ALLELOPATHIC EFFECT OF FOUR AGROFORESTRY TREE SPECIES ON THE GERMINATION AND GROWTH OF TWO WHEAT VARIETIES

A THESIS

BY

MD. ROKONUZZAMAN

Registration No. 1605107
Session: 2016
Thesis Semester: January-June, 2017

MASTER OF SCIENCE (M.S.)

IN

AGROFORESTRY AND ENVIRONMENT

DEPARTMENT OF AGROFORESTRY AND ENVIRONMENT

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

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June 2017

Dedicated

To

My Beloved Parents

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June 2017 ***The Author***

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ABSTRACT

An experiment was conducted at the research field of Agroforestry and Environment Department, Hajee Mohammad Danesh Science and Technology University, Bangladesh during the period of November 2016 to March 2017 to find out the allelopathic effect of four tree species on the germination, root architecture, shoot growth and yield of two wheat varieties (BARI Gom-27 and BARI Gom-28). There were five treatments including control viz. T_1 (Ghora neem tree leaf), T_2 (Ipil- ipil tree leaf), T_3 (Mango tree leaf), T_4 (Sada koroi tree leaf) and T_5 (only water; Control). There were two experiments; Experiment-1 was done in laboratory condition to test the allelopathic effect of four tree species on the germination of tested wheat varieties in Petridis and Experiment-2 was done in field condition to find out the allelopathic effect of trees on the germination, growth root architecture and yield. The concentration used in the laboratory experiment for each dry leaf powder was 5%. In case of field experiment 20g dry leaf powder were mixed in each experimental plot of size 1.5ft × 1.5ft. In case of laboratory experiment, germination percentage of BARI Gom-27 was highest (95%) in Control condition followed by Sada koroi leaf extract (60%), Mango leaf extract (40%), Ipil-ipil leaf extract (45%) and lowest percentage (20%) was found in Ghora neem leaf extract. In the same way, in case of BARI Gom- 28, the highest germination percentage (90%) was recorded in Control treatment, followed by Sada koroi leaf extract (39%), Ipil ipil leaf extract (33%), Mango leaf extract (30%) and lowest (21%) was recorded in Ghora neem leaf extract. Again in field experiment, BARI Gom-27 gave the highest (88.16%) germination in Control treatment followed by Ipil-ipil tree leaf extract (84.1%), Mango tree leaf extract (82.36%), Sada koroi leaf extract (78.88%) and lowest germination percentage (77%) was found in Ghora neem leaf extract. Likewise, germination percentage of BARI Ghom-28 was found highest (85.26%) in Control and lowest (73.66%) was found in Sada koroi leaf extract. In BARI Gom-27, the highest yield (2047.61kg/ha) was observed in Control followed by Sada koroi leaf extract (1666.67 kg/ha), Ipil-ipil leaf extract (1380.09 kg/ha), Mango leaf extract (1238.09 kg/ha) and lowest (1000 kg/ha) was in Ghora neem leaf extract. In the same way in case of BARI Gom-28 the highest (1857.14 kg/ha) yield was recorded in Control followed by Sada koroi leaf extract (1523.81 kg/ha), Ipil-ipil leaf extract (1285.71kg/ha), Mango leaf extract (1190.47 kg/ha) and lowest (1095.23 kg/ha) was in Ghora neem leaf extract. Finally it can be concluded that among the two wheat varieties, BARI Gom-27 gave good result in respect to the allelopathic of the tested four tree species. Among the four tested tree species, Sada koroi leaf extract was less allelopathic effect on wheat. So, BARI Gom-27 can be cultivated in association with Sada koroi tree. I think both BARI Gom-27 and 28 can be growth under sada koroi because 1.6 t/ha in 27 1.5 t/ha in statistically no difference.

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LIST OF ABBREVIATIONS

AEZ	:	Agro Ecological Zone
BARI	:	Bangladesh Agriculture Research Institute
BBS	:	Bangladesh Bureau of Statistics
CRD	:	Complete Randomized Design
DAS	:	Day After Sowing
FAO	:	Food and Agriculture Organization
ft	:	Feet
g	:	Gram
kg	:	Kilogram
mt	:	Metric tone
sqm	:	Square Meter
t	:	Ton

CHAPTER 1

INTRODUCTION

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INTRODUCTION

Combination between tree and crops interacts dynamically and provides multi-faceted aspects of improvement such as increased productivity, enrichment of soil with organic matter and nitrogen, transport of nutrients from lower to the upper layer of soil, conservation of environment and improved microclimates (Singh *et al.*, 2012). Allelopathy is also one amongst them when it comes to combine the both trees and crop for sustainable land use and to increase food production (Asrafi *et al.*, 2007). As trees remain a part of the agroforestry system for a longer period, and most of them produce a large amount of leaves and litter, their allele-chemical may play an important role in an overall improvement (Singh *et al.*, 2012). Allelopathy can play a major role in enhancing the production and productivity in agroforestry system by having the better understanding about tree-crop combination. Chemicals are used heavily in chemical farming for various purposes. While all pesticides can harm humans, insecticides and herbicides cause most human intoxication. The lowest quality pesticides are used in under-developed countries due to the inability of farmers to purchase more expensive and safer products. A study of Bangladesh Organic products Manufactures Association (2014) shows that, conventional agriculture depends on chemical fertilizers and toxic pesticides which are harmful to human health and which enter the food supply, penetrate water source, harm the livestock, deplete the soil and devastate natural eco-system. So, it is urgent need to find out the alternative to chemical pesticide to reduce the environment degradation and human health. Bio-pesticides can be a way to salvation from the negative impacts of chemical pesticides. But there is not any notable experiment occurred about the invention of bio-pesticides in organic farming. That’s why, pest management through bio-pesticide prepared from the allelopathic power of trees and crops can be a better solution for sustainable agroforestry with better environment condition and human health (Rahman *et al.*, 2010).

Leaf powder and other biomass constitute an important resources. Leaf litter management, quantity and quality of biomass applied to the soil, has a significant impact on soil quality and resilience, agronomic productivity and greenhouse gas emissions from soil to the atmosphere (FAO,1993) Soil quality and resilience have a profound impact on productivity and environment quality and soil quality is affected by leaf powder management (Doran *et al*., 1994).

Many researchers worked on the allelopathic effect of tree on different crops (Wu *et al.*, 2001; Sexena, 1984; Salam and Kato, 2010; Sahoo *et al.*, 2010). But leaf allelopathic effect of Gora neem, Ipil-ipil, Mango and Sada Koroi on BARI Gom-27 and BARI Gom-28 is rare. But before going to cultivate wheat under Gora neem, Ipil-ipil, Mango and Sada Koroi based cropland Agroforestry system, we should need to evaluate the allelopathic effects of the leaves of these trees on wheat. Considering the above fact, the present study was under taken to satisfied the following objectives:

Objectives:

i. To observe the allelopathic effect of trees on germination and morphologies of two wheat varieties.
ii. To find out the effect of leaf allelopathic effect on the biomass allocation of two wheat varieties.
iii. To determine the yield of wheat due to allelopathic effect.
iv. To find out the best wheat varieties in respect of allelopathic effects of four trees.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

The available literatures related to the present experiment are thoroughly reviewed and presented in this chapter under different sub headings.

2.1 Concept of Agroforestry

Agroforestry is an old system although its emergence as an academic discipline is quite new. Agroforestry practices combine agriculture and forestry on the same piece of land. Agroforestry system is defined as the sustainable management system for land that increases overall production, combines agricultural crops, trees and forest plants and/or animals simultaneously or sequentially and applies management practices, which are compatible with the cultural patterns of a local population (Bene *et al.*, 1977).

Saxena (1984) pointed out that agroforestry utilizes the inter space between tree rows for intercropping agricultural crops and that does not impair the growth and development of the trees but enables farmers to derive extra income in addition to benefits accrued from the use of fuel and timber from trees.

Nair (1977) defined agroforestry as a land use system that integrates trees, crops and animals in a way, which is scientifically sound, ecologically desirable, practically feasible and socially acceptable to the farmers.

King (1978) stated that agroforestry might be considered to be practiced whenever trees and agricultural crops are grown in mixture, provided that the combined widths of the rows of agricultural crops do not exceed the heights of the forest trees at maturity and provided further that the combined widths of rows of forest trees do not exceed the height of the tree crops at maturity or at some selected rotations.

It was hypothesized by Nair (1987) that an agroforestry system can play an important role in improving soil fertility by (i) increasing organic matter content of soil through addition of leaf' litter, pruning and other biomass (ii) efficient nutrient recycling within the system, (iii) biological N_2 fixation in case of leguminous shrubs and tree and (iv) possible complementary interactions among associated species due to differences in canopy structures, root systems and active zones of water-nutrient absorptions.

A widely used definition given by the International Council for Research in Agroforestry (ICRAF) is that agroforestry is a collective name for all land use system and practices where woody perennials are deliberately grown on the same form of spatial mixtures or in temporal sequences. There must be significantly ecological and economic interactions between woody and non woody components (Nair, 1987).

According to Solanki (1998), agroforestry can significantly contribute in increasing demands of fuel wood, fodder and cash flows and infrastructures 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 of output of economic goods (fuel, fodder, small timber, organic fertilizer etc.) and (iii) producing stable employment, improved income and basic material to rural populations.

Agroforestry does not mean planting trees in the fields or other places; rather it provides farmers with an effective land management system that can ensure more production in a balanced ecological environment (Haque, 1996).

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

A common hypothesis is strongly implied to the agroforestry systems that integration of trees with annual crops improves the chemical properties of the soil (Von Maydell, 1987).

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 a mixed canopy intercepts more solar energy.

Saka *et al*. (1990) stated that an agroforestry system can provide a sound ecological basis for increased crop and animal productivities, more dependable economic returns and greater diversities in social benefits on a sustained basis.

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

2.2 Effect of Tree-Crop Interaction in Agroforestry System

Saxena (1984) point out that agroforestry utilizes the inter space tree rows for intercropping with agricultural crops, this does not impair the growth and development of the trees but enables farmers to derive extra income in addition to benefits accrued from the use of fuel and timber from trees.

Akter *et al.* (1989) mentioned that farmers also considered tree as savings and insurance against risk of crop failure and low yield, as well as assets for their children. Some farmers stated that tree would contribute towards expenses for marriage of their daughters. In tree crop agroforestry system tree species are grown and managed in the farmland along with agricultural crops. The aim is to increase the overall yield of the land. This system is also based on the principle of sustained yield (Nair, 1990).

Agroforestry is the integration of tree and crop or vegetable on the same area of land is a promising production system for maximizing yield and maintaining friendly environment (Nair, 1990).

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

2.3 Performance of crops in agroforestry systems

Wu *et al.* (2001) experimented on the study considering the second most produced food among the cereal crops, wheat was another member of the Triticeae tribe and had allelopathic potential for the management of weeds, pests and diseases. Its allelopathic activity was due to the release of a broad set of allelochemicals, including phenolic acids (p-hydroxybenzoic, vanillic, p-coumaric, syringic and ferulic acids), hydroxamic acids and short-chain fatty acids. Both wheat residue allelopathy and wheat seedling allelopathy can be used for managing weeds, including resistant biotypes. Wheat varieties differ in allelopathic potential against weeds, indicating that the selection of allelopathic varieties may be a useful strategy in integrated weed management. Oueslati (2003) evaluated the allelopathic effects of diluted extracts from the roots, leaves and stems of two varieties (Karim and Om rabii) of durum wheat (*Triticum durum* L.) on germination rate and radicle length of one barley (*Hordeum vulgare* L. cultivarManel) and one bread wheat (*T. aestivum* cultivar Ariana). The leaf extract was more effective at depressing radicle length in both crops. Based on the results, the author suggests that durum wheat heterotoxicity could be depressive to crops in a sequence. Krogh *et al*., (2006) incorporated wheat and rye sprouts into the soil in order to follow the fate of the allelochemicals. In the wheat experiments, the authors report 6-methoxybenzoxazolin-2-one (MBOA) as the main compound; 2-hydroxy-7-methoxy-1,4- benzoxazin-3-one (HMBOA) and 2-hydroxy-1,4-benzoxazin- 3-one (HBOA) were detected as well and no phenoxazinones were detected. Macías *et al*., (2004a), analysing the fate of benzoxazinoids in two soils cultivated with two wheat varieties, verified that DIMBOA degraded rapidly, yielding MBOA in both studied soils at different doses and that MBOA, an intermediate in the degradation pathway from DIMBOA to 2- amino-7-methoxy-3Hphenoxazin-3-one (AMPO), was more resistant toward biodegradation. Recently the European Commission funded the FATEALLCHEM project, a multi-country ecological effort that aims at an environmental and human risk assessment of exploiting the allelopathic properties of winter wheat in conventional and organic farming, and developing a framework for future assessments of other allelopathic crops (Duke *et al*., 2007).

Rahman (2004) conducted an experiment with ginger on the existing multi-layered Garden at the Germplasm Center (GPC) of Fruit Tree Improvement Project (FTIP), Bangladesh Agricultural University, Mymensingh to determine the growth and development of different vegetables and spices. The highest yield (32.88 t/ha) was obtained from the partial shade conditions while the lowest yield was 18.75 t/ha of ginger was obtained from the severe shade conditions.

For two years Jaha and Lalnunmawia (2003) investigated the growth performance of three clump-forming edible bamboo species viz. *Dendrocalamus hamiltonii*, *D. longispathus* and *bambusa tulda* grown along with ginger. The growth of bamboo as well as yield of ginger was significant under fertilizer treatment compared to the control conditions.

Zaman *et al.* (2002) conducted an experiment at the Hill Agricultural Research Station, Khagrachari, Chittagong to determine the proper quantity of manure and to find out the optimum harvesting time for quality ginger production. They found that the combined effects of 2 t/ha manure coupled with harvesting after 9 months gave the highest performance (27.17).

Zaman *et al*. (2002) conducted an experiment at the Hill Agricultural Research Station, Khagrachari, Chittagong to investigate the desired plant population and the appropriate depth of seed placement into soil to get the maximum yield of ginger. They found that a plant spacing of 40 x 20 cm and rhizome placed at 9 cm depth produced the highest yield of 29.81 t/ha and 30.58 t/ha, respectively. They also found that the treatment combination of 40 x 20 cm spacing and rhizome placed at 9 cm depth gave the best value (39.00 t/ha).

Shanmughaved and Fiancies (2001) conducted intercropping trials for four crops in bamboo plantations. They intercropped pigeon pea, soybean, turmeric and ginger with *Bambusa bumos* and growth, yield and LER were assessed. Based on the calculated LER, they concluded that the productivity of one hectare under intercropping was equivalent to that of 1.2 ha or 1.1 ha under monoculture.

Koppad *et al*. (2001) conducted a study in the Varada watershed in Karnataka. India with the alternate land use system (agro-horticulture and agroforestry) in agricultural production. They found that use of the alternate land use system and the improved variety of ginger cv. Alleby gave air average yield of 245 kg/ha. They further stated that alternate land use system such as. Teak (*Tectona grandis*) based agroforestry and mango-based agriculture systems were successfully adopted by the fanners.

Pramono *et al*. (2000) worked with conservation technique in ginger plantations at lumban Julu, North Tapanuli. They reported that clue to land tenure considerations, farmer's produces ginger that grows rapidly and the ginger cultivation caused soil erosion. For this reason, soil conservation techniques were required to apply. They tested two treatments, i.e. (i) menkusii as a barrier between ginger plantation and (ii) menkusii + grass as barriers. They found that grass + merkusii brassies reduced soil erosions by up to 70% and surface runoff by up to 62%.

Islam *et al*. (1998) undertook a trial at Ichamati Research Centre, Chittagong in which *Eucalyptus camaldulensis* and *Acacia mangiun* (initially 1200 trees each, spaced at 2.27 x 2.75 m) were intercropped with lady's finger, barbate (*Vigna sinesis*), beans (*Dolichos lablab*), ginger, turmeric and arum (*Colocasia esculenta*). The financial benefit cost analysis of both the tree crops and agricultural crops were done separately and in combination.

The combination of tree and crops present a worth of benefit Tk. 12610 and the present worth of cost tk. 44,947. So, the net present worth was therefore, Tk. 32337 with a cost-benefit ratio of 0.28. Based on this they concluded that agroforestry system is profitable.

Gupta and Awasthi (1997) conducted a trial at Jagdalpur in the Kharif season rising ginger cv. Suprabha grown with mulches of palas leaves. Sal leaves, rice straw, dry grass, leaf or soil. They found that ginger grown with palas leaf mulch produced the highest fresh yield (21.90 t/ha) while mulched control produced 16.75 t/ha.

Hossain (1995) conducted a trial in Kazir Shimla, Mymensingh with the objective of growing ginger and turmeric in shady place of homesteads. He used varied plot size depending on the availability of spaces or fallow land of farmer. The area per farm under ginger cultivation in the homestead ranged from 3 to 15.75 sqm and average was 11.12 sqm. The corresponding yields per farm varied from 2 to 5 kg with an average of 3.42 t/ha, which was significant towards the income of farmers who normally kept the homestead lands fallow.

Zheo and Oesterhuis (1995) observed that when light intensity was reduced to 37% of full sunlight during flowering and fruiting the photosynthetic rate decreased by 47-45% resulting in a significant increase in boll shading with a concomitant decrease in lint yield of 18-52% in cotton.

Angeles and Mendoza (1988) reported that when intercropped with bananas and pineapples at Laguna, pawpaw cv. Smooth Cayenne plants were an average of 71.4 cm taller and their average stem diameter was 4.7 cm greater than when grown as a pure stand. Leaf production was also greater when intercropped. With longer petioles and greater laminar and petiolar DW being recorded. Intercropping also increased papaya fruit size, number and yield/tree from 0.9, 7.1 and 6.6 kg/tree, respectively, in pure stand to 1.7, 22.1 and 36.7 kg/tree, respectively. This was attributed to each pineapple plant in the intercrop and confirmed by increase in leaf N concentration of papaya when intercropped.

2.4 Position of wheat and change over time

Wheat is third highest growing cereals on the basis of cultivation area in Bangladesh. Farmers of Bangladesh cultivated wheat on 453421 ha of cultivated land and produced 1375270 mt of wheat in the year 2014 (Rashid and Hossain 2016). The average yield of wheat is 3.03 mt/ha. Wheat cultivation area shared 4.77% of net cropped area and 2.5% of total cropped area of Bangladesh in year 2010-11. Irrigated wheat cultivated area covered 3,46,558 ac of land which was 5.06% of total irrigated area of Bangladesh in the year 2010-11. The average per capita per day intake of rice was 416 gm and wheat was 26 gm. Wheat contributes 2.6% of per capita per day total consumption of Bangladesh people. Wheat consumption was increased by 2.14 times in 2010 compare to consumption amount of the year 2005 (BBS, 2010). Wheat grows in the sub-tropic and tropic region of Bangladesh. In that region the mean temperature during growing period (November to April) of wheat range from 18.8 0C to 25.3 0C. Prior to 1975–76, wheat was grown sporadically and was almost an unknown crop in Bangladesh (Banglapedia, 2006). Between 1970–71 and 1980–81, the cropped area under wheat jumped from 0.126 million ha to 0.591 million ha and production rose 10-fold from 0.11 million tons to 1.07 million tons, a 24.93 % annual mean growth rate (BARI, 2010).

Many varieties have been developed by Wheat Research Centre (WRC) but in details of varietal information and adoption information database was not developed which is very important and valuable for the scientist and policy planner. Although the Prodip covered highest area but other newly developed variety like BARI Gom 25, BARI Gom 26, BARI Gom 27 and BARI Gom 28 were the most promising varieties which showed increasing adoption path among the expert. These varieties have very good potentiality due to having short duration, tolerance to terminal heat stress, tolerant to salinity and lodging attributes. Satisfying higher demand for wheat consumption and ensuring food security through providing alternative to rice are the major concerning issue of the policy planner and the scientist (Rashid and Hossain 2016).

2.5 Regional status and history of wheat cultivation

Wheat cultivation area is grouped by zone on the basis intensive growing districts. Highest wheat growing zone in the year 2011-12 was Rangpur zone (62.8%) followed by Rajshahi (16.96%), Jessore (8%), Barisal (7.98%) and others (4.26%). The trend analysis revealed changing scenario of wheat cultivation area, production and yield of the different zone Wheat cultivation in Bangladesh within the period 2007-12 is grouped into 5 regions. Bangladesh experienced increased wheat cultivation area by 7.48% per annum within the period 2007-12. With per year change rate, wheat cultivation area has been increased at Rajshahi (0.28%), Rangpur (18.53%), and Barisal (2.76%) region and decreased at Jessore zone (-1.4%). The large number of growth rate in those regions helped to increase wheat cultivation area in Bangladesh. Increased wheat production (mt) per year was observed at Rajshah (7.33%), Rangpur (3.85%), Jessore (6.69%), and Barisal (13.37%) regions. In spite of having negative growth rate in other zone the country as whole achieved increase production (5.57%) per year with in that period 2007-12. The wheat cultivation area and production didn’t kept pace with positive relation. Highest rate of wheat yield (mt/ha) growth was observed of Barisal (10.62%), Jessore (8.38%) and Rajshahi (7.05%) zone. Although, there is an increase and decrease trend of yield among the zones. But Bangladesh as a whole couldn’t manage to increase yield per year (-1.9%) with in the period 2007-12.

2.6 Background of introducing wheat research in Bangladesh

Wheat breeding research started in Bangladesh after the liberation war. The ‘Noori 70', ‘Balaka’ and ‘Doel’ were first varieties developed by the scientists of BARI with the support of CIMMYT. The variety Noori 70 was developed in the year 1976 and ‘Balaka' and ‘Doel’ were developed in the year 1980. In the initial stages of wheat growing in Bangladesh, several Mexican varieties, especially ‘Sonora 64’ and ‘Kalyansona’, were successfully introduced in collaboration with the International Maize and Wheat Improvement Center (CIMMYT). However, the release of ‘Sonalika’ created a true breakthrough in wheat production in the year 1972. This fast maturing and high-yielding variety (yield = 2 tons ha−1) became very popular among wheat growers and adapted well to different production environments, and was adopted in 80% of the wheat area by the early 1980s (WRC, 2009). In 1983, the Wheat Research Centre (WRC) of Bangladesh Agricultural Research Institute (BARI), released four more highyielding (yield = 2–3 tons ha−1) varieties (‘Ananda’, ‘Kanchan’, ‘Barkat’, and ‘Akbar’). Among these, ‘Kanchan’ proved particularly adaptable and gradually replaced ‘Sonalika’ to became the predominant variety in Bangladesh by the early 1990s. Two other high-yielding varieties, ‘Aghrani’ and ‘Protiva’, were recommended by the Bangladesh National Seed Board in 1987 and 1993, respectively. These varieties were more responsive to a wider range of weather conditions as well as crop management practices such as fertilizers, irrigation and intercultural operations. Therefore, by the mid-1990s, adoption of high-yielding varieties were almost 100%, thereby increasing wheat productivity substantially. However, breeding efforts to develop high-yielding varieties still continued. Several more high-yielding varieties were developed. These included ‘BARI Gom 19’ (‘Sourav’) and ‘BARI Gom 20’ (‘Gourab’) released in 1998; ‘BARI Gom 21’ (‘Shatabdi’) in 2000; ‘BARI Gom 22’ (‘Sufi’), ‘BARI Gom 23’ (‘Bijoy’) and ‘BARI Gom 24’ (‘Prodip’) in 2005 (Pandit et al., 2011); and ‘BARI Gom 25’ and ‘BARI Gom 26’ released in 2010 (BARI, 2012b). In 2012, two varieties, ‘BARI Gom 27’ and ‘BARI Gom 28’, were released and also in adoption of wheat varieties in Bangladesh: 495 2014, another two more varieties, ‘BARI Gom 29’ and ‘BARI Gom 30’ were released.

2.7 Details of – Wheat

2.7.1 BARI Gom-27

Name of the Crop	Wheat
Varity Name	BARI Gom-27
Development Year	2012
Variety Image	
Developed By	Wheat Research Centre, BARI
Identifying Character	The variety is high yielding, short stature and 2-3 days earlier in heading than Shatabdi. It is resistant to stem rust (race Ug99) disease and moderately tolerant to terminal heat stress. It is resistant to leaf rust and tolerant to BpLB disease. Grains are white amber in colour and medium in size (35-40g). Leaf narrow, erect. Glaucosity in spike, culm and flag leaf sheath is weak. Brown necrosis in spike is present. Stem is flexible. Upper culm node hair few. Lower glume beak (LGB) length short (<5.1mm). LGB spicules- numerous, shoulder medium and deeply elevated. .
Crop Duration	105-110 days
Yield	3500-5400 (kg/ha)
Suitable Area	All over Bangladesh except areas of southern belt with salinity level more than 8 dS/m
Sowing Time	November 15-30
Harvesting Time	March-April
Major Diseases	Resistant to stem rust race Ug 99 and leaf rust and moderately resistant to Bipolaris leaf blight.

Source: (BARI, 2012b)

2.7.2 BARI Gom-28

Name of the Crop	Wheat
Varity Name	BARI Gom-28
Development Year	2012
Variety Image	
Developed By	Wheat Research Centre, BARI
Identifying Character	The variety is high yielding, short stature and 7-10 days earlier in heading than Shatabdi. It is highly tolerant to terminal heat stress due to its earliness. Grains are white amber in colour and medium in size (43.0-48.0g). Leaf broad, flag leaf attitude erect. Flag leaves are moderately spiral. Glaucosity in spike and culm is medium and strong in flag leaf sheath. Upper culm node hair few/medium. Lower glume beak (LGB) length is long (>12.1 mm). LGB spicules- numerous, LGB shape sloppy. Lower glume shoulder shape pointed and shoulder width medium and deeply indented.
Crop Duration	102-108 days
Yield	4000-5500 (kg/ha)
Suitable Area	All over Bangladesh except areas of southern belt with salinity level more than 8 dS/m.
Sowing Time	The optimum sowing time is November 15-30. The variety gives 15-20% higher yield than other varieties in case of sowing beyond optimum time.
Harvesting Time	March- April
Major Diseases	Resistant to leaf rust and moderately resistant to Bipolaris leaf blight.

Source: (BARI, 2012b)

2.8 Allelopathy

Allelopathy is a biological phenomenon by which an organism produces one or more biochemicals that influence the germination, growth, survival, and reproduction of other organisms. These biochemicals are known as allelochemicals and can have beneficial (positive allelopathy) or detrimental (negative allelopathy) effects on the target organisms and the community. Allelochemicals are a subset of secondary metabolites which are not required for metabolism (i.e. growth, development and reproduction) of the allelopathic organism. Allelochemicals with negative allelopathic effects are an important part of plant defense against herbivory.(Chang-Hung Chou, 2006)

The term allelopathy from the Greek-derived compounds *allelo-* and *-pathy* (meaning "mutual harm" or "suffering"), was first used in 1937 by the Austrian professor Hans Halsey Molischin the book *Der Einfluss einer Pflanze auf die andere - Allelopathie* (The Effect of Plants on Each Other - Allelopathy) published in German. He used the term to describe biochemical interactions that inhibit the growth of neighbouring plants, by another plant. In 1971, Whittaker and Feeny published a study in the journal *Science*, which defined allelochemicals as all chemical interactions among organisms. In 1984, Elroy Leon Rice in his monograph on allelopathy enlarged the definition to include all direct positive or negative effects of a plant on another plant or on micro-organisms by the liberation of biochemicals into the natural environment. Over the next ten years, the term was used by other researchers to describe broader chemical interactions between organisms, and by 1996 the International Allelopathy Society (IAS) defined allelopathy as "Any process involving secondary metabolites produced by plants, algae, bacteria and fungi that influences the growth and development of agriculture and biological systems. In more recent times, plant researchers have begun to switch back to the original definition of substances that are produced by one plant that inhibit another plant. Confusing the issue more, zoologists have borrowed the term to describe chemical interactions between invertebrates like corals and sponges.

Long before the term allelopathy was used, people observed the negative effects that one plant could have on another. Theophrastus, who lived around 300 BC noticed the inhibitory effects of pigweed on alfalfa. In China around the first century AD, the author of *Shennong Ben Cao Jing* described 267 plants that had pesticidal abilities, including those with allelopathic effects.

Allelopathy is not universally accepted among ecologists and many have argued that its effects cannot be distinguished from the competition which results when two (or more) organisms attempt to use the same limited resource, to the detriment of one or both. Allelopathy is a direct negative effect on one organism resulting from the input of substances into the environment by another. In the 1970s, great effort went into distinguishing competitive and allelopathic effects by some researchers, while in the 1990s others argued that the effects were often interdependent and could not readily be distinguished. *Stamp, Nancy (March 2003)*

However, by 1994 D. L. Liu and J. V. Lowett at the Department of Agronomy and Soil Science, University of New England in Armidale, NSW, Australia wrote two papers in the*Journal of Chemical Ecology* that developed methods to separate the allelochemical effects from other competitive effects, using barley plants and inventing a process to examine the allelochemicals directly.

2.9 Allelopathy of different multipurpose trees

Literature reveals that higher plant (tree-crops) releases some phytotoxins into soil, which adversely affect the germination and yield of crops. This type of tree-crop interactions was named phytochemical ecology/ecological biochemistry by (Harborne, 1977).

Azadiracta indica, or Neem Tree, is an evergreen tree native to Southeast Asia. All parts of the tree have been used medicinally for centuries. It is widely used in toothpastes, soaps and lotion today, as well as biological insecticide. Neem (*Azadiracta indica*) is a versatile tree native to South and Southeast Asia, Japan, tropical USA, South America, Australia and Africa (Bokhari and Aslam, 1985; Von Maydell, 1986).

Salam and Kato (2010) studied allelopathic potential of aqueous methanol extract of Neem leaves on seed germination and seedling growth of different plants *viz.,* Cress (*Lepidum sativum* L.), Lettuce (*Lactuca sativa* L.), Alfalfa (*Medicago sativa* L.), Wild Buckwheat (*Eriogonum compositum*), Sand Fescue (*Festuca myuros* L.), Timothy (*Phleum pratense* L.), Barnyard grass (*Echinochloa crusgalli*) and *Echinochloa colonum* .Neem leaves may contain growth inhibitory substances and may possess allelopathic potential. Therefore, Neem leaves may be a possible candidate for the isolation and identification of allelopathic substances and for the development of natural herbicides for sustainable agricultural production.

Sahoo *et al.* (2010) used aqueous leaf extract of different concentrations of *Mangifera indica* L. to investigate their effects on germination, shoot and root lengths and dry matter yield of 5 food crops *viz.*, *Capsicum annum* L. (Chilli), *Glycine max* (L.) Merr. (Soybean), *Zea mays* L. (Maize), *Oryza sativa* L. (Rice) and *Abelmoschus esculentus* (L.) Moench (Lady‟s finger). Both bioassays and pot culture indicated that the inhibitory effect was much more pronounced at higher concentrations, while the lowest concentration showed stimulatory effect in some cases. The most affected crop was lady's finger among the test crops. The inhibitory effect was much pronounced ($P<0.001$) in shoot and root lengths as compared with the germination of the receptor crops.

An experiment was established by Devaranavadgi *et al.* (2004) to assess the allelopathic effects of different tree species (*Acacia nilotica, Albizia lebbeck, Azadiracta indica, Cassia siamea, Dalbergia sissoo, Hardwickia binata* and *Leucaena leucocephala*) on Chickpea. Among the tree species, *Hardwickia binata* had significantly less allelopathic effect on Chickpea compared to other tree species. The germination percentage (80%), root length (18.65cm), shoot length (31.32 cm) and seedling dry weight at 10 days were least affected by *Hardwickia binata* as compared to other tree species. The maximum harmful effect was observed with *Acacia nilotica* which had higher total biomass production (3688kg/ha) and crown spread (8.2m).

Romman *et al.* (2010) carriedout an investigation on effect of *Euphorbia hierosolymitana* in Wheat (*Triticum durum* local var. Hourani), in both laboratory and glasshouse. Higher concentration of aqueous leachate of *E. hierosolymitana* reduced the germination rate. On the other hand, the radicle and coleoptile length of the germinated seeds of Wheat were significantly inhibited by the leachate. Also, the aqueous leaf leachate of *E. hierosolymitana* was found to inhibit significantly the growth of Wheat seedlings. Allelochemicals caused significant reduction in root and shoot length, fresh, dry weights and decreased the amount of total chlorophyll and protein contents

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

In this section the materials and methods have been presented which includes 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 study

The experiment was conducted in Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The geographical location of the site was between 25º 13´ latitude and 88º 23´ longitude, and about 37.5 m above the sea level.

3.2 Soil characteristics

The experimental plot was in a medium high land belonging to the old Himalayan Piedmont Plain Area (AEZ No. 01). Land was well-drained and drainage system was well developed. The soil texture was sandy loam in nature. The soil pH was 6.1 found in the field (Appendix I).

3.3 Weather and climate

The experimental site was situated under the tropical climate characterized by heavy rainfall from July to August and scanty the rest period of the year 80 to 90% is received between June and September. The remaining 10 to 20% rainfall is received during wheat growing season (November to April)

3.4 Seed Collection

Wheat seeds were collected from Wheat Research Centre, Nashipur, Dinajpur-5200. BARI Gom-27 and BARI Gom-28 was selected for both Laboratory and Field experiment.

3.4.1 Description of Wheat Verities

3.4.1.1 BARI Gom-27

This is a high yielding, short stature variety released in 2012. It is 2-3 days earlier in heading than Shatadi. It takes about 60-65 days for heading and 105-110 days to get maturity. . Leaf narrow, erect. Glaucosity in spike, culm and flag leaf sheath is weak. Brown necrosis in spike is present. Stem is flexible. Upper culm node hair few. Lower glume beak (LGB) length short (<5.1mm). LGB spicules- numerous, shoulder medium and deeply elevated.

Grains are white amber in colour and medium in size (35-40g). Spikes are medium in size with 45-50 grains per spike.. The variety is resistant to stem rust race Ug 99 and leaf rust and moderately resistant to Bipolaris leaf blight. Rapid expansion of this variety will combat the future threat of Ug99 race of stem rust in Bangladesh. Grain yield under optimum management is high, 3500-5400 kg/ha.

3.4.1.2 BARI Gom-28

This variety released in 2012. The variety is high yielding, short stature and 7-10 days earlier in heading than Shatabdi. It is highly tolerant to terminal heat stress due to its earliness. Grains are white amber in colour and medium in size (43.0-48.0g). Leaf broad, flag leaf attitude erect. Flag leaves are moderately spiral. Glaucosity in spike and culm is medium and strong in flag leaf sheath. Upper culm node hair few/medium. Lower glume beak (LGB) length is long (>12.1 mm). LGB spicules- numerous, LGB shape sloppy. Lower glume shoulder shape pointed and shoulder width medium and deeply indented. The crop duration is 102-108 days. The yield is 4000-5500kg/ha.

3.5 Experimental Treatments

The experiment was consisted of 2 (two) varieties of wheat with 5 (five) treatments. Each treatment consist of 3 (three) replication. Design of experiment was CRD in laboratory experiment and RCBD in field experiment.

3.6 Selection of Tree Species

Ghora Neem, Ipil-ipil, Sada Koroi and Mango tree leaves were selected for this experiment. The leaves were collected in 19 September 2016. Then the leaves were kept in electronic oven at temperature 70^0C and kept in 48 hours.

3.7 Preparation of Extract

The oven dried leaves were grinding in grinding machine and labeled it in different pot and juice was prepared at 5% concentration. Concentration was prepared by mixing 5 gm of tree leaf powder with 100 ml distilled water.

3.8 Treatment

There were five treatment combinations of plant extract including control. These extracts were applied in the wheat verities. The RCBD design was followed with three replications in each treatment. These are as follows:

T_1 = Ghora Neem leaf

T_2 = Ipil-ipil leaf

T_3 = Mango leaf

T_4 = Sada koroi leaf

T_5 =Control, only water

3.9 Laboratory Experiment

The lab experiment was started in 1 November 2016. For both varieties for every treatment three replications were given and in every Petridis 20 seeds were given. Petridis were full with sand and used 5% concentration juice. The germination data were collected for 12 hours interval per days.

3.10 Field Experiment

The land of the experiment plot was opened with spared on 15 November 2016. All weeds and stubble were removed from the land. The size of the plot was 1.5 ft × 15 ft that means 0.21sqm.

3.11 Application of Extract

Sada Koroi, Ghora Neem, Ipil-ipil and mangoes 20g powder were given for one time in each replication.

3.12 Seed sowing

For each replication 50g seed was sown.

3.13 Intercultural operations

3.13.1 Weeding

The experiment plots were free twice by Khurpi at 20 and 50 days after sowing before irrigation.

3.13.2 Irrigation

Three irrigation were applied at 25,55,and 85 days after sowing at crown root initiation stage, at booting stages and maturity stages respectively, as per recommendation of BARI (1900) care was taken to avoid water flow from one plot to another or overflow the boundary of the plots.

3.14 Harvesting and Post-Harvest Operations

About 80% plants flowered at 90 days after sowing (DAS). According to the treatments the plants were harvested on 4th march 2017. The harvested crops of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The bundles were dried in open sunshine for two days and then threshing, cleaning, winnowing and drying of seeds were carefully. The weights of grains were converted to hectare basis.

3.15 Sampling and Data Collection

Before harvesting 5 sample plants were randomly selected from each experiment plots. The sample was properly tagged and the data of the following parameter were collected. The parameter were growth and yield components.

3.16 Germination Data

Germination data were collected on the germination percentage, germination speed, shoot number and days of germination initiation etc. Germination speed was calculated as under (Chiapusio *et al*., 1997):

$S= (N1\times1) + (N2–N1)\times1/2 + (N3- N2)\times1/3 + \ldots + (Nn- Nn-1) \times1/n.$

Where, N1, N2, N3, …, Nn-1, Nn refers to the proportion of germinated seeds on the 1^{st} , 2^{nd} , $3^{th,}$ days, …, n-1, n days.

The inhibitory / stimulatory effects of extracts on tested crops were expressed in percentage (%) of control and were calculated according to T/C, where T, is the "treatment" data and C is the "control" data. The effect is stimulatory when the result is greater than 100%, and the effect was inhibitory when the result was less than 100% of control.

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

The present experiment was carried out to investigate the germination, morphology and yield of **BARI Gom-27 and BARI Gom-28** influenced by four Agroforestry tree leaf extract. The results of the experiment was shown in tables and figures currently and discussed in this chapter under the following sub-headings.

4.1 Laboratory Experiment

4.1.1 Germination Percentage of BARI Gom-27 at lab

The germination percentage of BARI Gom -27 varied due to four treatments compared to control. (Fig. 1) shows the germination percentage in different treatment. The highest (95%) germination percentage was found in control followed by Sada koroi (60%), Ipil-ipil (45%), Mango (40%) and lowest in Ghora neem (20%).

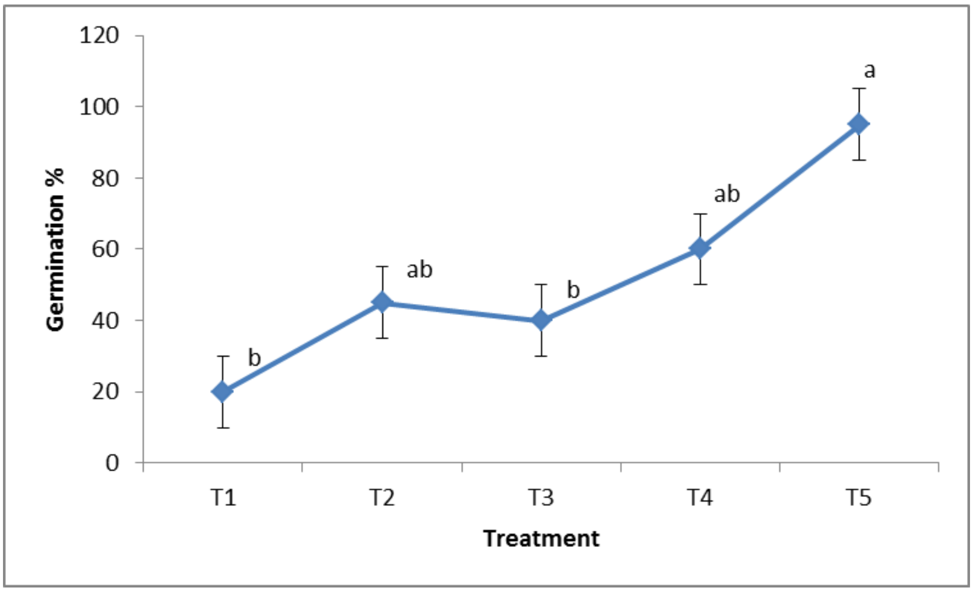

Figure 1: Effect of different tree leaves on the Germination percentage of BARI Gom -27

4.1.2 Germination speed of BARI Gom-27 at lab

Figure 2 shows the germination speed of BARI Gom-27 in different treatment. The highest germination speed was found in T_5 (11.42) followed by T_4 (9.23), T_3 (5.91), T_2 (4.95) and lowest in T_1 (0.843).

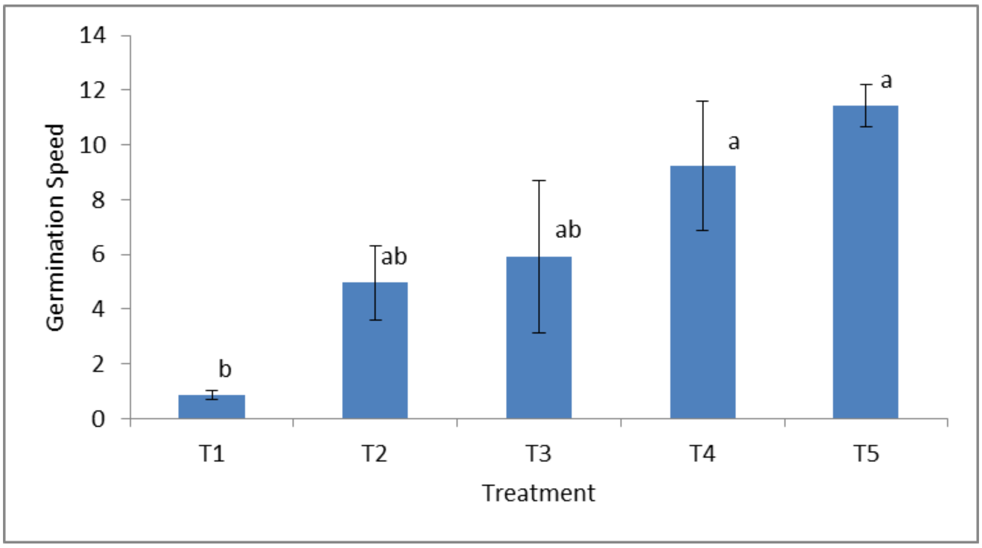

Figure 2: Effect of different tree leaves on the Germination speed of BARI Gom-27

4.1.3 Germination Percentage of BARI Gom-28 at lab

The germination percentage of BARI Gom -28 varied due to four treatments compared to control. (Fig. 3) shows the germination percentage in different treatment. The highest (88.16%) germination percentage was found in control followed by Ipil-ipil (84.1%), Mango (82.36%), Sada koroi (78.88%) and lowest in Ghora neem (77%).

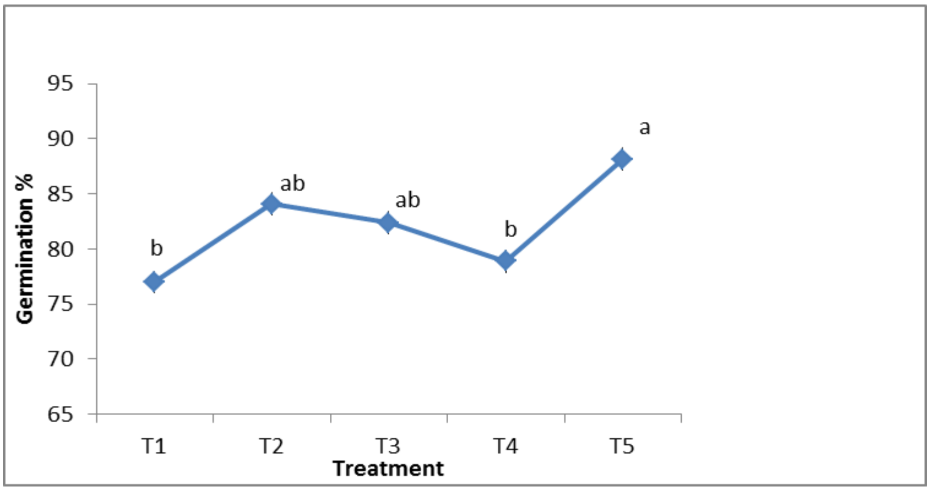

Figure 3: Effect of different tree leaves on the Germination percentage of BARI Gom-28

4.1.4 Germination speed of BARI Gom-28 at lab

Figure 4 shows the germination speed of BARI Gom-28 in different treatment. The highest germination speed was found in T_5 (7.19) followed by, T_2 (4.89), T_4 (4.33), T_3 (2.54) and lowest in T_1 (1.33).

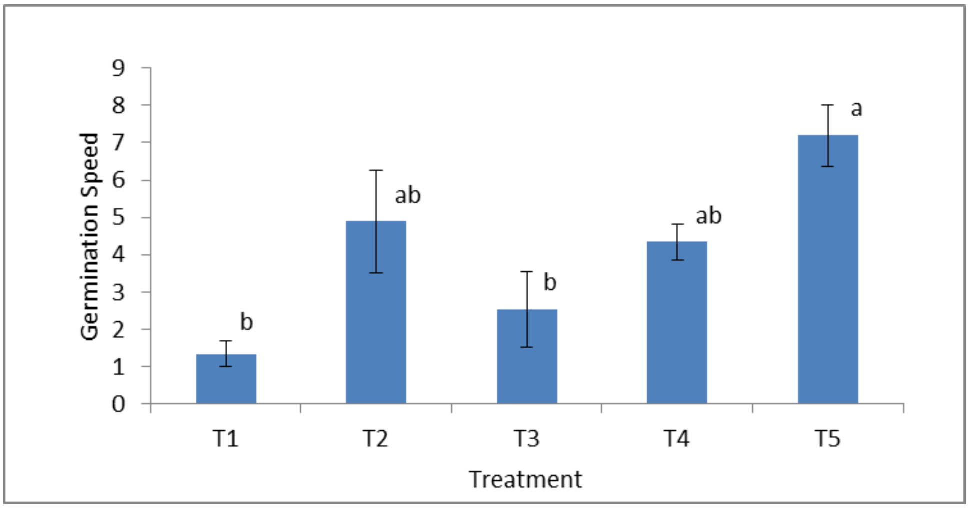

Figure 4: Effect of different tree leaves on the Germination speed of BARI Gom-28

4.1.5 Field Experiment

4.1.6 Germination Percentage of BARI Gom-27 at field

The germination percentage of BARI Gom -27 varied due to four treatments compared to control. (Fig. 5) shows the germination percentage in different treatment. The highest (90%) germination percentage was found in control followed by Sada koroi (39%), Ipil-ipil (33%), Mango (30%) and lowest in Ghora neem (21%)

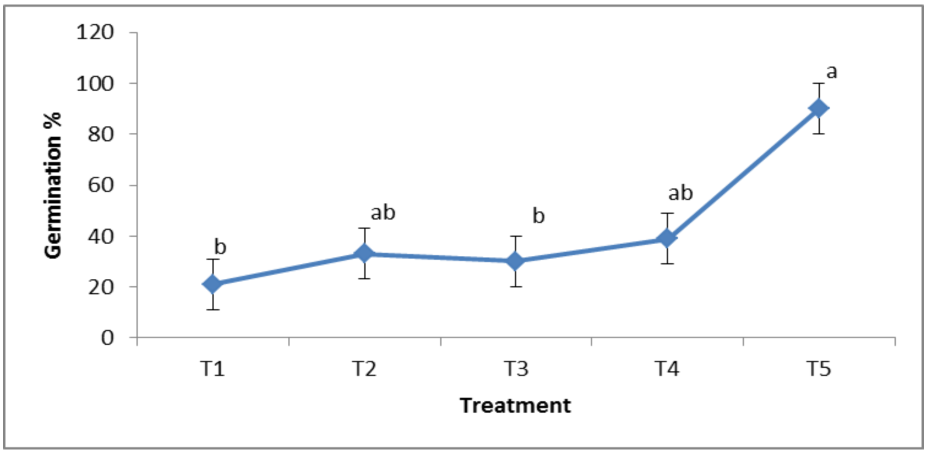

Figure 5: Effect of different tree leaves on the Germination percentage of BARI Gom -27

4.1.7 Germination speed of BARI Gom-27 at field

Figure 6 shows the germination speed of BARI Gom-27 in different treatment. The highest germination speed was found in T_5 (211) followed by T_2 (180.52), T_4 (177), T_3 (156.24) and lowest in T_1 (151.56).

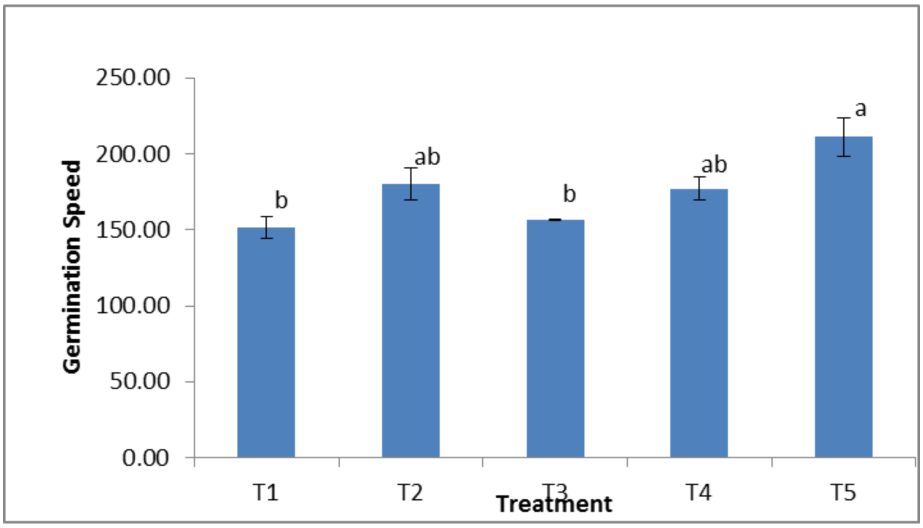

Figure 6: Effect of different tree leaves on the Germination speed of BARI Gom -27

4.1.8 Germination Percentage of BARI Gom-28 at field

The germination percentage of BARI Gom-28 varied due to four treatments compared to control. (Fig. 7) shows the germination percentage in different treatment. The highest germination percentage was found in control (88.26%) followed by Ipil-ipil (80.62%), Ghora neem (79.46%), Sada koroi (73.66%), and lowest in Mango (77.72%)

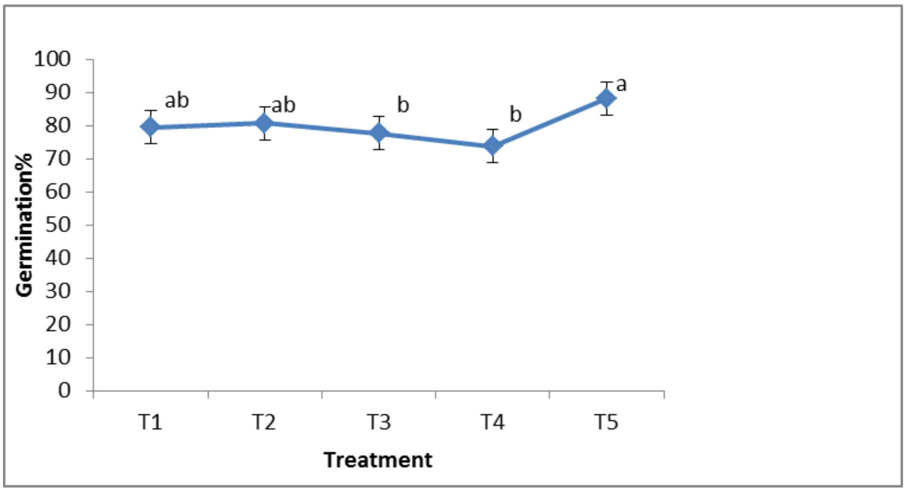

Figure 7: Effect of different tree leaves on the Germination percentage of BARI Gom-28

4.1.9 Germination speed of BARI Gom-28 at field

Figure 8 shows the germination speed of BARI Gom-28 in field experiment by different treatment. The highest germination speed was found in T_2 (148.85) followed by T_1 (129.91), T_5 (127.33), T_3 (108.33) and lowest in T_4 (86.2).

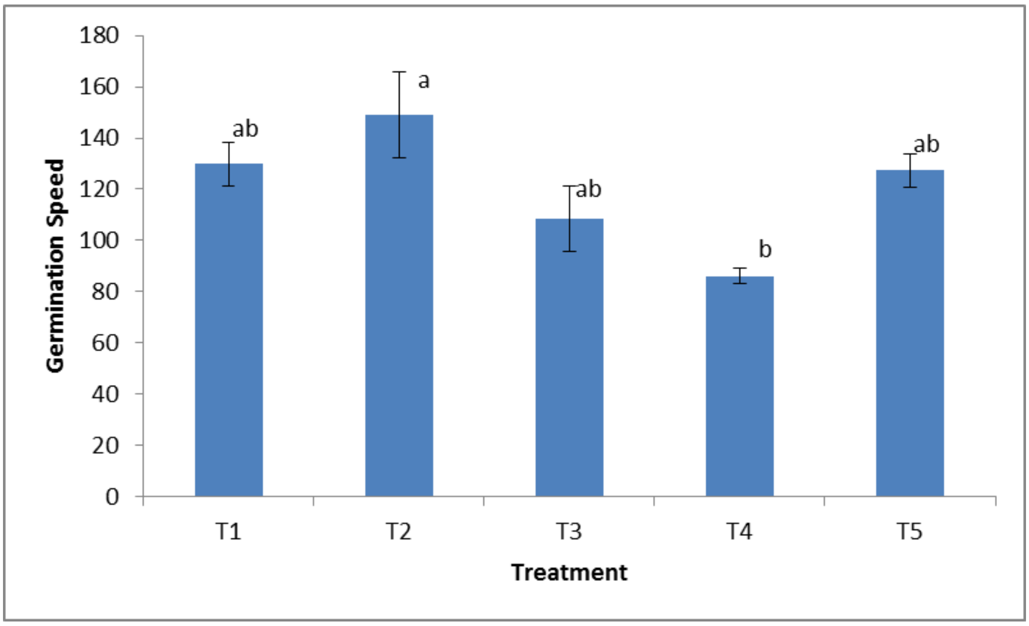

Figure 8: Effect of different tree leaves on the Germination speed of BARI Gom-28

4.2 Morphology of Bari Ghom-27

4.2.1 Morphology after 1 month

In case of BARI Gom -27 tree extract application, shoot length, root length, leaf length, root collar diameter was statistically varied among the treatments (Table 1). Shoot length was highest in T_5 (39.27 cm) and lowest in T_3 (25.59 cm). Root length was highest in T_5 (7.6 cm) and lowest in T_1 (3.67 cm). Leaf length was highest in T_5 (18.94 cm) and lowest in T_3 (12.35 cm). Root collar diameter was highest in T_5 (3.21 cm) and lowest in T_3 (2.29 cm).

Table 1: Effect of tree leaf extracts on the morphological characteristics of shoot and root of BARI Gom-27 after 1 month

Treatment	Shoot length (cm)	Root length (cm)	Leaf length (cm)	Root collar diameter (cm)
T_1	28.52bc (±.91)	3.67b (±.62)	13.65cd (±.78)	2.49bc (±.09)
T_2	31.99b (±1.16)	6.4a (±.32)	16.58ab (±.44)	2.9ab (±.05)
T_3	25.59c (±.61)	3.88b (±.06)	12.35d (±.62)	2.29c (±.09)
T_4	33.03b (±1.13)	4.4b (±.34)	15.33bc (±.23)	2.43c (±.07)
T_5	39.27a (±1.05)	7.6a (±.38)	18.49a (±.53)	3.21a (±.16)

Note: T_1 = Ghora Neem, T_2 = Ipil-ipil, T_3=Mango, T_4= Sada Koroi, T_5= Control.In a column, different letter (s) show statististically significant at P≤0.05 by Tukey‟s Range Test.

4.2.2 Morphology after 2 months

In case of BARI Gom -27 tree extract application, shoot length, root length, leaf length, root collar diameter was statistically varied among the treatments (Table 2). Shoot length was highest in T_5 (80.08 cm) and lowest in T_3 (52.92 cm). Root length was highest in T_5 (8.46 cm) and lowest in T_3 (4.32 cm). Leaf length was highest in T_5 (25.70 cm) and lowest in T_3 (17.15 cm). Root collar diameter was highest in T_5 (3.71 cm) and lowest in T_3 and T_4 (3.13 cm).

Table 2: Effect of tree leaf extracts on the morphological characteristics of shoot and root of BARI Gom -27 after 2 month

Treatment	Shoot length (cm)	Root length (cm)	Leaf length (cm)	Root collar diameter (cm)
T_1	58.95cd (±2.96)	4.71c (±0.22)	19.56bc (±1.06)	3.28b (±0.14)
T_2	64.44bc (±1.71)	6.91b (±0.41)	21.38b (±0.66)	3.8a (±0.06)
T_3	52.92d (±2.04)	4.32c (±0.06)	17.15c (±0.27)	3.13b (±0.04)
T_4	68.98b (±1.59)	5.07c (±0.41)	22.53b (±0.59)	3.13b (±0.02)
T_5	80.08a (±1.11)	8.46a (±0.35)	25.70a (±1.11)	3.71a (±0.07)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statistically significant at P≤0.05 by Tukey’s Range Test.

4.2.3 Morphology after 3 months

In case of BARI Gom-27 tree extract application, shoot length, root length, leaf length, root collar diameter was statistically varied among the treatments (Table 3). Shoot length was highest in T_5 (90.31 cm) and lowest inT_3 (69.59 cm). Root length was highest in T_5 (8.77 cm) and lowest in T_3 (4.65 cm). Leaf length was highest in T_5 (29.15 cm) and lowest in T_3 (21.53 cm). Root collar diameter was highest in T_5 (4.76 cm) and lowest in T_4 (3.67 cm).

Table 3: Effect of tree leaf extracts on the morphological characteristics of shoot and root of BARI Gom-27 after 3 month

Treatment	Shoot length (cm)	Root length (cm)	Leaf length (cm)	Root collar diameter (cm)
T_1	72.52b (±1.59)	5.07c (±.11)	22.91b (±.56)	3.94b (±.04)
T_2	76.16b (±1.93)	7.07b (±.43)	23.73b (±.68)	4.51a (±.06)
T_3	69.59b (±1.34)	4.65c (±.18)	21.53b (±.89)	3.93b (±.14)
T_4	76.38b (±1.42)	5.30c (±.31)	25.39ab (±1.69)	3.67b (±.18)
T_5	90.31a (±1.99)	8.77a (±.28)	29.15a (±.30)	4.76a (±.10)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statistically significant at $P \leq 0.05$ by Tukey's Range Test.

4.3 Morphology of BARI Gom-28 at field

4.3.1 Morphology after 1 month

In case of BARI Gom-28 tree extract application, shoot length, root length, leaf length, root collar diameter was statistically varied among the treatments (Table 4). Shoot length was highest in T_5 (39.48 cm) and lowest in T_4 (27.83 cm). Root length was highest in T_5 (7.31 cm) and lowest in T_1 (3.76 cm). Leaf length was highest in T_2 (24.11 cm) and lowest in T_4 (14.67 cm). Root collar diameter was highest in T_5 (3.11 cm) and lowest in T_4 (2.46 cm).

Table 4: Effect of tree leaf extracts on the morphological characteristics of shoot and root of BARI Gom -28 after 1 month

Treatment	Shoot length (cm)	Root length (cm)	Leaf length (cm)	Root collar diameter (cm)
T_1	31.29c (±1.17)	3.76c (±.20)	17.25bc (±.56)	2.55bc (±.12)
T_2	37.48ab (±1.15)	7.26a (±.12)	24.11a (±1.21)	2.99ab (±.06)
T_3	32.59bc (±1.26)	4.5b (±.11)	20.42ab (±.66)	2.49bc (±.09)
T_4	27.83c (±.79)	3.8c (±.15)	14.67c (±.86)	2.46c (±.06)
T_5	39.48a (±.86)	7.31a (±.10)	22.81bc (±.92)	3.11a (±.17)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statististically significant at $P \leq 0.05$ by Tukey's Range Test.

4.3.2 Morphology after 2 months

In case of BARI Gom- 28 tree extract application, shoot length, root length, leaf length, root collar diameter was statistically varied among the treatments (Table 5). Shoot length was highest in T_5 (80.92 cm) and lowest in T_4 (59.77 cm). Root length was highest in T_2 (7.5 cm) and lowest in T_1 (3.93 cm). Leaf length was highest in T_2 (27.03 cm) and lowest in T_4 (18.12 cm). Root collar diameter was highest in T_2 (3.86 cm) and lowest in T_3 (3.11 cm).

Table 5: Effect of tree leaf extracts on the morphological characteristics of shoot and root of BARI Gom-28 after 2 month

Treatment	Shoot length (cm)	Root length (cm)	Leaf length (cm)	Root collar diameter (cm)
T_1	64.33b (±1.33)	3.93c (±0.17)	20.69b (±0.82)	3.32bc (±0.15)
T_2	74.05a (±3.62)	7.5a (±0.11)	27.03a (±1.22)	3.86a (±0.06)
T_3	62.13b (±2.00)	4.66b (±0.07)	22.33b (±0.62)	3.11c (±0.06)
T_4	59.77b (±0.69)	4.01bc (±0.21)	18.12b (±0.89)	3.14c (±0.03)
T_5	80.92a (±1.04)	7.43a (±0.13)	26.86a (±0.98)	3.67ab (±0.05)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statististically significant at $P \leq 0.05$ by Tukey's Range Test.

4.3.3 Morphology after 3 months

In case of BARI Gom-28 tree extract application, shoot length, root length, leaf length, root collar diameter was statistically varied among the treatments (Table 6). Shoot length was highest in T_5 (93.67 cm) and lowest in T_4 (69.0 cm). Root length was highest in T_2 (7.63 cm) and lowest in T_1 (4.06 cm). Leaf length was highest in T_2 (28.24 cm) and lowest in T_4 (19.29 cm). Root collar diameter was highest in T_5 (4.76 cm) and lowest in T_3 (3.86 cm).

Table 6: Effect of tree leaf extracts on the morphological characteristics of shoot and root of BARI Gom -28 after 3 month

Treatment	Shoot length (cm)	Root length (cm)	Leaf length (cm)	Root collar diameter (cm)
T_1	69.09b (±0.06)	4.06c (±0.19)	21.22bc (±0.62)	3.99b (±0.01)
T_2	89.80a (±0.04)	7.63a (±0.11)	28.24a (±1.12)	4.52a (±0.02)
T_3	76.77b (±0.07)	4.89b (±0.15)	23.07b (±0.61)	3.86b (±0.02)
T_4	69b (±0.06)	4.17bc (±0.21)	19.29c (±0.61)	3.88b (±0.02)
T_5	93.67a (±0.02)	7.63a (±0.19)	27.86a (±0.65)	4.76a (±0.02)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statististically significant at $P \leq 0.05$ by Tukey's Range Test.

4.4 Biomass Allocation of Bari Gom-27 at field

4.4.1 Biomass after 1 month

In case of BARI Gom-27 tree extract application, shoot length, root length, leaf length, root collar diameter was statistically varied among the treatments (Table 7). Shoot dry weight was highest in T_2 (0.68 cm) and lowest in T_1 (0.41 cm). Root dry weight was highest in T_1 (0.21 cm) and lowest inT_3 (0.11 cm). Total dry weight was highest in T_2 (0.88 cm) and lowest in T_4 (0.5 cm). Shoot/Root ratio was highest in T_1 (8.26 cm) and lowest in T_2 (5.02 cm). Quality index was highest in T_2 (0.06 cm) and lowest in T_1 and T_4 (0.03 cm).

Table 7: Biomass allocation and quality index of BARI Gom-27 at different treatments after 1 month

Treatment	Shoot dry weight (gm)	Root dry weight (gm)	Total dry weight (gm)	Shoot/Root ratio	Quality index
T_1	0.41bc (±.07)	0.19ab ± (0.02)	0.57c (±.060)	8.26a (±1.44)	0.03d (±.01)
T_2	0.68a (±.01)	0.19ab (±.01)	0.88a (±.020	5.02a (±.27)	0.06a (±.02)
T_3	0.47bc (±.02)	0.11c (±.08)	0.58bc (±.03)	6.59a (±.09)	0.04b (±.01)
T_4	0.47c (±.03)	0.13bc (±.06)	0.5c (±.09)	7.61a (±.72)	0.03b (±.01)
T_5	0.47ab (±.05)	0.21a (±.01)	0.81ab (±.06)	5.18a (±.20)	0.05a (±.03)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statististically significant at P≤0.05 by Tukey's Range Test.

4.4.2 Biomass after 2 month

In case of BARI Gom-27 tree extract application, shoot length, root length, leaf length, root collar diameter was statistically varied among the treatments (Table 8). Shoot dry weight was highest in T_1 (0.89 cm) and lowest in T_3 (0.61 cm). Root dry weight was highest in T_5 (9.54 cm) and lowest inT_3 and T_4 (0.17 cm). Total dry weight was highest in T_5 (10.43 cm) and lowest in T_3 (0.78 cm). Shoot/Root ratio was highest in T_1 (12.54 cm) and lowest in T_2 (9.4 cm). Quality index was highest in T_5 (0.49 cm) and lowest in T_4 (0.03 cm).

Table 8: Biomass allocation and quality index of BARI Gom -27 at different treatments after 2 month

Treatment	Shoot dry weight (gm)	Root dry weight (gm)	Total dry weight (gm)	Shoot/Root ratio	Quality index
T_1	0.64b (±.08)	0.24a (±0.02)	0.88a (±0.09)	12.54ab (±0.59)	0.04a (±0.4)
T_2	0.8ab (±0.06)	0.27a (±0.03)	1.07a (±0.09)	9.4b (±0.63)	0.05a (±0.4)
T_3	0.61b (±0.05)	0.17a (±0.02)	0.78a (±0.07)	12.26ab (±0.65)	0.04a (±0.5)
T_4	0.62b (±0.02)	0.17a (±0.0008)	0.79a (±0.02)	13.78a (±1.11)	0.03a (±0.1)
T_5	0.89a (±0.04)	9.54a (±0.23)	10.43a (±9.18)	9.51b (±0.53)	0.49a (±0.44)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statististically significant at P≤0.05 by Tukey's Range Test.

4.4.3 Biomass after 3 month

In case of BARI Gom 27 tree extract application, shoot length, root length, leaf length, root collar diameter, weight/100seed was statistically varied among the treatments (Table 9). Shoot dry weight was highest in T_1 (1.3 cm) and lowest in T_1 (1.03 cm). Root dry weight was highest in T_2 and T_5 (0.44 cm) and lowest in T_4 (0.31 cm). Total dry weight was highest in T_5 (1.74 cm) and lowest in T_1 (1.36 cm). Shoot/Root ratio was highest in T_3 (15.03 cm) and lowest in T_5 (10.33 cm). Quality index was highest in T_2 and T_5 (0.08 cm) and lowest in T_1, T_2 and T_3 (0.03 cm).

Table 9: Biomass allocation and quality index of BARI Gom-27 at different treatments after 3 month

Treatment	Shoot dry weight (gm)	Root dry weight (gm)	Total dry weight (gm)	Shoot/Root ratio	Quality index
T_1	1.03c (±0.04)	0.32b (±.02)	1.36b (±.04)	14.33a (±.53)	0.06b (±.0002)
T_2	1.20ad (±0.03)	0.44a (±.02)	1.65a (±.0003)	10.83b (±.41)	0.08a (±.0002)
T_3	1.07bc (±0.05)	0.35ab (±0.02)	1.42b (±.05)	15.03a (±.73)	0.06ab (±.0004)
T_4	1.07bc (±0.03)	0.31ab (±0.01)	1.37b (±.02)	14.52a (±1.01)	0.06b (±1.0001)
T_5	1.3a (±0.03)	0.44ab (±0.03)	1.74a (±.0.05)	10.33b (±.56)	0.08a (±.0004)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statististically significant at P≤0.05 by Tukey's Range Test.

4.5 Biomass allocation of BARI Gom-28 at field

4.5.1 Biomass after 1 month

In case of BARI Gom-28 tree extract application, shoot length, root length, leaf length, root collar diameter was statistically varied among the treatments (Table 10). Shoot dry weight was highest in T_2 (0.68 cm) and lowest inT_4 (0.36 cm). Root dry weight was highest in T_2 (0.19 cm) and lowest in T_3 (0.12 cm). Total dry weight was highest in T_2 (0.87 cm) and lowest in T_4 (0.52 cm). Shoot/Root ratio was highest in T_1 (8.34 cm) and lowest in T_2 (5.15 cm). Quality index was highest in T_2 (0.05 cm) and lowest in T_3 and T_4 (0.03 cm).

Table 10: Biomass allocation and quality index of BARI Gom-28 at different treatments after 1 month

Treatment	Shoot dry weight (gm)	Root dry weight (gm)	Total dry weight (gm)	Shoot/Root ratio	Quality index
T_1	0.47b (±.07)	0.17a (±.03)	0.6bc (±0.07)	8.34a (±0.49)	0.04bc (±0.3)
T_2	0.68a (±.02)	0.19a (±0.01)	0.87a (±0.03)	5.15b (±0.11)	0.05a (±0.2)
T_3	0.51ab (±.05)	0.12a (±0.0005)	0.62bc (±0.05)	7.26a (±0.47)	0.03c (±0.2)
T_4	0.36b (±.03)	0.15a (±0.0005)	0.52c (±0.03)	7.34a (±0.21)	0.03c (±0.2)
T_5	0.59ab (±.07)	0.18a (±0.01)	0.78ab (±0.07)	5.4b (±0.17)	0.04ab (±0.2)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statististically significant at $P \leq 0.05$ by Tukey's Range Test.

4.5.2 Biomass after 2 month

In case of BARI Gom-28 tree extract application, shoot length, root length, leaf length, root collar diameter was statistically varied among the treatments (Table 11). Shoot dry weight was highest in T_1 (0.84 cm) and lowest in T_4 (0.66 cm). Root dry weight was highest in T_5 (0.3 cm) and lowest in T_4 (0.18 cm). Total dry weight was highest in T_5 (1.15 cm) and lowest in T_4 (0.84 cm). Shoot/Root ratio was highest in T_1 (16.4 cm) and lowest in T_2 (9.87 cm). Quality index was highest in T_5 (0.03 cm) and lowest in T_1, T_3 and T_4 (0.01 cm).

Table 11: Biomass allocation and quality index of BARI Gom-28 at different treatments after 2 month

Treatment	Shoot dry weight (gm)	Root dry weight (gm)	Total dry weight (gm)	Shoot/Root ratio	Quality index
T_1	0.75a (±0.04)	0.27ab (±0.0008)	1.02ab (±0.04)	16.4a (±0.56)	0.01a (±0.01)
T_2	0.83a (±0.03)	0.28a (±0.02)	1.11a (±0.0008)	9.87b (±0.37)	0.02a (±0.1)
T_3	0.67a (±0.01)	0.19bc (±0.02)	0.86bc (±0.02)	13.32bc (±0.58)	0.01a (±0.1)
T_4	0.66a (±0.06)	0.18c (±0.0005)	0.84c (±0.05)	14.96ab (±0.81)	0.01a (±0.6)
T_5	0.84a (±0.03)	0.3a (±0.02)	1.15a (±0.02)	10.96cd (±0.52)	0.03a (±0.01)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statististically significant at $P \leq 0.05$ by Tukey's Range Test.

4.5.3 Biomass after 3 month

In case of BARI Gom-28 tree extract application, shoot length, root length, leaf length, root collar diameter, weight/100seed was statistically varied among the treatments (Table 12). Shoot dry weight was highest in T_5 (1.27 cm) and lowest in T_4 (1.01 cm). Root dry weight was highest in T_2 (0.43 cm) and lowest in T_4 (0.3 cm). Total dry weight was highest in T_5 (1.68 cm) and lowest in T_4 (1.31 cm). Shoot/Root ratio was highest in T_1 (17.08 cm) and lowest in T_2 (11.76). Quality index was highest in T_5 (0.7 cm) and lowest in T_3 and T_4 (0.06 cm).

Table 12: Biomass allocation and quality index of BARI Gom-28 at different treatments after 3 month

Treatment	Shoot dry weight (gm)	Root dry weight (gm)	Total dry weight (gm)	Shoot/Root ratio	Quality index
T_1	1.09ab (±0.09)	0.36abc (±0.70)	1.46abc (±0.02)	17.08a (±0.07)	0.07a (±1.45)
T_2	1.21ab (±0.09)	0.43a (±0.32)	1.65ab (±0.03)	11.76c (±0.04)	0.07a (±1.34)
T_3	1.05ab (±0.15)	0.34bc (±1.11)	1.39bc (±0.06)	15.74ab (±0.07)	0.06a (±3.23)
T_4	1.01b (±0.11)	0.3c (±0.94)	1.31c (±0.01)	16.61a (±0.06)	0.06a (±1.14)
T_5	1.27a (±0.10)	0.41ab(±0.43)	1.68a (±0.03)	12.29bc (±0.03)	0.7a (±1.76)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statististically significant at $P \leq 0.05$ by Tukey's Range Test.

4.6 Yield

4.6.1 Yield of BARI Gom-27

In case of BARI Gom-27 the weight was varied among different treatments (Table 13). In plot the highest (43g) weight was observed in Control, followed by Sada koroi leaf (35g), Ipil-ipil leaf (29g), Mango leaf (26g) and lowest in Ghora leaf (21g).The weight was converted into kg/ha. In case of hectare the highest (2047.64kg) weight was in Control and lowest (1000kg) was in Ghora neen leaf.

Table 13: Effect of different tree leaves on the yield of BARI Gom-27

Treatment	**Total weight (g)/plot**	Total weight in kg/ha
T_1	21bc (±0.88)	1000a (±0.57)
T_2	29ab (±0.67)	1380.95a (±0.57)
T_3	26abc (±0.88)	1238.09a (±0.57)
T_4	35c (±0.33)	1666.67a (±0.57)
T_5	43a (±0.57)	2047.6a (±0.57)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statistically significant at $P \leq 0.05$ by Tukey's Range Test.

4.6.2 Yield of BARI Gom-28

In case of BARI Gom-28 the weight was varied among different treatments (Table 14). In plot the highest (39g) weight was observed in Control, followed by Sada koroi leaf (32g), Ipil-ipil leaf (27g), Mango leaf (25g) and lowest in Ghora leaf (23g).The weight was converted into kg/ha. In case of hectare the highest (1857.14kg) weight was in Control and lowest (1095.23kg) was in Ghora neen leaf.

Table 14: Effect of different tree leaves on the yield of BARI Gom-28

Treatment	**Total weight (g)/plot**	Total weight in kg/ha
T_1	23b (±.88)	1095.23b(±.57)
T_2	27a (±.88)	1285.71ab(±.58)
T_3	25a (±.67)	1190.47ab(±.57)
T_4	32a (±1.14)	1523.81ab(±.58)
T_5	39a (±.88)	1857.14a(±.58)

Note: T_1= Ghora Neem, T_2= Ipil-ipil, T_3 = Mango, T_4 = Sada koroi, T_5=Control. In a column, different letter(s) show statistically significant at $P \leq 0.05$ by Tukey's Range Test.

4.7 Discussion

Germination, plant height, leaf length, root length and yield of BARI Gom-27 and BARI Gom-28 was highest in control condition than Ghora neem, Ipil-ipil, Mango, and Sada koroi tree leaf extract. Among the trees Sada koroi tree leaf extract showed better germination in BARI Gom-27 and Ghora neem tree leaf extract shows less germination in both lab and field experiment. These findings are in agreement with Salam and Kato (2010) who studied allelopathic potential of aqueous methanol extract of Neem leaves on seed germination and seedling growth. Plant height of BARI Gom-27 and BARI Gom-28 increased over time in all treatments. Plant height was found significantly higher in Sada koroi extract in BARI Gom-27 compared to other tree extract. The higher plant height of wheat in Sada koroi based agroforestry system as compared to Ghora neem possessed inhibitory substances and might have allelopathic potential (Chaudhry, 2003). Leaf extract did not affect the leaf length of these wheat varieties. Similar findings have also been reported by Bhardwaj *et al.* (2005), Takleay (2004), Patil *et al.* (2002), Pant (1993) and Sidhu and Hans (1998). The yield per hectare of BARI Gom-27 was found statistically significant among different treatments. The higher yield was found in Sada koroi tree leaf treatment. In case of BARI Gom-28 the yield per hectare is statistically significant. Similar results were observed by (Lehmann *et al.,* 2002; Bhardwaj *et al.,* Sarvdve, 2014). In our study, we found highest yield of BARI Gom-27 in control treatment (2047 kg/ha). Among the tree extracts, highest yield of BARI Gom-27 was recorded in Sada Koroi treatment (1667 Kg/ha) compared to other extract treatments. On the other hand, the average yield of wheat reported 3030 kg/ha (Rashid and Hossain 2016). The yield loss might be due to the allelopathic affect of trees on the wheat variety. The total production i.e. wheat yield and tree yield might be more if we add together per hectare. Same trend of result was recorded in case of BARI Gom 28 but its production is lower (1524 kg/ha) than BARI Gom 27.

Although the Prodip covered highest area but other newly developed variety like BARI Gom 25, BARI Gom 26, BARI Gom 27 and BARI Gom 28 were the most promising varieties which showed increasing adoption path among the expert. These varieties have very good potentiality due to having short duration, tolerance to terminal heat stress, tolerant to salinity and lodging attributes. Satisfying higher demand for wheat consumption and ensuring wood demand through agroforestry practices are the major concerning issue of the policy planner and the scientist (Rashid and Hossain 2016).

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

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SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

An experiment was conducted at the Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Bangladesh during November 2016 to February 2017 to find out the germination, root architecture, shoot growth and yield of BARI Gom 27 and BARI Gom 28. There were two experiments. Experiment 1 was laboratory experiment and experiment 2 was field experiment. The experiments were laid out in complete randomized design. Experiment- 1 was conducted in petridis and experiment-2 was conducted in field. There were five treatments including control viz. T_1 (Ghora neem), T_2 (Ipil-ipil), T_3 (Mango), T_4 (Sada koroi) and T_5 (Control only water). All statistics were calculated with Statistics 10 software and MS Excel 2007.

The results of the research showed that germination percentage , number of shoots, root length, biomass were affected by different tree leaves .Control showed better germination compared to all the treatments of tree leaves. Among the trees Sada koroi tree leaf showed better germination and growth. In case of laboratory experiment, germination percentage in BARI Gom-27 was highest in Control condition (95%) and lowest percentage was found in Ghora neem leaf (20%). In the same way, in BARI Gom-28, the highest germination percentage was recorded Control treatment (90%) and lowest was Ghora neem leaf (21%). In field experiment, highest percentage of germination of BARI Gom- 27 was observed in Control (88.16%) and lowest germination percentage was found in Ghora neem leaf (77%). Likewise, germination percentage of BARI Ghom-28 was found highest in Control (85.26%) and lowest was found in Sada koroi leaf (73.66%).

The highest yield of BARI Gom-27 was observed in Control (2047.61 kg/ha) and lowest was in Ghora neem (1000kg/ha). The highest yield in BARI Gom-28 was in Control (1857.14kg/ha) and lowest was in Ghora neem (1095.23kg/ha).

5.2 Conclusion

It can be concluded that the four tree leaf like Ghora neem, Ipil-ipil, Mango, and Sada koroi had negative effects on the germination, growth and yield of wheat. Among those Sada koroi tree had less negative effect and Ghora neem tree had more negative effect on BARI Gom-27 and BARI Gom-28. But Sada koroi tree shows good result in BARI Gom-27 compare to BARI Gom-28. Therefore, BARI Gom-27 can be cultivated with Sada koroi tree in an agroforestry system.

5.3 Recommendations

The recommendations that can be put forward from the present study are as follows:

i. The experiment was conducted in laboratory at 5% concentration. Therefore, further research can be recommended in 2.5%, 10% or other suitable concentrations in field.

ii. Allelopathic effect of the four trees on wheat should be tested in different region of the country.

REFERENCES

REFERENCES

AAFC (2005). Durum wheat: 2005-2006 situation and outlook. Bi-weekly Bulletin. Agriculture Agri-Food Canada. December 16, 2005. Vol. 18. No. 20.

Akter, M.S., Abedin, M.Z. and Quddus. M.A. (1989). Why farmers grow tree in agricultural fields: some thoughts, some results. Research Report 1988-89. On Farm Research Division, Joydebpur. pp. 75-82.

Angeles, D. E. Mendoza, D. B. (1988). Performance of papaya grown as monocrop and as intercrop with pineapple and banana. Philippine, Agriculturist. 71(2): 173-177.

Ashrafi, Z., Mashhadi, H. R. and Sadeghi, S. (2007). Allelopathic Effects of Barley (*Hordeum vulgare*) on Germination and Growth of Wild Varley (*Hordeum spontaneum*). *Pakistan Journal of Weed Science Research.* 13: 99-112.

Banglapedia. 2006. BANGLAPEDIA—national encyclopedia of Bangladesh http://www.banglapedia.org/httpdocs/HT/W_0053.htm 2 November 2012.

BARI (Bangladesh Agricultural Research Institute). (2010). Wheat production in Bangladesh: a success story http://www.bari.gov.bd/index.php?option = com_ simplestforum and view= postlist and topic=true and forumId =1 and parentId = 288 4 November 2012.

BARI (Bangladesh Agricultural Research Institute). (2012b). Year of release and average yield of Bangladesh wheat varieties developed since 1974.

Bari, M. S. and Rahim, M. A. (2009). Performance of carrot as intercrop in multistrata sissoo woodlot. J. Agrofor. Environ. 3(2): 31-34.

BARI. (2013). http://baritechnology.org/en/home/tech_commodity. Joydebpur, Gazipur-1701, Bangladesh. Agroforesrtry Abstr. 1(3): 125.

BBS. (2010). Household Income and Expenditure Survey, Bangladesh Bureau of Statistics.

Bene, J. C. beall H. W. and Cole. A. (1977). Trees, food and people. IDRC, Ottawa.

Bhardwaj B. B., Gupta S. R., Saini R., Sodhi J. S. and Singh A. (2005). Nutrient dynamics in a populous deltoids agroforestry system at Kuruksheter. Bulletin of the National Institute of Ecology 15: 99-108.

Bhatia, K S. and Singh, R. P. (1994). Trees for sustainable agriculture production. Banglapedia. 2006. BANGLAPEDIA—national encyclopedia of Bangladesh http://www.banglapedia.org/httpdocs/HT/W_0053.htm 2 November 2012.

Bokhari, M. H. and Aslam, K. M. (1985). Neem (Melia Azadirachta A. Juss). A Useful Tree in Northern Nigeria. *Annals of Borno. II:* 83-86.

Chang-Hung Chou (2006). Introduction to allelopathy, Part 1, 1-9, doi:10.1007/1-4020-4280-9_1

Chaudhry A. K. (2003). Comparative Study of Different Densities of Poplar in Wheat Based Agroforestry System in Central Punjab. M. S. Thesis, University of Agriculture, Faisalabad-pakistan.

Chiapusio, G., Sanchez, A. M., Reigosa, M. J., Gonzalez, L. and Pellissier, F. (1997). Do germination indices adequately reflect allelochemical effects on the germination process. *Journal of Chemical Ecology*, 23(11): 2445-2453.

Clarke JM (2005). Durum wheat improvement in Canada. In: Royo, C., Nachit, M. M., Di Fonzo, N., Araus, J. L., Pfeiffer, W. H. and Slafer, G. A. (eds.) Durum wheat breeding. Current approaches and future strategies. Vol.2. P: 921-938.

Devaranavadgi, S. B., Hunshal, C. S., Wali, S. Y., Patil, M. B. and Bellakki, M A. (2003). Studies on allelopathic effects in sorghum based agri-silviculture system. *Karnataka Journal of Agricultural Sciences*. 16(3): 426-429.

Doran, J. C. and Turnbull, J. W. (1997). Australian trees and shrubs: species for land rehabilitation and farm planting in the tropics. 384 pp.

Duke S. O., Baerson S. R., Rimando A. M., Pan Z., Dayan F. E. and Belz R. G. (2007). Biocontrol of weeds with allelopathy: Conventional and transgenic approaches, in: Vurro M., Gressel J. (Eds.), Novel biotechnologies for biocontrol agent enhancement and management, Springer, The Netherlands, pp. 75–85.

Elias, E. M. and Manthey, F. A. (2005). End products: present and future uses. In: Mohan Jain S, Brar DS, Ahloowalia BS (Eds.) Molecular Techniques in Crop Improvement. Kluwer Academic Publishers. Dordrecht, The Netherlands. P: 63-86.

FAO (Food and Agricultural Organuzation) and UNDP (United Nations Development Programme), (1993). Land Response appraisal of Bangladesh for Agricultural Development. Rep. No-2 Agro-ecological Regions of Bangladesh Food and Agricultural Organization United Nations Development Programme.

Gooding, M. J. and Davies, W. P. (1997). Wheat production and utilization. Systems, quality and the environment. CAB International. Cambridge. UK.

Gupta, C.R. and Awasthi, O. P. (1997). Effect of mulch material on growth and yield of ginger. Veg. Sci. 24(1): 13-25.

Halsey, R. W. (2004). In search of allelopathy: An eco-historical view of the investigation of chemical inhibition in California coastal sage scrub and chamise chaparral. *Journal of the Torrey Botanical Society* 131: 343-367. The California Chaparral Institute also offers a PDF-format version of this paper

Haque, M. A. (ed) (1996). Agroforestry in Bangladesh. Swiss Development Co-operation (SDC), Dhaka and BAU, Mymensingh, 11 p.

Harbome, J. B. (1977). Introduction to Ecological Biochemistry. Academic Press, New York

Harou (1983). Economic principles of appraise Agricultural Administration, 12: 121-139.

Hossain, A. (1995). Plantation of Turmeric and Ginger in Shadow fallow land in the homestead area. Bangladesh J. Crop Sci., 10(2): 20-22.

Islam, S. S. Kibria, S. S. and Chowdhury, M. H. 1998. Financial analysis of agroforestry Forest. Sci. 27 (2): 76-81.

Jha, L. K. and Lalnunmawia, F, 2003. Agroforestry with bamboo and ginger to rehabilitate degraded areas in North East India. Indian J. of Bamboo and Rattan. 2 (2): 103-109.

Kerber, E. R. and Tipples, K. H. (1969). Effects of the D genome on milling and baking properties of wheat. Canadian Journal of Plant Science. 49: 255-263.

King, K. F. S. and Chandler, M. T. 1978. The wastelands. ICRAF, nairobi, pp. 85.

Koppad, A. G., K. Manjappa and A. M. Chandrasekhariah. (2001). Impact of different conservation measures on rehabilitation on degraded lands and agricultural productivity. Indian J. Soil Conservation. 29(2): 148-151.

Krogh, S. S., Mensz, S. J. M., Nielsen, S. T., Mortensen, A. G., Christophersen, C. and Fomsgaard, I.S. (2006). Fate of Benzoxazinone allelochemicals in soil after incorporation of wheat and rye sprouts, J. Agric. Food Chem. 54: 1064–1074.

Lehmann, J., Gebaur, G. and Zech, W. (2002). Nitrogen cycling assessment in a hedgerow intrcropping system using 15N enrichment. Nutrient Cycling in Agroecosystems 62:1-9.

Liu, D. and Lovett, J. (1994). Biologically active secondary metabolites of barley I Developing techniques and assessing allelopathy in barley Journal of Chemical Ecology. 19: 2217-2230.

Macías, F. A., Oliveros-Bastidas A., Marín D., Castellano D., Simonet A. M., Molinillo J. M. G. (2004a). Degradation studies on Benzoxazinoids. Soil degradation dynamics of 2, 4-Dihydroxy-7-methoxy-(2H) 1, 4-benzoxazin-3(4H)-one (DIMBOA) and its degradation products, phytotoxic allelochemicals from Gramineae, J. Agric. Food Chem. 52: 6402–6413.

Nair, P. K. R. (1977). Agroforestry Research: A retrospective and prospective appraisal. Proc. Int. Cont. International Cooperation in Agroforestry. ICRAF, Nairobi. pp. 275-296.

Nair, P. K. R. (1987). The torpics. In: Lal, R. *et al.* (des) tropical land clearing for sustainable agriculture. IBSRAM. Agroforestry in the context of land clearing and development in Proc. series No. 3, Bangkok, Thailand.

Nair, P. K. R. (1990). An introduction to agroforestry. Kluwer Academic publishers, ICRAF.

Ong, C. K. (1988). The interaction light, water and nutrients in agroforestry system. Chapter for book on "Application of Biological Research on Asian Agroforestry". J. A., 885.

Oueslati, O. (2003). Allelopathy in two durum wheat (*Triticum durum* L.) varieties, Agric. Ecosyst. Environ. 96: 161–163.

Pandit, D. B. Mandal, M. S. N. Hakim, M. A. Barma, N. C. D. Tiwari, T. P. and Joshi, A. K. 2011. Farmers' preference and informal seed dissemination of first Ug99 tolerant wheat variety in Bangladesh. Czech Journal of Genetics and Plant Breeding 2011; 47 (Special Issue): S160-S164.

Pant, A. K. (1993). Effect of variable soil fertility on wheat productivity and nutrient dynamics in an agri-silviculture system. Pantnager, Uttarakhand. P.240.

Patil, R. H. Hunshal, C. S. and Itnal, C. J. (2002). Influence on bund planted Eucalyptus trees row on winter wheat. Allelopathy J. 10(1): 21-28.

Pramono, I. B. basuki, T. M. and sembiring, S. (2000). Soil conservation techniques in ginger plantations at lumban Julu, North Tapanuli. Buletin Penelitan Kehutanan Pematang siantar, 15(2): 11-17.

Rahman, M. A. (2004). Growth and development of different vegetable and spices grown under multilayer agroforestry system. M. S. Thesis, BAU, Mymensingh, Bangladesh.

Rashid, M. A., and Hossain, T. M. (2016). Adoption of wheat varieties in Bangladesh: expert elicitation approach. *Bangladesh Journal of Agricultural Research*, *41*(3), 491-505.

Rice, Elroy Leon (1984). *Allelopathy*, (first edition, november 1974 by the same editor) (Second ed.), Academic Press, pp. 422.

Romman, A S. Mohammad, S. and Rida, S. (2010). Allelopathic effects of spurge (*Euphorbia hierosolymitana*) on wheat (*Triticum durum*). *American-Eurasian J. Agric. and Environ. Sci.* 7(3): 298-302.

Sahoo, U. K., Jee, L., Vanlalhriatpuia, K., Upadhyaya, K. and Lalremruati, J. H. (2010). Allelopathic effects of leaf leachate of *Mangifera indica* L. on initial growth parameters of few home garden food crops. *World Journal of Agricultural Sciences*. 6(5): 579-588.

Saka, A. R., Bunderson, W. T., Mbekeani, Y. and Ltimu, O. A. (1990). Planning and implementing Agroforestry for small holder farmers in Malawi. In: Planning for agroforestry, Budd *et al*. (Eds) Elsevier Applied Sci. London.

Salam, M. A. and Kato, H. N. (2010). Evaluation of allelopathic potential of neem (*Azadirachta indica.* A. Juss) against seed germination and seedling growth of different test plant species. *International Journal of Sustainable Agriculture.* 2(2): 20-25.

Sarvade, S., Mishra, H. S., Kaushal, R., Chaturvedi, S., Tewari, S., and Jadhav, T. A. (2014). Performance of wheat (*Triticum aestivum* L.) crop under different trees and fertility levels. African Journal of Agroforestry Research, 9(9), 866-873.

Saxena, M. B. L. (1984). Improved crops varieties in Agroforestry. Agroforestry in Arid and Semi- Arid Zones. Central Arid Zones Research institute, Jodhpur, India. 27:77-80.

Shanmughaved, P. and Francis, K. (2001). Intercropping trials of four crops in bamboo plantations. Bamboo and Rattan, 1: 3-9.

Sidhu, D. S. and Hans, A. S. (1998). Preliminary studies on the effect of ghora neem leaf litter on accumulation of biomass in wheat. J. Tropical Forestry. 4(4): 328-333.

Singh H. P., Kohli R. K. and Batish, D. R. (2012). Effect of poplar (*Poplus deltoids*) Sheltered on The Growth and Yield of Wheat in Punjabi, India. Agroforestry Systems, 40(2): 207-213.

Solanki, K. R. (1998). Agroforestry research in India. Indian Agric. Sciences 68.

Stamp, Nancy (March 2003), "Out of the quagmire of plant defense hypotheses", The Quarterly Review of Biology, 78(1): 23–55.

Tekley, T. (2004). Seeasonal dynamics in the concentration of macro nutrient and organic constituents in green and senesced leaves of three agroforestry species in southern Ethiopia. Plant and Soil. 267: 297-307.

Von Maydell, J. J. (1987). Agroforestry in the dry zone of Africa: past, present and future Agroforestry: A decade of development (Steppler, H. A. and Nair, P. K. R. eds.): 89-116.

WRC (Wheat Research Center). (2009). Annual Report, 2008–09. Nashipur, Dinajpur, Bangladesh. 181 P. cancer cell lines. *Steroids*, 74(9): 761-765.

Wu, S. B., Ji, Y. P., Zhu, J. J., Zhao, Y., Xia, G., Hu, Y. H. and Hu, J. F. (2009). Steroids from the leaves of Chinese *Melia azedarach* and their cytotoxic effects on human.

Zaman, M. M., Nazrul, M. I., Mondal, H. P. Alam, M. S. and Uddin, M. S. (2002). Effect of plant spacing and depth on the yield of Ginger. Annual Report. Spices Research Centre. BARI, Shibgnj, Bogra. 85p.

Zheo, D. and Oesterhuis, D. M. (1995). Effect of shading and PGR-IV on cotton components of yield. Special report Agricultural Experiment station. Division of Agriculture, University of Arkansas, 172: 121-125.

APPENDICES

APPENDICES

Appendix I: The soil properties of Agroforestry and Environment farm HSTU, Dinajpur

Soil characters	Physical and chemical properties
Texture	
Sand (%)	67
Silt (%)	33
Clay (%)	5
Textural class	Sandy loam
CEC (meq/ 100g)	8.00
pH	6.1
Organic matter (%)	1.25
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)	25.0
Sulphur (µg/g)	3.1
Boron (µg/g)	0.28
Iron (µg/g)	5.30
Zinc (µg/g)	0.90

Source: Soil Resources Development Institute, Dinajpur (2016).

Appendix II (a): Number of germinated seeds of different treatments of BARI Gom-27 in field experiment

Treatment	D0.5	D1	D1.5	D2	D2.5	D3	D3.5
T_1	24	38	77	92	107	118	131
T_2	32	60	90	115	130	138	145
T_3	16	36	73	74	125	133	142
T_4	28	49	92	105	122	127	136
T_5	29	72	111	128	143	148	152

Note: T_1 = Ghora neem, T_2=Ipil-ipil, T_3=Mango, T_4 = Sada koroi, T_5 = Control

Appendix II(b): Number of germinated seeds of different treatments of BARI Gom-28 in field experiment

Treatment	D0.5	D1	D1.5	D2	D2.5	D3	D3.5
T_1	38	52	71	92	114	128	137
T_2	48	69	82	103	122	129	139
T_3	26	40	48	85	123	127	134
T_4	16	27	41	59	102	117	127
T_5	24	50	64	97	131	140	147

Note: T_1 = Ghora neem, T_2=Ipil-ipil, T_3=Mango, T_4 = Sada koroi, T_5 = Control

Appendix III (a): Descriptive Statistics of Shoot height of BARI GOM 27 influence by tree extract after one month

Treatment	N	Mean	SD	SE Mean	c.v
T_1	3	28.52	1.56	0.90	5.47
T_2	3	31.99	2.01	1.16	6.28
T_3	3	25.59	1.06	0.67	4.15
T_4	3	33.03	1.95	1.12	5.90
T_5	3	39.27	1.82	1.05	4.65

Note: T_1 = Ghora neem, T_2=Ipil-ipil, T_3=Mango, T_4 = Sada koroi, T_5 = Control

Appendix III (b): Analysis of variance of Shoot height of BARI GOM 27 influence by tree extract after one month

Source of variance	Degrees of Freedom	Sum square values	Mean Sqare Values	F Values	P Vallues
Treatment	4	319.92	89.89	27.12	0
Error	10	29.49	2.94		

Appendix VI (a): Descriptive Statistics of Shoot height of BARI GOM 27 influence by tree extract after two months

Treatment	N	Mean	SD	SE Mean	c.v
T_1	3	68.95	5.12	2.95	8.69
T_2	3	64.44	2.97	1.71	4.65
T_3	3	52.92	3.53	2.04	6.68
T_4	3	68.98	2.76	1.59	4.01
T_5	3	80.08	1.93	1.12	2.42

Note: T_1 = Ghora neem, T_2=Ipil-ipil, T_3=Mango, T_4 = Sada koroi, T_5 = Control

Appendix VI (b): Analysis of variance of Shoot height of BARI GOM 27 influence by tree extract after two months

Source of variance	Degrees of Freedom	Sum square values	Mean Sqare Values	F Values	P Vallues
Treatment	4	1278.43	319.61	27.07	0
Error	10	118.06	11.80		

Appendix V (a): Descriptive Statistics of Shoot height of BARI GOM 27 influence by tree extract after three months

Treatment	N	Mean	SD	SE Mean	c.v
T_1	3	72.52	2.76	1.59	3.82
T_2	3	76.16	3.34	1.92	4.87
T_3	3	69.58	2.32	1.34	3.34
T_4	3	76.38	2.45	1.41	3.21
T_5	3	90.31	3.44	1.99	3.82

Note: T_1 = Ghora neem, T_2=Ipil-ipil, T_3=Mango, T_4 = Sada koroi, T_5 = Control

Appendix V (b): Analysis of variance of Shoot height of BARI GOM 27 influence by tree extract after three months

Source of variance	Degrees of Freedom	Sum square values	Mean Sqare Values	F Values	P Vallues
Treatment	4	758.93	189.73	22.49	0.0001
Error	10	84.37	8.34		

Appendix VI (a): Descriptive Statistics of Shoot height of BARI GOM 28 influence by tree extract after one month

Treatment	N	Mean	SD	SE Mean	c.v
T_1	3	31.29	2.04	1.18	6.52
T_2	3	37.48	1.99	1.15	5.32
T_3	3	32.59	2.19	1.26	6.71
T_4	3	27.83	1.36	0.78	4.89
T_5	3	39.48	1.50	0.86	3.79

Note: T_1 = Ghora neem, T_2=Ipil-ipil, T_3=Mango, T_4 = Sada koroi, T_5 = Control

Appendix VI (b): Analysis of variance of Shoot height of BARI GOM 28 influence by tree extract after one month

Source of variance	Degrees of Freedom	Sum square values	Mean Sqare Values	F Values	P Vallues
Treatment	4	267.39	66.84	19.59	0.0001
Error	10	34.11	3.41		

Appendix VII (a): Descriptive Statistics of Shoot height of BARI GOM 28 influence by tree extract after two months

Treatment	N	Mean	SD	SE Mean	c.v
T_1	3	64.33	2.31	1.33	3.59
T_2	3	74.05	6.28	3.62	8.49
T_3	3	62.14	3.47	2.0	5.57
T_4	3	59.76	1.19	0.69	2.0
T_5	3	80.92	1.80	1.04	2.23

Note: T_1 = Ghora neem, T_2=Ipil-ipil, T_3=Mango, T_4 = Sada koroi, T_5 = Control

Appendix VII (b): Analysis of variance of Shoot height of BARI GOM 28 influence by tree extract after two months

Source of variance	Degrees of Freedom	Sum square values	Mean Sqare Values	F Values	P Vallues
Treatment	4	956.71	239.17	19.42	0.0001
Error	10	123.11	22.31		

Appendix VIII (a): Descriptive Statistics of Shoot height of BARI GOM 28 influence by tree extract after three months

Treatment	N	Mean	SD	SE Mean	c.v
T_1	3	17.08	1.22	0.70	7.14
T_2	3	11.76	0.56	0.32	4.78
T_3	3	15.74	1.92	1.11	12.25
T_4	3	16.61	1.62	0.93	9.78
T_5	3	12.30	0.75	0.94	6.17

Note: T_1 = Ghora neem, T_2=Ipil-ipil, T_3=Mango, T_4 = Sada koroi, T_5 = Control

Appendix VIII (b): Analysis of variance of Shoot height of BARI GOM 28 influence by tree extract after three months

Source of variance	Degrees of Freedom	Sum square values	Mean Sqare Values	F Values	P Vallues
Treatment	4	74.39	18.59	10.63	0.0013
Error	10	17.18	1.47		

Appendix IX: Some Photographs

Plate 1: Collection of tree leaves

Plate 2: Drying of leaves in oven

Plate 3: Grinding of leaves

Plate 4: Preparation of solution

Plate 5: Sowing of seed in the field

Plate 6: Morphological growth of wheat

Plate 7: Irrigation application in wheat

Plate 8: Harvesting of Wheat