b	11.52bc
V ₅	68.31d	75.68d	89.74d	10.57c	11.91b	10.94c
Level of Significance	**	**	**	**	**	**
CV%	3.90	5.18	4.19	10.16	10.87	11.55

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

Where,

V₁= BR10, V₂= BR11, V₃= BRRI dhan 33, V₄= BRRI dhan 39, V₅= Sorna

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

Table 6. Interaction effect of tree and rice variety on plant height and number of effective tiller/hill.

Interaction		Plant height (cm)			Number of effective tiller/hill		
		45DAT	60DAT	75DAT	45DAT	60DAT	75DAT
T ₁	V ₁	84.17bc	96.43	109.7abcd	13.05ab	14.82	12.85
	V ₂	83.77c	99.10	113.2abcd	13.73a	14.90	12.98
	V ₃	71.35fgh	81.17	93.13ijk	11.93abcde	12.93	11.98
	V ₄	77.32d	86.32	101.1fgh	12.1abcde	13.03	11.82
	V ₅	65.67i	76.00	86.00k	10.95defg	13.95	11.25
T ₂	V ₁	89.18a	101.10	113.4abcd	11.18bcdefg	12.70	10.90
	V ₂	90.03a	101.60	115.8ab	12.95abc	13.68	12.77
	V ₃	72.07efg	81.90	92.93ijk	11.07cdefg	12.23	11.98
	V ₄	76.75de	86.18	101.8efg	10.13fg	12.98	11.13
	V ₅	66.88hi	73.97	86.65k	10.15efg	11.98	10.30
T ₃	V ₁	84.07bc	96.05	109.3bcd	11defg	12.98	12.18
	V ₂	85.30abc	96.08	108cde	11.23bcdefg	13.00	12.25
	V ₃	76.15def	86.00	99.67ghi	9.85g	11.35	10.35
	V ₄	72.32efg	85.00	101.7efg	10.52efg	11.23	11.85
	V ₅	73.75defg	86.10	90.95jk	10.4efg	11.70	11.80
T ₄	V ₁	88.85ab	99.67	116.4a	11.18bcdefg	12.23	12.10
	V ₂	89.32a	99.22	114.4abc	12.82abcd	13.05	12.27
	V ₃	71.07gh	89.07	99.15ghi	10.2efg	11.02	10.32
	V ₄	86.30abc	97.93	106.7def	11.27bcdefg	11.20	11.30
	V ₅	65.95i	76.05	86.57k	10.8efg	11.00	10.40
Level of Significance		**	NS	**	**	NS	NS
CV%		3.90	5.18	4.19	10.16	10.87	11.55

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

Where, T₁= Control (open field), T₂= Black siris, T₃= Guava, T₄= Mango

V₁= BR10, V₂= BR11, V₃= BRRI dhan 33, V₄= BRRI dhan 39, V₅= Sorna

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

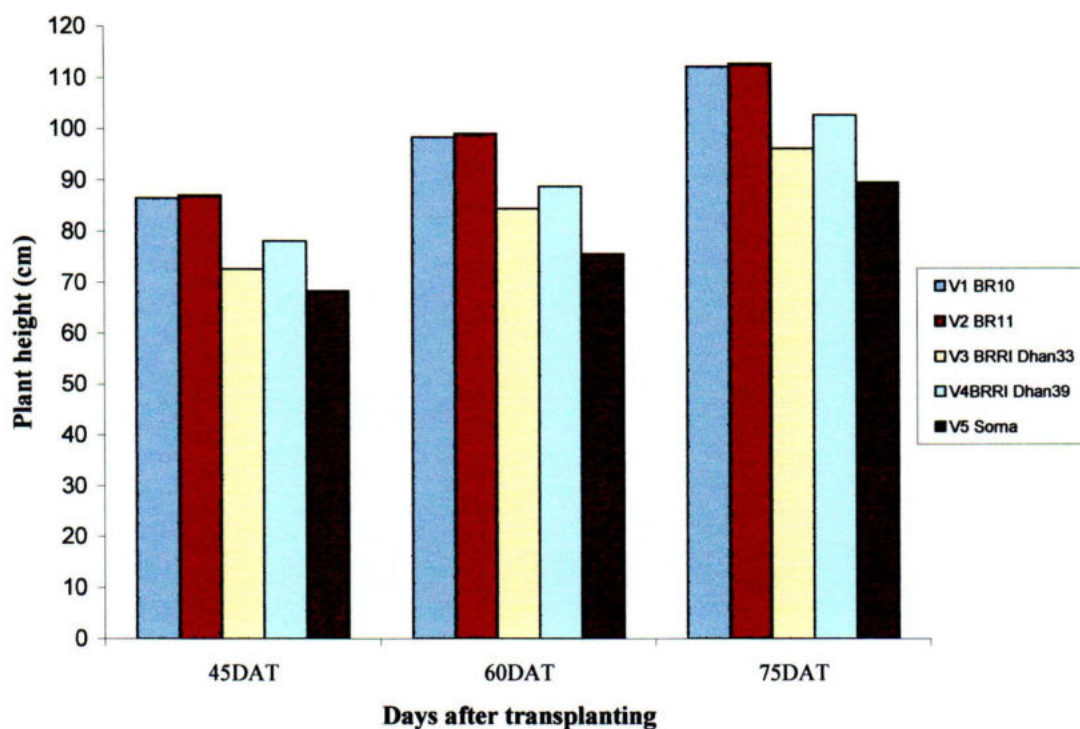


Fig 2. Effect of variety on plant height at 45, 60 and 75 DAT

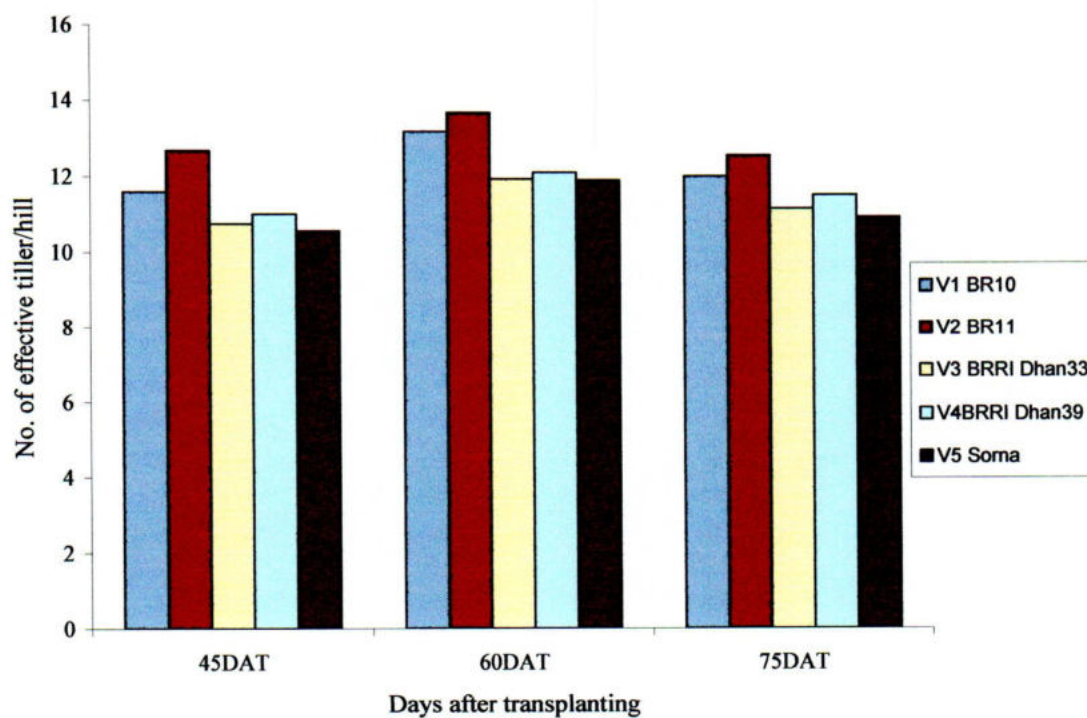


Fig 3. Effect of variety on number of effective tiller/hill at 45, 60 and 75 DAT

4.1.6 Plant fresh weight

Main effect of tree

The results showed that plant fresh weight was significantly different by the effect of tree species (Table 7). Significantly the highest plant fresh weight (95.57 g) was found in T₁ (open field) and the lowest plant weight (63.40 g) was found under T₃. The second highest plant fresh weight (82.43g) was obtained under T₂ which was statistically similar to that of T₄ (77.61 g).

Effect of rice variety

The plant fresh weight was found significantly affected by the influence of varieties. The highest plant fresh weight (85.61 g) was produced by V₂, followed by V₁ (84.75 g) and significantly the lowest plant weight (75.40 g) was found in V₅. (Table 8). The plant fresh weight obtained from V₃ (80.25 g) and V₄ (78.70 g) were statistically similar.

Interaction effect of tree and rice variety

Plant fresh weight was significantly different on interaction of tree and variety (Table 9). The highest plant fresh weight (98.80 g) was produced in T₁V₂ combination and the lowest plant weight (58.70 g) was found in T₃V₄ combination.

4.1.7 Straw fresh weight

Main effect of tree

Straw fresh weight was significantly affected due to the effect of tree species (Table 7). Significantly the highest straw fresh weight (78.57 g) was produced in T₁ followed by T₂ (68.03 g) and the lowest straw fresh weight was (50.62 g) found under T₃.

Effect of rice variety

Straw fresh weight of rice was significantly influenced by varietal effect (Table 8). The highest straw fresh weight (70.32 g) was found in V₁. The lowest straw fresh weight (60.19 g) was found in V₅. However, V₁ and V₂ were statistically similar as well as V₃ and V₅ were statistically similar.

Interaction effect of tree and rice variety

Straw fresh weight of rice was significantly affected by the interaction of tree and variety (Table 9). The maximum fresh weight of straw (82.20 g) was produced in T₁V₂ combination and the minimum straw fresh weight (47.90 g) was found in T₃V₄ combination.

4.1.8 Root Fresh Weight**Main effect of tree**

Root Fresh weight of rice was significantly affected by the tree due to the shading and interaction between tree and crop roots. The highest root fresh weight (11.3 g) was obtained from T₁ followed by T₄ (9.88 g), although T₂ statistically similar to that of T₄ (9.22 g). Significantly the lowest root fresh weight (7.88 g) was obtained from T₃.

Effect of rice variety

Root fresh weight of rice was also significantly influenced by varietal effect (Table 8). The maximum root fresh weight (10.51 g) was found in V₅ and the minimum weight (8.82 g) was in V₂. The second highest (9.55 g) was found in V₄ followed by V₁ (9.24 g).

Interaction effect of tree and rice variety

Interaction effect of tree and rice was significant (Table 9). The highest root fresh weight (16.50 g) was obtained in T₁V₅ combination followed by T₂V₃ combination and the lowest (6.05 g) was obtained in T₂V₅ combination.

4.1.9 Straw Dry Weight

Main effect of tree

Straw dry weight of rice was significantly affected by the tree due to tree-crop association (Table 7). The highest straw weight (28.68 g) was found in T₁ and the lowest straw dry weight (22.08 g) was found in T₂ which was statistically similar to T₃ (22.35 g).

Effect of rice variety

The result showed that dry straw weight of rice varieties was significantly different (Table 8). The highest straw dry weight (27.86 g) was found in V₂ which was statistically similar to that of V₁ (27.34 g) and the lowest straw dry weight (22.29 g) was found in V₄ which was statistically similar to that of (22.54 g) V₅.

Interaction effect of tree and rice variety

The Interaction effect of trees species and rice varieties was significantly varied (Table 9). The highest straw dry weight (33.70 g) was found in T₁V₂ combination and lowest straw dry weight (17.63 g) was found in T₂V₅ combination.

4.1.10 Root dry weight

Main effect of tree

Root dry weight was significantly affected by the trees due to shading as well as root interaction between tree and crop (Table 7). Significantly the highest dry weight of root (6.45 g) was produced in T₁, followed by T₄ (5.76 g). Significantly the lowest root dry weight (5.28 g) was found under T₃. The value of root dry weight found identical under T₂ (5.66 g) and T₄ (5.28 g).

Effect of rice variety

The results showed that root dry weight was significantly influenced by varietal effect (Table 8). Significantly the highest root dry weight (6.11 g) was found in V_5 that was followed by V_4 (5.38 g) and the root dry weight of V_1 (5.65 g) was statistically similar to that of V_4 . The lowest root dry weight (5.43 g) was produced in V_2 , although V_3 produced the root dry weight (5.9 g) was identical that of V_2 .

Interaction effect of tree and rice variety

The interaction effect of tree and rice variety was significantly varied on root dry weight (Table 9). The maximum root dry weight (9.38 g) was found in T_1V_5 combination and the minimum root dry weight (4.1 g) was found in T_2V_5 combination.

4.1.11 Straw root fresh weight**Main effect of tree**

Straw root fresh weight was significantly influenced by the shading effect of tree species (Table 7). The results showed that significantly the highest straw root fresh weight (89.91 g) was produced in T_1 followed by T_2 (76.72 g) and significantly the lowest straw root fresh weight (58.30 g) was produced under T_3 .

Effect of rice variety

The straw root fresh weight of the rice variety was significantly affected (Table 8). The results showed that significantly the highest straw root fresh weight was (78.91 g) in V_1 followed by V_2 (76.79 g), and the lowest was found (70.66 g) in V_5 .

Interaction effect of tree and rice variety

The interaction effect of tree and rice variety was significantly different on straw root fresh weight (Table 9). The highest straw root fresh weight (94.13 g) was produced in T₁V₅ combination and the lowest (55.42 g) was found in T₃V₄ combination.

4.1.12 Straw root dry weight

Main effect of tree

Straw root dry weight was significantly influenced by the shading effect of tree (Table 7). The highest straw root dry weight (35.12 g) was found under T₁ which was statistically similar to that of T₄ (31.66 g) and the lowest (27.60 g) was found in T₃ which was similar to T₂ (27.64 g).

Effect of rice variety

The straw root dry weight of rice was significantly affected by the varietal effect (Table 8). The highest straw root dry weight (33.35 g) was found in V₂ followed by V₁ (33.10 g) and the lowest straw root dry weight (28.84 g) was found in V₄, although V₃ and V₅ were statistically similar to that of V₄.

Interaction effect of tree and rice variety

The interaction effect of tree and rice variety on straw root dry weight was significantly different (Table 9). The highest straw root dry weight (41.60 g) was found in T₁V₅ combination and the lowest (21.48 g) was found in T₂V₅ combination.

4.1.13 Days to maturity**Main effect of tree**

Days to maturity of rice varieties was not significantly affected by the shade effect of tree species (Table 7). The results showed that highest duration for maturity was (137.2 days) under T_4 and the lowest (136.2 days) under T_1 .

Effect of rice variety

Days to maturity was significantly influenced by different variety of rice (Table 8). The highest days to maturity (148.3 days) was observed in V_5 and the lowest days to maturity (119.7 days) was observed in V_3 .

Interaction effect of tree and rice variety

The interaction effect of tree and rice variety on days to maturity was not significant (Table 9). The highest days to maturity of rice was found (148.50 days) in both T_3V_5 , T_4V_1 and T_4V_5 combination and the lowest days to maturity (119 days) in T_1V_3 combination.

Table 7. Effect of tree on plant fresh weight, straw fresh & dry weight plant⁻¹, root fresh & dry weight plant⁻¹, straw root fresh & dry weight plant⁻¹ and days to maturity

Tree	Plant fresh weight (g)	Straw fresh weight Plant ⁻¹ (g)	Root fresh weight Plant ⁻¹ (g)	Straw dry weight Plant ⁻¹ (g)	Root dry weight Plant ⁻¹ (g)	Straw root fresh weight Plant ⁻¹ (g)	Straw root dry weight Plant ⁻¹ (g)	Days to maturity
T ₁	95.57a	78.57a	11.31a	28.68a	6.45a	89.91a	35.12a	136.20
T ₂	82.43b	68.03b	9.22b	22.08c	5.66b	76.72b	27.64b	136.30
T ₃	63.40c	50.62d	7.88c	22.35c	5.28c	58.30d	27.60b	136.90
T ₄	77.61b	62.03c	9.88b	25.70b	5.76b	71.04c	31.66a	137.20
Level of Significance	**	**	**	**	**	**	**	NS
CV%	5.45	6.92	12.47	3.49	4.36	6.74	11.43	8.19

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

Where, T₁= Control (open field), T₂= Black siris, T₃= Guava, T₄= Mango trees

** =Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Table 8. Effect of variety on plant fresh weight, straw fresh & dry weight plant⁻¹, root fresh & dry weight plant⁻¹, straw root fresh & dry weight plant⁻¹ and days to maturity

Variety	Plant fresh weight (g)	Straw fresh weight Plant ⁻¹ (g)	Root fresh weight Plant ⁻¹ (g)	Straw dry weight Plant ⁻¹ (g)	Root dry weight Plant ⁻¹ (g)	Straw root fresh weight Plant ⁻¹ (g)	Straw root dry weight Plant ⁻¹ (g)	Days to maturity
V ₁	84.75a	70.32a	9.24bc	27.34a	5.65c	78.91a	33.10a	147.60a
V ₂	85.61a	68.28a	8.82c	27.86a	5.43d	76.97a	33.35a	143.90a
V ₃	80.25b	61.04bc	9.74ab	23.48b	5.90d	71.07b	29.13b	119.70b
V ₄	78.70b	64.22b	9.55bc	22.29c	5.83bc	73.34b	28.84b	123.90b
V ₅	75.40c	60.19c	10.51a	22.54c	6.11a	70.66b	28.90b	148.30a
Level of Significance	**	**	**	**	**	**	**	**
CV%	5.45	6.92	12.47	3.49	4.36	6.74	11.43	8.19

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

Where,

V₁= BR10, V₂= BR11, V₃= BRRI dhan 33, V₄= BRRI dhan 39, V₅= Sorna

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Table 9. Interaction effect of tree and rice variety on plant fresh weight, straw fresh & dry weight plant⁻¹, root fresh & dry weight plant⁻¹, straw root fresh & dry weight plant⁻¹ and days to maturity.

Interaction		Plant fresh weight (g)	Straw fresh weight Plant ⁻¹ (g)	Root fresh weight Plant ⁻¹ (g)	Straw dry weight Plant ⁻¹ (g)	Root dry weight Plant ⁻¹ (g)	Straw root fresh weight Plant ⁻¹ (g)	Straw root dry weight Plant ⁻¹ (g)	Days to maturity
T ₁	V ₁	95.00ab	79.20ab	9.23def	28.13d	5.50efgh	88.43ab	33.63bcd _e	147.50
	V ₂	98.80a	82.20a	9.45cdef	33.70a	5.30ghi	91.65a	39.13ab	143.50
	V ₃	92.00ab	76.95abc	10.13cde	22.70gh	5.60efgh	87.07ab	28.30efg	119.00
	V ₄	93.70ab	76.75abc	11.27bc	26.65e	6.28c	88.28ab	32.92cde	123.50
	V ₅	80.65e	77.75ab	16.50a	23.22h	9.38a	94.13a	41.60a	147.50
T ₂	V ₁	91.00bc	77.3ab	9.93cde	28.38d	5.9cde	87.22ab	34.53bcd	146.00
	V ₂	91.85bc	72.9bcd	8.83defg	24.33f	5.2hi	81.72bc	30.02def	143.00
	V ₃	83.20dc	76.70b	12.18b	22.13h	7.23b	75.30c	28.35efg	120.00
	V ₄	81.40e	66.70de	9.10defg	17.95j	5.88def	75.80c	23.83gh	124.00
	V ₅	67.70f	57.53f	6.05h	17.63j	4.1j	63.55d	21.48h	148.00
T ₃	V ₁	68.70f	54.70fg	8.25efg	24.38f	5.03i	62.95d	29.40defg	148.00
	V ₂	69.00f	48.90g	7.28gh	23.23fgh	5.2hi	55.43d	28.17efg	144.00
	V ₃	60.90gh	48.90g	7.25gh	23.15fgh	5.28hi	55.90d	28.42efg	119.80
	V ₄	58.70h	47.90g	7.53fgh	20.88i	5.43ghi	55.42d	26.40fgh	124.00
	V ₅	66.70fg	52.70fg	9.08defg	20.13i	5.475fgh	61.78d	25.6fgh	148.50
T ₄	V ₁	84.30cde	70.10cde	9.55cde	28.50d	6.18cd	77.05c	34.50bcd	148.50
	V ₂	85.57cde	69.10de	9.725cde	30.2c	5.88def	79.07c	36.08bc	145.00
	V ₃	68.40f	52.60fg	9.43cdef	25.92e	5.50efgh	62.02d	31.42cdef	120.00
	V ₄	81.00e	65.55e	10.30cd	23.7fg	5.73efg	63.85c	29.40defg	124.00
	V ₅	68.80f	52.80fg	10.40bcd	20.17i	5.50efgh	63.2d	26.92fgh	148.50
Level of Significance		**	**	**	**	**	**	**	NS
CV%		5.45	6.92	12.47	3.49	4.36	6.74	11.43	8.19

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

Where,

T₁= Control (open field), T₂= Black siris, T₃= Guava, T₄= Mango trees

V₁= BR10, V₂= BR11, V₃= BRRI dhan 33, V₄= BRRI dhan 39, V₅= Sorna

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

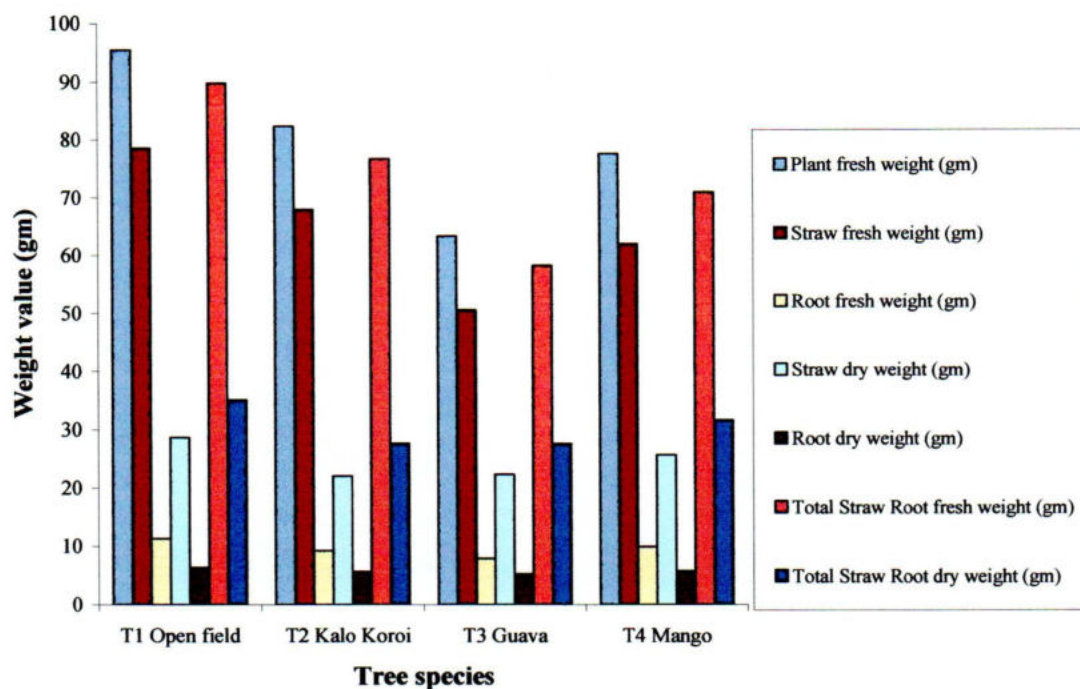


Fig. 04. Effect of tree on plant fresh weight, straw fresh & dry weight plant⁻¹, root fresh & dry weight plant⁻¹, total straw root fresh & dry weight plant⁻¹

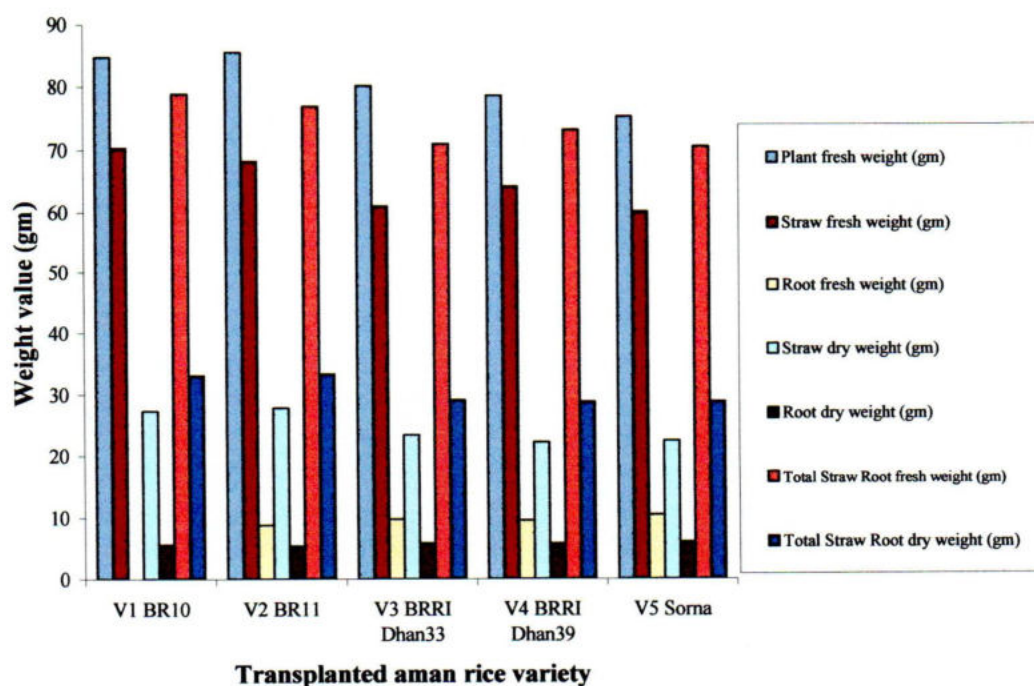


Fig. 05. Effect of variety on plant fresh weight, straw fresh & dry weight plant⁻¹, root fresh & dry weight plant⁻¹, total straw root fresh & dry weight plant⁻¹

Yield and yield contributing characters

4.2.1 Panicle length

Main effect of tree

The panicle length of rice was not significantly affected by the tree due to shading condition. (Table 10). The highest panicle length was (24.62 cm) obtained in T₁ (Open field) and the lowest length was (22.80 cm) under T₄ (Mango).

Effect of rice variety

The panicle length of rice was significantly influenced by the varietal effects (Table 11). The maximum panicle length (25.38 cm) found in BR11 (V₂) and minimum length was (22.13 cm) found in Sorna (V₅). The panicle length of BR10 (V₁) was (24.57 cm) which was statistically similar to that of (V₂) BR11. BRRI dhan 33 (V₃) (23.58 cm) and BRRI dhan 39 (V₄) (22.77 cm) were statistically similar to Sorna (V₅).

Interaction effect of tree and rice variety

The interaction effect of tree and rice variety was not significant on panicle length. (Table 12). The highest panicle length was found (26.17 cm) in T₁V₂ combination and the lowest (19.58 cm) in T₄V₅ combination.

4.2.2 Number of grain

Main effect of tree

The number of grain per panicle of rice was not significantly affected by the shading effect of tree. (Table 10). The highest number of grains per panicle was found (157.4) in T₁ (open field) and the lowest number of grains per panicle was found (146.4) under T₃ (Guava). The results showed that all of them were statistically similar with one another.

Effect of rice variety

The number of grain per panicle was significantly influenced due to the variety (Table 11). Significantly the highest number of grain per panicle (162.6) was obtained from V_2 (BR11) followed by V_1 and V_3 . The lowest grain per panicle (141.6) was found in V_5 (Sorna).

Interaction effect of tree and rice variety

Interaction effect on number of grain per panicle was not significant (Table 12). The highest number of grain per panicle (172.5) was found in T_1V_2 combination while the lowest number of grains per panicle (135.8) was in T_3V_5 combination.

4.2.3 Unfilled grain**Main effect of tree**

Unfilled grains Panicle⁻¹ of rice was significantly affected by the tree (Table 10). The highest unfilled grain Panicle⁻¹ was found (16.16) under T_3 (Guava) and lowest unfilled grain Panicle⁻¹ was found (12.10) in T_1 (open field) which was statistically similar to that of T_4 (Mango).

Effect of rice variety

Unfilled grain Panicle⁻¹ of rice was also significantly influenced due to the varietal effect (Table 11). The maximum unfilled grain Panicle⁻¹ was obtained (17.47) in V_4 (BRRI dhan 39) and minimum unfilled grain panicle⁻¹ was obtained (9.57) in V_2 (BR11). The second highest was obtained (16.90) in V_4 (BRRI dhan 33) which was statistically similar to that of V_4 (BRRI dhan 39).

Interaction effect of tree and rice variety

Interaction effect on unfilled grain Panicle⁻¹ of rice was significant (Table 12) the highest unfilled grain Panicle⁻¹ was found (20.88) in T_3V_4

combination and the lowest unfilled grain Panicle⁻¹ was found (7.18) in T₁V₂ combination.

4.2.4 1000-grain weight

Main effect of tree

Weight of 1000 grain of rice was significantly affected by the tree due to the shedding effect (Table 10). The highest weight of 1000 grain was (20.40 g) obtained in T₁ (open field) and the lowest weight of 1000 grains was (20.12 g) found under T₃ (Guava).

Effect of rice variety

1000 grain weight of rice was also significantly influenced by varietal effect (Table 11). The maximum weight of 1000 grain was found (21.63 g) in V₂ (BR11) which was similar to V₃ and the minimum weight of 1000 grain was (17.43 g) found in V₅ (Sorna).

Interaction effect of tree and rice variety

Weight of 1000 grain of rice showed not significant results due to interaction of trees and varieties (Table-12). The highest weight of 1000 grain was 21.73g in T₁V₂ combination and the lowest 1000 grain weight was (17.38g) in T₁V₅ combination.

4.2.5 Grain yield

Main effect of tree

Grain yield of rice was significantly affected due to the different types of tree species (Table 10). Significantly the highest grain yield (3.855 t ha⁻¹) was produced in T₁ (open field) followed T₂ (3.86 t ha⁻¹) and significantly the lowest yield of rice (3.50 t ha⁻¹) was found under Guava (T₃). The results also showed that grain yield under Black siris (3.86 t ha⁻¹) and under Mango (3.66 t ha⁻¹) were statistically similar.

Effect of rice variety

The results showed that grain yield (t/ha) of rice was significantly affected by the variety (Fig. 7). The maximum grain yield was produced (4.74 t ha^{-1}) in BR11 (V_2) and the second highest yield was produced (4.506 t ha^{-1}) in BR10 (V_1) which was statistically similar to V_2 and the third highest yield was produced (3.181 t ha^{-1}) in BRRI dhan 33 (V_3) which was statistically similar to BRRI dhan 39 (V_4). Significantly the lowest grain yield was produced (2.831 t ha^{-1}) in Sorna (V_5)

Interaction effect of tree and rice variety

Interaction effect of tree and rice variety was showed significant variation on grain yield (Table 12). The highest grain yield was found (5.00 t ha^{-1}) in T_1V_2 followed by (4.82 t ha^{-1}) T_2V_2 combination. The lowest grain yield was found (2.65 t ha^{-1}) in both T_3V_5 and T_4V_5 combination.

Table 10. Effect of tree on yield and yield contributing characters of transplanted Aman rice

Tree	Panicle length (cm)	No of grain/ Panicle	Unfilled grain/ Panicle	1000 grain weight (g)	Yield / plot (Kg)
T ₁	24.62	157.40	12.10c	20.40a	2.41a
T ₂	23.97	150.90	14.42b	20.18b	2.36b
T ₃	23.35	146.40	16.16a	20.12c	2.20c
T ₄	22.80	147.50	12.79c	20.22b	2.30b
Level of Significance	NS	NS	*	*	*
CV%	9.72	6.27	8.33	11.29	8.85

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

Where,

T₁= Control (open field), T₂= Black siris, T₃= Guava, T₄= Mango trees

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Table 11. Effect of variety on yield and yield contributing characters of transplanted Aman rice

Variety	Panicle length (cm)	No of grain/ Panicle	Unfilled grain/ Panicle	1000 grain weight (g)	Yield / plot (Kg)
V ₁	24.57ab	151.10b	11.36c	20.31b	2.81a
V ₂	25.38a	162.60a	9.57d	21.63a	2.96a
V ₃	23.58bc	151.10b	16.90a	21.22ab	1.99b
V ₄	22.77c	146.40bc	17.47a	20.31c	1.94b
V ₅	22.13c	141.60c	14.04b	17.43d	1.77c
Level of Significance	**	**	**	**	**
CV%	9.72	6.27	8.33	11.29	8.85

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

Where,

V₁= BR10, V₂= BR11, V₃= BRR1 dhan 33, V₄= BRR1 dhan 39, V₅= Sorna

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

Table 12. Interaction effect of tree and rice variety on yield and yield contribution characters

Interaction		Panicle length (cm)	No of grain/ Panicle	Unfilled grain/ Panicle	1000 grain weight (g)	Yield / plot (Kg)
T ₁	V ₁	25.38	154.00	8.85h	20.38	2.97b
	V ₂	26.17	172.50	7.18i	21.73	3.13a
	V ₃	24.63	166.00	16.63c	21.27	2.10e
	V ₄	23.77	148.80	16.80c	20.27	1.98f
	V ₅	23.15	146.00	11.05fg	17.38	1.86fg
T ₂	V ₁	24.30	152.50	13.93e	20.30	2.83bc
	V ₂	25.35	168.30	11.13g	21.70	3.01b
	V ₃	23.63	148.80	18.58b	21.08	2.04e
	V ₄	23.35	148.30	15.70c	20.33	2.04e
	V ₅	23.23	146.50	12.77ef	17.50	1.90f
T ₃	V ₁	24.33	149.00	13.57e	20.17	2.67d
	V ₂	24.75	157.50	11.05fg	21.42	2.86bc
	V ₃	22.58	145.00	18.55b	21.27	1.90f
	V ₄	22.55	145.00	20.88a	20.27	1.86fg
	V ₅	22.55	135.80	16.75c	17.45	1.66h
T ₄	V ₁	24.27	149.00	9.10h	20.40	2.79c
	V ₂	25.25	162.00	8.93h	21.65	2.86bc
	V ₃	23.48	144.50	13.85de	21.25	1.90f
	V ₄	21.40	143.80	16.50c	20.38	1.90f
	V ₅	19.58	138.30	15.58cd	17.40	1.66h
Level of Significance		NS	NS	**	NS	*
CV%		9.72	6.27	8.33	11.29	8.85

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

Where,

T₁= Control (open field), T₂= Black siris, T₃= Guava, T₄= Mango trees

V₁= BR10, V₂= BR11, V₃= BRRI dhan 33, V₄= BRRI dhan 39, V₅= Sorna

** = Significant at 1% level of probability,

* = significant at 5% level of probability,

NS= Not significant.

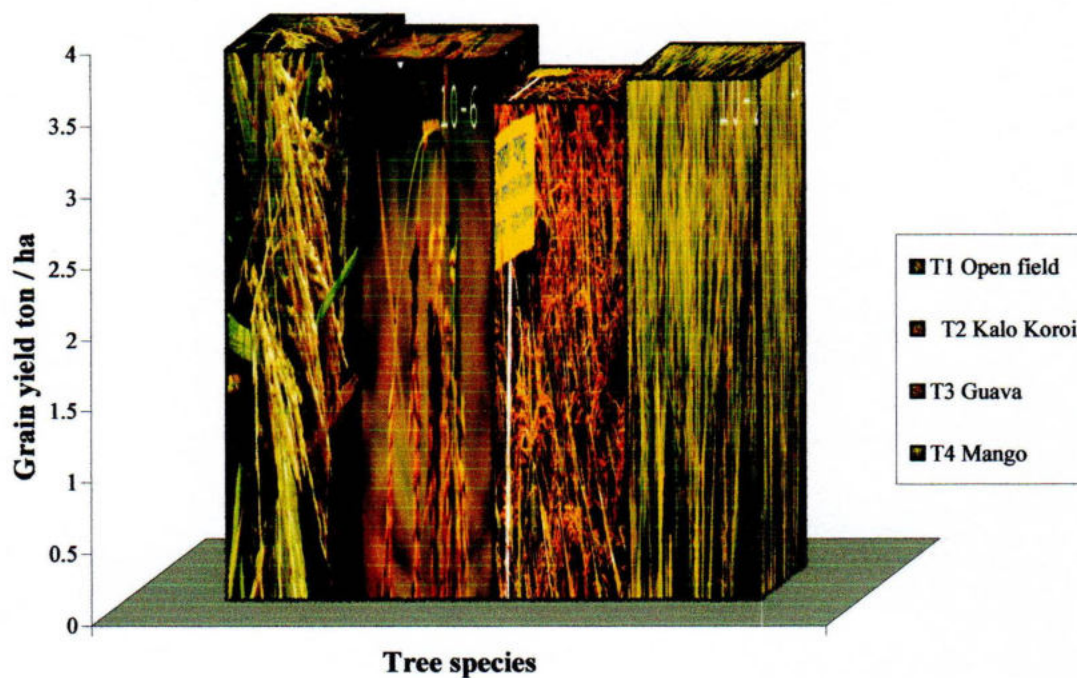


Fig. 06. Effect of tree on grain yield ton / ha.

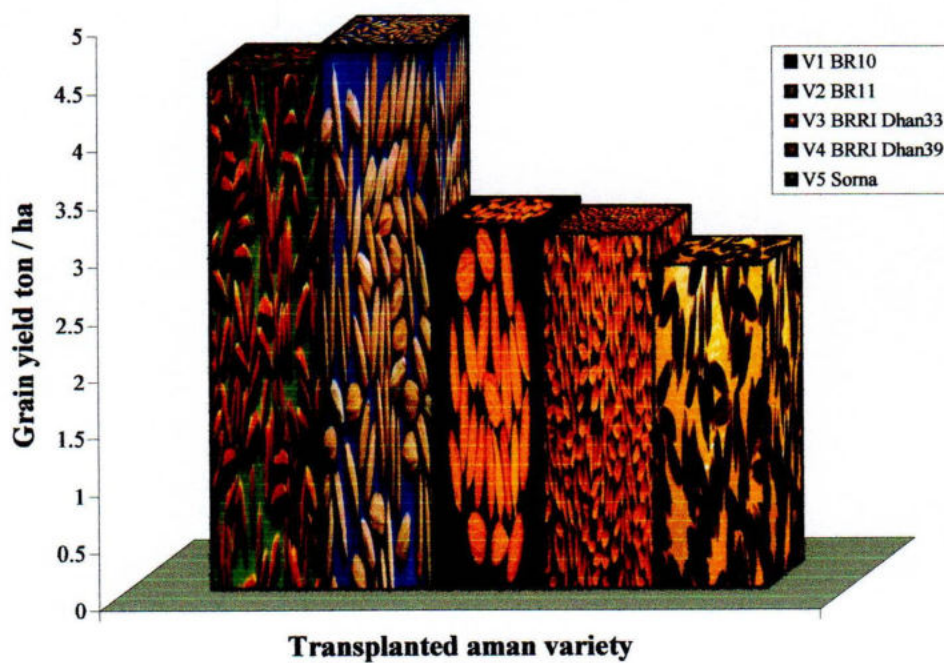


Fig. 07. Effect of variety on grain yield ton / ha.

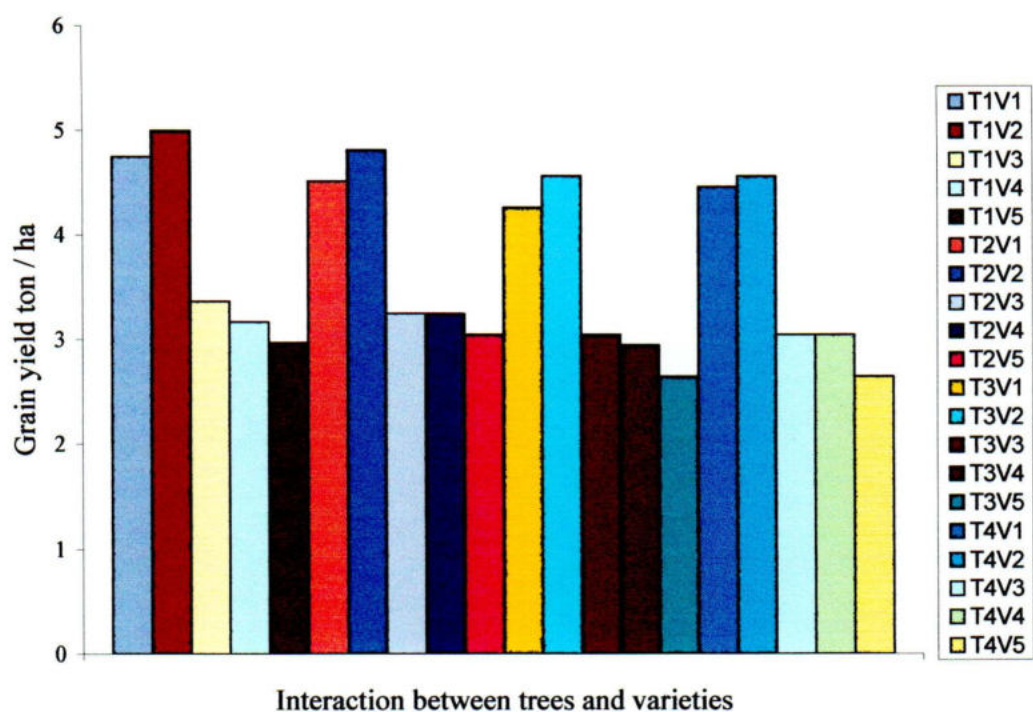


Fig. 08. Interaction effect of tree and rice variety on grain yield ton / ha.

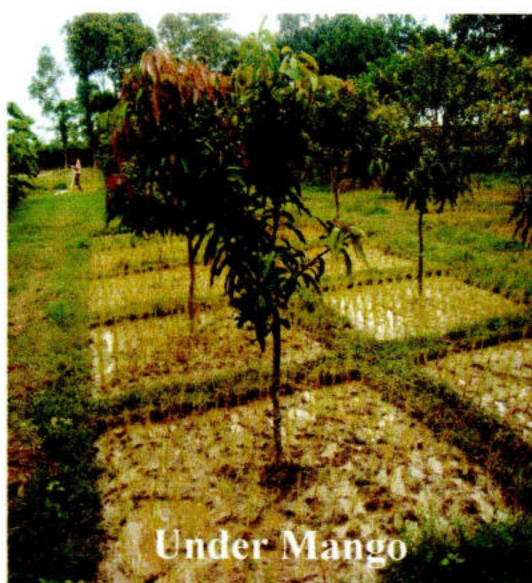
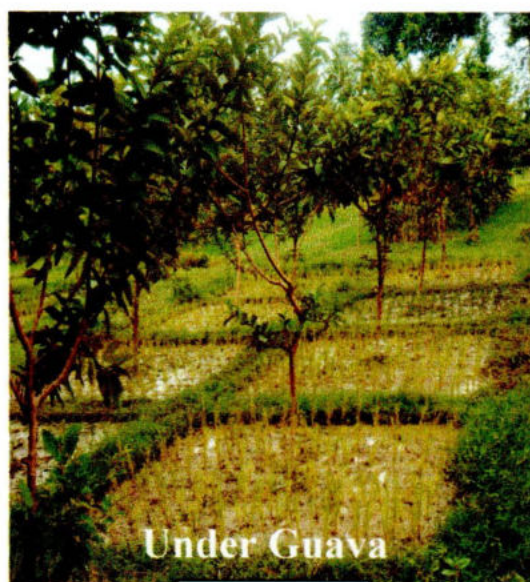
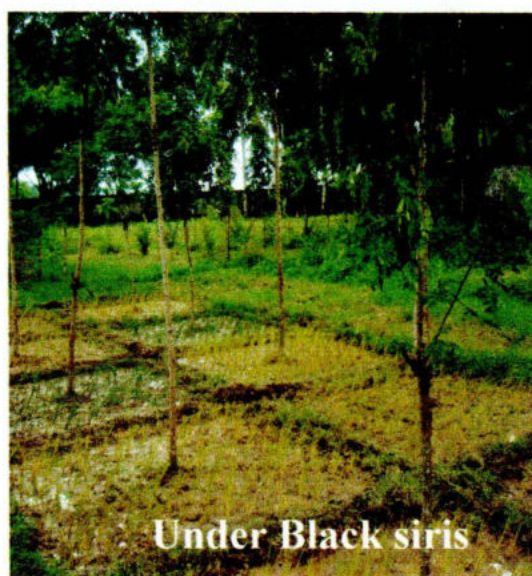
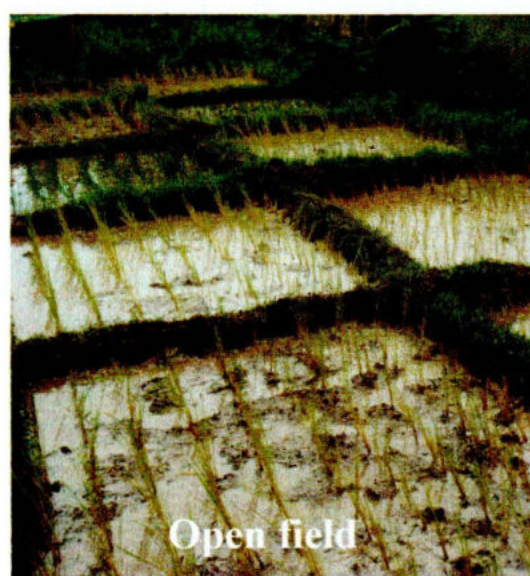
**T₄****T₃****T₂****T₁**

Plate 01. Different transplanted aman rice variety were shown in different treatment at early stage (T₁= open field, T₂= under Black siris, T₃= under guava and T₄= under mango trees).

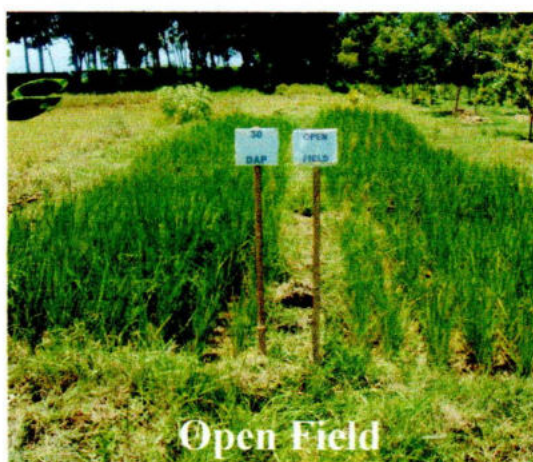
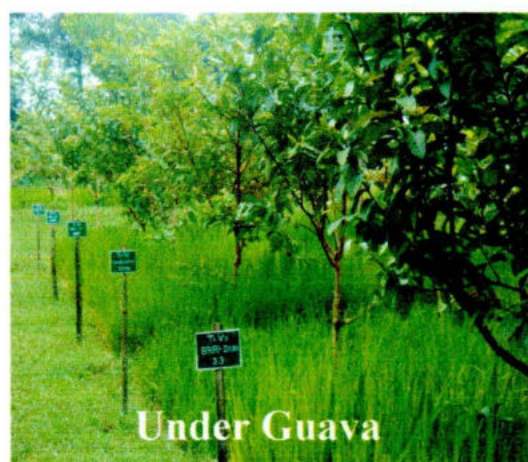
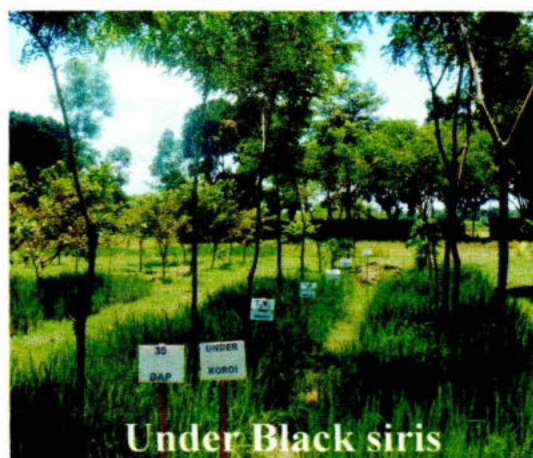
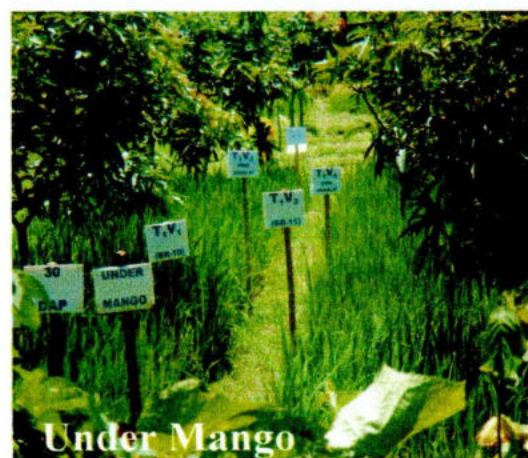
 T_1  T_3  T_2  T_4

Plate 02. Different transplanted aman rice variety 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).

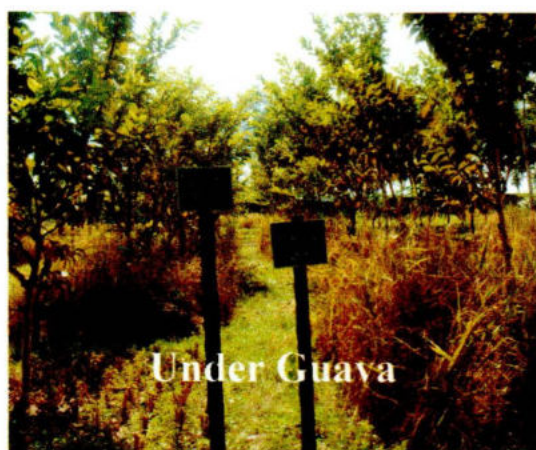
**T₁****T₂****T₃****T₄**

Plate 03. Different transplanted aman rice variety were shown in different treatment at harvesting stage (T₁= open field, T₂= under Black siris, T₃= under guava and T₄= under mango trees).

The cultivation of rice in association with different multipurpose tree species is now not a popular practice in our country. It is rarely practiced in some northern districts (Rangpur, Dinajpur, Rajshahi etc.) of Bangladesh.

There is a huge diversity of agroforestry systems throughout the world, in which the incorporation of bushes and trees results in many benefits. Trees improve the microclimate and water holding capacity of the soil. This system is now getting popularity among the farmers of the country in comparison with last several decades. The present research has been undertaken to evaluate the performance of vegetative growth, yield and yield contributing characters of five transplanted aman rice varieties cv. BR10, BR11 BRRI dhan 33, BRRI dhan 39 and Sorna in association with Black siris, Guava and Mango as compared to the open field. The selected 3 tree species was (3) years old. The average plant height of Black siris 3.80 m which was higher than Mango and Guava, and average canopy diameter 100 cm of Black siris which was lower than Mango and Guava.

In tree rice association, it observed that under Black siris respective variety was produced better yield than other trees. The reasons might be Black siris is a deciduous tree and shade casting was less because of low canopy size (100 cm) and plant height was the highest (3.8 m) than Mango and Guava. Guava exhibited low performance because of dense crown shape than Black siris and Mango trees. In case of control treatment yield and yield contributing parameters showed the best performance. These results well agreed with Hocking and Islam (1995), who reported that rice cultivars grown under *Acacia nilotica* and *Borassus flabellifer* tree produced lower grain yield, dry matter yield and grains/ panicle compared with crops grown in the open field.

It was observed highest yield of rice (3.78 ton/ha) was recorded under T₂ (Black siris) followed by (3.66 ton/ha) under T₄ (Mango). The lowest grain yield (3.5 t ha⁻¹) was obtained under T₃ (Guava). This result is more or less similar to the findings of Roy *et al.* (2005) they reported that grain and straw yields of rice were significantly influenced by tree species. The highest grain yield (3.27 t ha⁻¹) and straw yield (3.82 t ha⁻¹) were obtained from plots with *M. azadarach* and the lowest grain (2.57 t ha⁻¹) and straw (2.87 t ha⁻¹) yield were obtained from plot with *Albizia lebbeck*.

Now regarding differential varietal effect the plant height at 30, 45, 60, 75 DAT, number of effective tiller at 45, 60, 75 DAT, number of leaf/hill, length & breadth of leaf blade at 30 DAT, panicle length, no. of grain/panicle, unfilled grain/panicle, 1000 grain weight and yield (ton/ha) was significantly different. The highest plant height (68.58 cm), (87.11 cm), (99.00 cm) and (112.8 cm) at 30, 45, 60 and 75 DAT was found in V₂. The number of effective tiller (12.68), (13.67) and (12.57) at 45, 60 and 75 DAT was found in V₂ which was statistically similar to that of V₁. The highest panicle length (25.38cm), number of grain/panicle (162.6) was observed in V₂. The highest unfilled grain / panicle (17.47) was recorded in V₄. The highest 1000 grain weight (21.63g) was found in V₂. Grain yield was found highest (2.96 Kg/plot) in V₂. The results showed that V₂ (BR 11) produced highest yield because it is the high yielding modern variety and partial shade tolerant.

From the interaction effect of tree and rice variety number of leaf/hill, length & breadth of leaf blade, plant height at 30, 45 and 75 DAT, no. of effective tiller at 45 DAT unfilled grain/panicle, grain yield, plant fresh weight, straw – root fresh & dry weight/plant was significantly different. But plant height at 60 DAT, no of effective tiller at 30, 60 and 75 DAT, Panicle length (cm), no. of grain/panicle, 1000 grain weight (g) and days of maturity were not

significant. The highest plant height (71.70 cm), (90.03 cm) and (116.40 cm) at 30, 45 and 75 DAT was observed in T₂V₂, T₂V₂, & T₄V₁ Combination. The lowest plant height (46.17 cm), (65.95 cm), (86.57 cm) was found in T₄V₅, combination at 30, 45 and 75DAT. The highest no of effective tiller (13.73) at 45 DAT was recorded in T₁V₂ combination and the lowest (9.85) was found in T₃V₃ at 45 DAT. The highest yield (5.00 t/ha) was found in T₁V₂ combination followed by (4.82 /ha) in T₂V₂ combination. The lowest yield combination (2.65 t/ha) was found in both T₃V₅ and T₄V₅.

Reduction of yield and yield contributing characters of rice varieties under different tree-rice association in the present investigation might be due to shading (lack of appropriate light intensities) effect. However, research report is not available in relation to the research lower grain yield under shade was due to the cumulative effect of reduction in the number of effective tillers hill⁻¹, number of grains panicle⁻¹ and plant height and increase in sterility of panicles, 1000 grain weight. Jadhav (1987) and Chaturvedi and Ingram (1989) have reported similar results.

CHAPTER 5

SUMMARY AND CONCLUSION

CHAPTER 5

SUMMARY AND CONCLUSION

A field experiment was carried out at the agroforestry, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, during June 2006 to November 2006 to evaluate the performance of 5 transplanted Aman rice variety under 3 multipurpose tree species in Agroforestry system. The experiment was conducted in newly established orchard of multipurpose tree species namely *Mangifera indica* (Mango), *Albizia lebbeck* (Black siris) and *Psidium guajava* (Guava) the tree saplings were planted at the spacing (3 m×3 m) in the year 2004 (3 years old)

The experiment included five recommended modern transplanted Aman rice varieties viz, (BR10, BR11, BRRRI dhan 33, DRRI dhan 39 and Sorna), the experiment was laid out in split plot design with four replications. The unit plot size was 2.5 m×2.5 m (6.25 m²). Before transplanting, the land was fertilized by using fertilizer rate 180 kg/ha Urea, 100 kg/ha TSP, 70 kg/ha MP and 5-7 ton cow dung respectively. Urea fertilizer was used 3 times in equal portion 1st application during final land preparation, 2nd 15 DAT and finally 45 DAT in top dressing method followed by irrigation. Seeds of rice were sown 4th June 2006 in seed bed and 10th July transplanted in to the main plots. After transplanting necessary intercultural operations were done accordingly. Eight (two from each orientation) hills were randomly selected from each unit plot for recording different data in each plot on plant characters.

The data were recorded two broad heads, i) growth stage ii) harvesting stage. The data were analyzed statistically and means were adjusted by DMRT (Duncan's Multiple Range Test). The results of the research were showed that effect of trees were significant in respect of number of leaf/hill, length &

breadth of leaf blade, plant height (cm) at 30 DAT, plant fresh weight, straw-root fresh & dry weight plant⁻¹, unfilled grain per panicle, 1000 grain weight and grain yield respectively. Plant height at 45, 60 and 75 DAT, number of effective tiller at 30, 45, 60 and 75 DAT panicle length, number of grain / panicle, days to maturity were not significant. The effect of tree on yield of rice variety (3.855 t/ha) was produced highest under T₁ and the lowest (3.66 t/ha) under T₃. The second highest (3.78 t/ha) was produced under Black siris followed by (3.66 t/ha) under T₄. The result was revealed that the production of rice will be ranked as Open field > Black siris > Mango > Guava.

Due to the varietal effect, the results showed that significantly influenced on varieties. The result was found significant in respect of number of leaf/hill, length & breadth of leaf blade plant height and number of tiller/hill at 30 DAT, plant height & number of effective tiller at 45, 60 and 75 DAT, plant fresh weight, straw-root fresh & dry weight plant⁻¹, panicle length, number of grain/panicle, unfilled grain/panicle, 1000 grain weight, grain yield and days to maturity respectively. The highest plant fresh weight (85.61 gm) was found in V₂ and followed by (84.75 gm) in V₁. The lowest plant fresh weight (75.40 gm) was found in V₅. The second highest plant fresh weight (80.25 gm) in V₃ followed by (78.70 gm) in V₄ respectively. The highest grain yield (4.744 t/ha) was found in V₂ followed by (4.506 t/ha) in V₁ and the lowest grain yield (2.831 t/ha) was found in V₅. The second highest grain yield (3.181 t/ha) was observed in V₃ followed by (3.106 t/ha) in V₄. Therefore, it will be mentioned that most of the transplanted Aman rice variety suitable for yield in shade condition ; but their degree of suitability will be as BR11 > BR10 > BRRI dhan 33 > BRRI dhan 39 > Sorna.

On the other hand, the highest number of grain/panicle (172.50) was found in T₁V₂ combination and second highest number of grain (168) T₂V₂ combination, The highest 1000 grain weight (21.73 gm) was found T₁V₂ and followed by (21.70) obtain from T₂V₂ combination. From the results and foregoing discussion, it is clear that open field is so good for the production

of Aman rice but in avocation of MPT_s like (Black siris, Guava, Mango trees) it could be grown well, Based of the findings of the experiment it will be concluded that under the Black siris tree appears as the best than other trees. The results of this experiment clearly included that the choice of species of tree and Aman rice variety for an Agroforestry cultivation system is very significant. Therefore, before making choice about the shade plants the crop which is usually supposed to be grown in partial shade condition BR11 was performed statistically best in point of yield contributing character in association with Black siris T₂V₂ arrangement respectively.

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APPENDICES

Appendix I. The chemical properties of soil in Agroforestry farm HSTU, Dinajpur

Soil characters	Physical and chemical properties
Texture	
Sand (%)	65
Silt (%)	30
Clay(%)	5
Textural class	Sandy loam
CEC (meq/ 100g)	8.07
p ^H	5.35
Organic matter (%)	1.06
Total nitrogen (%)	0.10
Sodium (meq/ 100g)	0.06
Calcium (meq/ 100g)	1.30
Magnesium (meq/ 100g)	0.40
Potassium (meq/ 100g)	0.26
Phosphorus (µg/g)	24.0
Sulphur (µg/g)	3.2
Boron (µg/g)	0.27
Iron (µg/g)	5.30
Zinc (µg/g)	0.90

Source: Soil Resources Development Institute, Dinajpur (2006).

**Appendix II. Weather data of the experimental site during the period
from July to November, 2006**

Month	* Air Temperature (C)			*Rainfall (mm) (Minimum)	*Relative Humidity (%)
	Maximum	Minimum	Average		
July	31.72	26.54	29.13	130	85.58
August	31.64	26.32	28.98	128	88.35
September	30.54	25.43	27.99	254	89.93
October	31.62	23.86	27.74	370	86.10
November	29.70	19.09	24.40	00	82.37

* = Monthly average

Source: Meteorological Station, Wheat Research Center, Nosipur, Dinajpur (2006).

Appendix III. Monthly average light intensity during June to November 2006

Month	Date	Light intensity at different time of the day (lx)			Total light intensity (lx)	Average light intensity (lx)	Monthly mean light intensity (lx)
		10 AM	12 AM	4 PM			
June	06.6.06	36200	37600	35700	109500	36500	28891
	13.6.06	29700	37200	32400	99300	33100	
	20.6.06	22000	23200	22600	67800	22600	
	27.6.06	23800	24700	21600	70100	23366	
July	04.7.06	30200	33300	22800	86300	28766	40191
	11.7.06	42200	47300	41600	131100	43700	
	18.7.06	38800	47700	40100	126600	42200	
	25.7.06	40700	56200	41400	138300	46100	
August	01.8.06	41100	50800	42200	134100	44700	44624
	08.8.06	40700	48100	43300	132100	44033	
	15.8.06	41000	50200	40900	132100	44033	
	29.8.06	42200	52000	43000	137200	45733	
September	05.9.06	41400	49900	43200	134500	44833	41291
	12.9.06	40500	47600	39700	127800	42600	
	19.9.06	39200	45100	38500	122800	40933	
	26.9.06	36400	42200	36600	115200	38400	
October	03.10.06	35900	41100	36000	113000	37666	36383
	17.10.06	35200	40000	33600	108800	36266	
	24.10.06	34900	39600	33800	108300	36100	
	31.10.06	34700	38600	33200	106500	35500	
November	07.11.06	34100	37500	35900	107500	35833	34116
	14.11.06	33600	36300	34000	103900	34633	
	21.11.06	33100	35500	31400	100000	33333	
	28.11.06	32500	34700	30800	98000	32666	

Appendix IV. Summary of analysis of variance (Mean square values) for plant height and number of effective tiller/hill

Source of Variation	Degrees of Freedom	Plant height (cm)				Number of effective tiller/hill			
		30 DAT	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Replication	3	359.00**	431.04**	283.42**	204.42**	11.49 ^{NS}	29.85**	16.76 ^{NS}	29.29**
Factor A	3	129.19**	45.81 ^{NS}	91.24 ^{NS}	31.54 ^{NS}	0.54 ^{NS}	10.89 ^{NS}	15.40 ^{NS}	3.12 ^{NS}
Error	9	16.52 ^{NS}	24.95 ^{NS}	62.96 ^{NS}	21.93 ^{NS}	3.33 ^{NS}	3.34 ^{NS}	4.78 ^{NS}	5.17 ^{NS}
Factor B	4	1274.91**	1108.47**	1535.77**	1613.96**	4.32**	11.58**	10.60**	6.95**
AB	12	32.16**	59.00**	40.37 ^{NS}	50.59**	0.42 ^{NS}	1.07 ^{NS}	0.57 ^{NS}	1.55 ^{NS}
Error	48	5.69 ^{NS}	9.38 ^{NS}	21.42 ^{NS}	18.53 ^{NS}	1.25 ^{NS}	1.32 ^{NS}	1.86 ^{NS}	1.80 ^{NS}
CV(%)		3.99	3.90	5.18	4.19	7.74	10.16	10.87	11.55

* = Indicate significant at 5% level of probability

** = Indicate significant at 1% level of probability

NS= Not significant

Appendix V. Summary of analysis variance (mean square values) for plant fresh wt, straw fresh weight, root fresh wt, straw dry wt, root dry wt, straw root fresh wt, straw root dry wt, days to maturity

Source of Variation	Degrees of Freedom	Plant fresh weight (g)	Straw fresh wt (g)	Root fresh wt (g)	Straw dry wt (g)	Root dry wt (g)	Straw root fresh wt (g)	Straw root dry wt (g)	Days of maturity
Replication	3	774.83	988.54**	7.60 ^{NS}	19.03**	4.08**	930.07**	51.49 ^{NS}	764.41 ^{NS}
Factor A	3	3528.90**	2725.05**	40.93**	194.84**	4.62**	3439.56**	261.63**	4.77 ^{NS}
Error	9	59.94 ^{NS}	54.08 ^{NS}	2.94 ^{NS}	1.07 ^{NS}	0.04 ^{NS}	53.38 ^{NS}	26.23 ^{NS}	332.43 ^{NS}
Factor B	4	286.42**	313.22**	6.32**	115.83**	1.07**	239.71**	97.86**	3032.55**
AB	12	142.30**	90.02**	17.50**	39.66**	5.27**	137.67**	61.57**	1.46 ^{NS}
Error	48	18.89 ^{NS}	20.10 ^{NS}	1.42 ^{NS}	0.74 ^{NS}	0.06 ^{NS}	24.87 ^{NS}	12.15 ^{NS}	124.47 ^{NS}
CV (%)		5.45	6.92	12.47	3.49	4.35	6.74	11.43	8.16

* = Indicate significant at 5% level of probability

** = Indicate significant at 1% level of probability

NS= Not significant

Appendix VI. Summary of analysis of variance (mean square values) for panicle length, number of grain/panicle unfilled grain/panicle, 1000 grain weight, grain yield

Source of Variation	Degrees of freedom	Panicle length (cm)	No. of grain/panicle	Unfilled grain/panicle	1000 grain wt (g)	Yield (Kg/plot)
Replication	3	12.04 ^{NS}	604.61 ^{NS}	18.19 [*]	14.27 [*]	1.57 [*]
Factor A	3	12.39 ^{NS}	492.07 ^{NS}	65.63 ^{**}	0.03 [*]	0.58 [*]
Error	9	14.62 ^{NS}	271.33 ^{NS}	3.43 ^{NS}	13.51 ^{NS}	0.63 ^{NS}
Factor B	4	27.77 ^{**}	965.84 ^{**}	187.79 ^{**}	43.03 ^{**}	12.45 ^{**}
AB	12	2.31 ^{NS}	69.48 ^{NS}	11.89 ^{**}	0.03 ^{NS}	0.02 [*]
Error	48	5.30 ^{NS}	89.25 ^{NS}	1.33 ^{NS}	5.18 ^{NS}	0.22 ^{NS}
CV (%)		9.72	6.27	8.33	11.29	8.85

* = Indicate significant at 5% level of probability

** = Indicate significant at 1% level of probability

NS= Not significant

Appendix VII. Effect of tree on grain yield (t/ha) of transplanted Aman rice

Tree	Yield (ton/ha)
T ₁	3.855a
T ₂	3.78 b
T ₃	3.50 c
T ₄	3.66 b
Level of Significance	*
CV%	8.85

Appendix VIII. Effect of rice variety on grain yield (t/ha) of transplanted Aman rice

Variety	Yield (ton/ha)
V ₁	4.506 a
V ₂	4.744 a
V ₃	3.181b
V ₄	3.106b
V ₅	2.831c
Level of Significance	**
CV%	8.85



Appendix IX. Interaction effect of tree and rice variety on grain yield (t/ha)

Interaction		Yield (ton/ha)
T ₁	V ₁	4.75b
	V ₂	5.00a
	V ₃	3.37e
	V ₄	3.17f
	V ₅	2.97fg
T ₂	V ₁	4.52bc
	V ₂	4.82b
	V ₃	3.25e
	V ₄	3.25e
	V ₅	3.05f
T ₃	V ₁	4.27c
	V ₂	4.57bc
	V ₃	3.05f
	V ₄	2.95fg
	V ₅	2.65h
T ₄	V ₁	4.47c
	V ₂	4.57bc
	V ₃	3.05f
	V ₄	3.05f
	V ₅	2.65h
Level of Significance		*
CV%		8.85