EFFECT OF MANGO VARIETIES AND FERTILIZER ON THE GROWTH AND YIELD OF CHILLI

A Thesis
By

MD. ASADUR RAHMAN LEBU

Student No.: 1805335

Thesis Semester: January-June 2020

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

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DEPARTMENT OF AGROFORESTRY AND ENVIRONMENT
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

JUNE 2020

DEDICATED
TO MY
BELOVED PARENTS
AND
HONORABLE TEACHERS

<u>DECLARATION</u>

I hereby declare that the work presented in this thesis titled **“EFFECT OF MANGO VARIETIES AND FERTILIZER ON THE GROWTH AND YIELD OF CHILLI”** has been carried out by me and that it has not been submitted for any previous degree. All quotations have been distinguished by quotation marks and all sources of information specifically acknowledged by references to the authors.

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June 2020 *The Author*

EFFECT OF MANGO VARIETIES AND FERTILIZER ON THE GROWTH AND YIELD OF CHILLI

ABSTRACT

A field experiment was carried out at the Mithapukur upazila, Rangpur during January, 2020 to April, 2020 to evaluate the performance of chili production under three different mango variety based agroforestry systems. The experiment was laid out in two factorial RCBD with 3 (three) replications. Factor A (Three Variety treatment) viz. V_1= BARI Amm-11, V_2= BARI-4 and V_3= Thai Baromasi and Factor B (Four Fertilizer Applications) viz. F_1= No Fertilizer, F_2= Cow-dung, F_3= Chemical fertilizer and F_4= Chemical fertilizer + Cow-dung. Therefore there will be twelve treatment combinations (3 varietal treatment x 4 fertilizers application). The total numbers of experimental plots were 36. The result of the experiment revealed plant height (00, 15, 30 and 45 days after transplanting: DAT), number of leaf/plant (00, 15, 30 and 45 DAT), first flowering days after transplanting, first fruiting days after transplanting, number of fruit/plant, weight of fruit/plant (g), total Number of fruit/plot, total weight of fruit/plot (kg), fruit length (cm), fruit diameter (cm), fresh weight/Plant (g), dry weight/Plant (g) and yield (t/ha) of chili significantly varied due to different varietal treatments and fertilizer applications when cultivated under three mango based agroforestry systems. In case of main effects of varietal treatments, the highest chili fruit yield (4.97 t/ha) was recorded from the BARI Amm-4 (V_2) treatment and the lowest fruit yield (3.12 t/ha) was obtained from the Thai Baromasi (V_3) based agroforestry system. In case of main effects of fertilizer applications, the highest chili fruit yield (4.69 t/ha) was recorded from the plot where chemical fertilizer (F_3) was applied and the lowest fruit yield (3.62 t/ha) was obtained from the plot where no fertilizer (F_1) was applied. In case of interaction effects of the varietal treatments and fertilizer applications on chilli, the highest chili fruit yield (5.62 t/ha) was observed from V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination. From the economic point of view, the highest benefit-cost ratio (2.83) was also recorded from the V_2F_3 treatment combination and the lowest benefit-cost ratio (1.56) was observed in those plots where chili was grown under Thai Baromasi mango variety (V_3) with cow-dung (F_1) application. Not much information is available on the use of different mango variety as varietal treatment associated with other crops such as chilli. So, this research findings are helpful for selection mango orchard according to variety for chilli cultivation as well as others crops.

Keywords: Mango, Fertilizer, Chilli, Growth, Yield, Variety

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CHAPTER I

INTRODUCTION

1.1 Background information of the study

Agriculture is the key driver of the growth of Bangladesh economy. The overall contribution of the agriculture sector was 14.23 percent in GDP during the year 2017-18 (MoF 2018). Along with major crops, several minor crops are being cultivated to feed the huge population of Bangladesh. Apart from the dominant rice-based cropping systems of Bangladesh, wheat, maize, potato, pulses, oilseed and wide range of summer and winter vegetables are grown in the country. Inputs requirement (i.e., seeds, fertilizers, pesticides and insecticides, labour, water etc.), profitability, marketing and value chain studies of these crops are important for productivity and farm return (Hossain and Siddique, 2015; Sultana *et al.* 2015; Siddique *et al.* 2015). In this regard, chilli is a valuable spice and also an important cash crop in Bangladesh. People prefer and consume it (both dried and green) for its color, pungency and spicy taste (Mathukrishnan *et al.* 1993). It is a vitamin (both A and C) rich crop. Moreover, we get iron, magnesium and potassium from chilli. It has medicinal values also. About 103381.49 ha of land of Bangladesh is under chilli cultivation in both Rabi (winter season) and Kharif (spring and summer season), the production is about 136,872 metric ton. Only 0.81 metric tons per hectare was the national yield per hectare for Chilli in Bangladesh in 2002-03 but now it’s about 1.32 metric ton per hectare (BBS 2017). In Bangladesh, there are comparatively fewer number of studies related with chilli profitability. Amon the few studies, Sabur and Atiar (1993) examined the trend, seasonal variability and relative profitability of spices in Bangladesh. The study revealed that the benefit cost ratio of green Chilli production was 1.55. The estimation of financial profitability by (Huda *et al.* 2008) ranked highly profitable spices as following order: ginger, chilli, turmeric, garlic and onion. While Chowdhury *et al.* (2012) mentioned that net profit margin for green Chilli was 7.26 tk/kg in local market whereas Tk. 13.42/kg for UK and Middle East countries. In addition, Hoq et al. (2014) reported economic studies in Bogra, the northern district where plenty of Chilli are produced by the smallholder farmers. It was observed that green chili cultivation was profitable and per hectare net return was Tk.92250. Another study revealed that per hectare total cost of Chilli production for small, medium and large farmers were tk. 119909, 134222 and123626 respectively (Meoya 2011). Therefore, it is important and justified to analyze the cost and return of green Chilli production in the Bangladesh. Thus, the present study was designed to analyze the financial profitability of green chilli under different mango variety, to calculating costs and returns of green Chilli production. This study hypothesized that green Chilli is a profitable crop to cultivate under mango tree and chilli farmers of Bangladesh are subjected to the production, socio-economic and marketing barriers.Most of the farmers were facing the problem of lack of high yielding varieties and land. Farmers were also facing the problem of lack of labor availability and extreme weather. One of the important problems of Chilli production is the disease. About eighty percent of all farmers reported about the problem of lack of operating capital and not getting any credit support during the production period of Chilli. Lack of farmers association and crop insurance problems were also crucial for the chilli producers. According to seventy-two percent farmers, Chilli market is controlled by some dominant traders who used to cheat them while buying produce from them and lack of proper market monitoring authority was the reason behind that.

In Bangladesh, different crops are cultivated in winter season. Among the different winter vegetables, chilli is not only most important winter vegetables in Bangladesh but also well-known and high demandable popular vegetables grown successfully during brumal season in Bangladesh Though the aforementioned chilli is very common to all and have good potential in our climate, none of them was systematically tested in agroforestry system or in natural shade condition to see their production ability under partial shade conditions. For identifying the compatible tree-crop combination in plain land, particularly species i.e. different crops should be screened out in terms of their adaptability and yield in association with the early stage of tree. Considering the above-mentioned facts and potentiality, this study was undertaken to identify a sustainable farming system for the plain land areas of Bangladesh for investigating the growth and yield performance of chilli in association with three mango variety.

Mango (*Mangifera indica*) is an important component of agroforestry systems in many parts of the world (Nair, 1989). Mango offers great advantage in agroforestry due to the spatial advantage it provides for intercropping, as it is generally planted at wide spacing to accommodate the large crowns that are needed to support the fruit yield. Wider spacing of the trees ensure large gaps in the canopy upto 30% of the land area. They also offer ample scope for exploitation of soil depth due to spatially differential root distribution of component crops in the system ensuring a higher nutrient and water use efficiency. Root abundance of plants is usually highest at the topsoil (Canadell *et al*., 1996). . Mango has a long taproot that can often reach up to 6 m soil depth. Bulk of the root activity (75 %) in mango was found to be at a shallow depth (47.3 cm) in an 18 year old tree (Bojappa and Singh, 1974), while it was estimated to be as deep as 215.9 cm in an 8 year old tree (Kotur *et al.* 1997). This wide variation in root activity provides scope for effective integration of other crops. . The trees generally branch at a height of 0.6–2 m above ground level. Mangoes do not make a good over story tree for cropping shade tolerant species as their dense canopy produces heavy shade due to low branching and evergreen dense foliage. This poses serious limitations to intercropping with shade intolerant crops. However, mango orchards in their early stages of development offer ample scope for intercropping. However, mango litter decomposes at slower rate compared to many tropical trees (Musvoto *et al*., 2000). By virtue of its slow rate of decomposition, it may not be preferred for quick soil fertility correction (Musvoto and Campbell 1995). Under tropical conditions, Musovoto *et al.* (2000) reported N immobilization during decomposition of mango residues. They attributed this immobilization to high polyphenol (18.6%) content. Nitrogen concentration shows an apparent increase over time primarily due to the leaching of labile carbon sources from the decomposing litter. Moderate change in concentration for most of the nutrients across months indicates the slow nutrient releasing mature of mango litter. Despite its limitation for short term correction of soil fertility, mango leaves can be used for long–term buildup of soil organic matter (Mubarak *et al*., 2008). Mango litter can act as a slow nutrient releaser for longer periods; thereby play a major role in maintaining long term soil fertility. In a study on the allellopathic effects of mango in Kerala, Southern India, it was found that leaf leachates were detrimental to bitter gourd while it had no effect on cowpea and brinjal (John *et al*., 2007). Mango enjoys a prominent place among the cultivated fruit crops in the tropics. Its wide tolerance to climatic and edaphic extremes often adds to its cosmopolitan distribution throughout the world. The growth habit, spatial and temporal advantages permit integration of mongo with many other crops, qualifying its suitability as an agroforestry species. At larger orchard level, mango offer wide scope for intercropping with compatible trees and arable crops. However, heavy shade in mature mango orchards may limit the range of crops suitable for integration with mango. Extensive field trials are yet to be taken up to evaluate the performance of mango under diverse polyculture systems and to evolve suitable crop combinations for different agro climatic conditions.

1.2 Research Problems

Farmers those have mango orchard are cultivating different kinds of vegetables and spices at the floor of mango orchard. But usually they are using not appropriate fertilizers and not aware about which variety will give much yield and economic benefits. So, we need to identify the suitable mango variety for chilli production as well as minimizing fertilizer use efficiency in the floor of mango orchard. Here, Chilli is our test crop, we may apply these finding on tomato, ladies finger, eggplant etc.

1.3 The objectives of the current study are

Considering the above circumstances, the present study was conducted with chilli as test crop and three mango varieties as varietal treatment components using different fertilizer applications package with the following objectives:

1. To identify suitable mango variety for chilli production under mango based agroforestry system.
2. To find out the appropriate fertilizer dozes for chilli production under mango based agroforestry system.
3. To assess the economic return of chilli production under mango based agroforestry system.

CHAPTER II

REVIEW OF LITERATURE

Agroforestry is an effective land management practice that simultaneously addresses biophysical, economical and socio ecological components. Such kind of diversity and interaction leads to a greater functional and structural complexity compared to conventional agro-ecosystems. A review of the previous research and findings of researchers having relevance to this study which were gathered from different sources like literature, journals, thesis, reports, newspaper etc. will be represented by this chapter. However, some of the literature related to this investigation are reviewed in this chapter. The relevant literatures pertaining to the present study have been reviewed in this chapter under the following heads:

2.1 Concept and Benefits of Agroforestry system

2.2 Agroforestry system based on mango

2.3 Chilli based agroforestry system

2.4 Effect of fertilizer doses on chilli cultivation

2.1 Concept and Benefits of Agroforestry system

Agroforestry is a collective name of land use systems through maximum utilization of agricultural land in order to provide multiple outputs as well as protect the natural resources (Nurul *et al.* 2011; Handayani and Prawito, 2011). It involves the integration of agricultural crops, plant materials, and livestock production (Suratman *et al.*, 2011). These systems capture the traditional agriculture practices and adapt it using modern and new scientific technologies and knowledge (Wong, 2001; Oxfam Case Study, 2011; Handayani and Prawito, 2011) with the aim to provide long term sustainability instead of focusing on the maximum yield production.

According to a study conducted by Kassie and Zikhali (2009), a sustainable agriculture involves interaction of soil, crop, and livestock production which could benefit the environment such as nutrient cycling and fixing as well as soil restoration. In addition, low external input technology is also considered as sustainable agricultural development based on the criteria of the practices (Kassie and Zikhali, 2009). It involves soil and water management, soil fertility management, crop establishment, and controlling weeds and pests (Tripp, 2006).

It shows that agroforestry systems are fulfilling those criteria by practicing low external input technology which considered as sustainable agriculture practices. In a study conducted by Handayani and Prawito (2011), the agroforestry systems are considering the criteria of self-sufficiency, economically viable for small scale farm, diversification of components and adaptation of new technologies. Therefore, agroforestry systems are a positive, creative and sustainable alternative approach to replace the monoculture systems which largely depend on the forest clearance (Wong, 2001; Oxfam Case Study, 2011). Wong (2001) claims that the overall income of agroforestry systems is greater than monoculture systems. Hence, the systems are seen as an approach in sustainable agriculture practices since it contributes to the positive development in agriculture industry in terms of environment, social and economic aspects (Oxfam Case Study, 2011; Suratman *et al.*, 2011).

Since agroforestry systems are a part of sustainable agriculture practices, the environmental benefits of agroforestry systems continuously give impacts towards human population. Ahmad Fauzi and Huda Farhana (2006) claims that agroforestry systems are practiced to increase land productivity, sustainability, and equity as well as accomplish the social goals.

The components in agroforestry systems consist of agricultural crops, plant materials and animal species especially livestock. The integration between those components involves agronomic studies that support the selection of those components in agroforestry systems by means of environmental benefits. The interaction of plants, animals, soil, and water may beneficially provide food and feed resources as well as environmental sustainability (Handayani and Prawito, 2011).

As mentioned by Nair (2011), agroforestry systems are recognized as an approach in environmental protection. It becomes the foundation for the improvement and development of agriculture into industrialized nations in the world.

Hasnol *et al.* (2012) mentioned that the integration of leguminous cover crops (LCC) in the agricultural land could improve the soil fertility and crops growth as well as reduces immaturity period of the crops. The establishment of cover crops such as Mucuna bracteata becomes crucial in the peat soil area for the reduction of peat fire risk during dry season. Hence, positive mutual interactions between components are able to develop sustainable agriculture setting which improve the productivity and the welfare of the rural community. Agroforestry systems are mostly practiced by the farmers in rural communities. The norm of agroforestry systems involves the poor, small farmers and rural communities who are living in the gloom of poverty and hunger (Sharashkin and Gold, 2005). It has been reported that 50% of the 4 billion poor, rural people are depending largely on the livestock in order to sustain their basic quality of life (Dahlan Ismail, 2009; Kassie and Zikhali, 2009). Meanwhile, in a study conducted by Ahmad *et al.* (2008), oil palm crops are more suitable to be integrated with fruit trees species. Basically, the integration of agricultural crops with fruit trees and vegetables are significantly providing additional nutrition for human especially in poor countries (Handayani and Prawito, 2011). Furthermore, natural medicinal or herbs plant has the ability to heal many diseases and ailments naturally faced by poor communities. For example, 80% and 70% of African and Indonesian people depend on the medicinal herbs that are planted in their agricultural land. Therefore, the benefits of agroforestry on environmental and social aspects are closely linking each aspect to another in order to provide a better nation in developing countries.

Agroforestry systems are one of the approaches that are considered as sustainable agriculture practices due to the practice of zero-burning techniques. Considering that the issue of forest clearance for the preparation of monoculture systems has caused environmental problems, such as air pollution, agroforestry systems improve the air quality by practicing zero burning techniques in which plants and animal waste are processed to be used as organic fertilizers (Dahlan Ismail, 2009).

Agroforestry systems have 80% higher conservation value of water than monoculture systems (Handayani and Prawito, 2011). Better interaction of belowground plant materials in agroforestry systems assist the water quality of the farm. In addition, the usage of plant materials as riparian buffers are strongly encouraged and supported by agricultural policies in the United State due to its advantages in improving water quality (Tomer *et al.* 2009).

Agroforestry systems that combine and interact various species of flora and fauna provides a habitat for the biodiversity. According to Callo-Concha *et al.* (2009), agroforestry systems are the provision of the environmental services in agriculture sector through its benefits on conserving the biodiversity. Callo-Concha *et al.* (2009) found that agroforestry system can help to preserve a higher level of biodiversity as well as provide sustainable landscape connectivity through the encouragement and intensification of the agricultural practices.

Agroforestry systems that integrate various types of plant materials have the capability to capture and utilize natural growth resources such as light, nutrients, and water. The systems provide higher probability to sequester carbon (C) than single species crops cultivation as the integration between trees and crops are possibly become carbon sink sources and provide temporary storage of carbon (Handayani and Prawito, 2011).

The amount of carbon storages that produced by plant-soil systems are possibly mitigate the climate change (Somarriba *et al.,* 2013). The carbon stocks in shaded area of agroforestry systems are seen helping to mitigate climate change. For example, the canopy of trees and oil palm crops integration provides shades and reduces the heat problems faced by livestock such as cattle (Dahlan Ismail, 2009).

In relation to the social aspects, the benefits acquired from the environmental aspects of agroforestry systems are simultaneously defeating the sustainable agriculture issue of food security, food safety and environmental degradation (Yue-Wen, 2009; Handayani and Prawito, 2011). This is due to the goal of agroforestry systems which is to fulfill human needs in food consumption and maintain the standard environmental quality of the surrounding ecosystems (Handayani and Prawito, 2011).

2.2 Mango based agroforestry system

Mango is an important component of agroforestry systems in many parts of the world (Nair, 1989). Mango offers great advantage in agroforestry due to the spatial advantage it provides for intercropping, as it is generally planted at wide spacing to accommodate the large crowns that are needed to support the fruit yield.

Canadell *et al.* (1996) reported that the wider spacing of the trees ensure large gaps in the canopy upto 30% of the land area. They also offer ample scope for exploitation of soil depth due to spatially differential root distribution of component crops in the system ensuring a higher nutrient and water use efficiency. Root abundance of plants is usually highest at the topsoil.

Quantity and quality of litter production is an important characteristic of a tree useful for agroforestry systems. Small holding farmers often substitute high cost mineral fertilizers with plant litter as a plant nutritional source. Plant litter also helps in maintaining soil physical properties such as, aggregate stability and water–holding capacity. Trees in agroforestry systems can be an important source of such plant residues. Accumulation of organic matter in soils too depends mainly on inputs and decomposition rates of organic material. This in turn results in enhanced biological activity in the system leading to ecological stability in the rhizosphere. However, mango litter decomposes at slower rate compared to many tropical trees (Musovoto *et al*., 2000). Under tropical conditions, Musovoto *et al.* (2000) reported N immobilization during decomposition of mango residues.

Nitrogen concentration shows an apparent increase over time primarily due to the leaching of labile carbon sources from the decomposing litter. Moderate change in concentration for most of the nutrients across months indicates the slow nutrient releasing mature of mango litter. Despite its limitation for short term correction of soil fertility, mango leaves can be used for long–term buildup of soil organic matter (Mubarak *et al*., 2008).

Mango litter can act as a slow nutrient releaser for longer periods; thereby play a major role in maintaining long term soil fertility. In a study conducted in Sudan, Mubarak et al. (2008) observed that half-life value for mango litter was about 17.6 weeks. Time taken for 50% loss (mineralization) of N, P and K from mango litter was 24.1, 18.4 and 6.9 weeks respectively. Mass–loss dynamics over a period is best described by the single exponential decay model. As per the single exponential decay model, mango had the lowest decay rate constant (k=0.64 year–1) among the four fruit trees tried (Pleguezuelo *et al*., 2009).

Mubarak *et al.* (2008) also found k–value for mango as 2.08 year–1. This difference may be a consequence of the decay model itself, since biomass decrease is faster at the beginning and becomes slower at the end. Thus while the former experiment lasted 536 days; the later lasted only for 84 days. Furthermore, decay rate is strongly influenced by soil moisture, temperature, soil faunal abundance, microbial activity etc.

In a study on the allelopathy effects of mango in Kerala, Southern India, it was found that leaf leachates were detrimental to bitter gourd while it had no effect on cowpea and brinjal (John *et al.,* 2007).

Alum and Sarker, 2011, Alum *et al.*, 2010, Zaman *et al.* 2010, reported that the mango is more often encountered as a component of homegardens, where they are allowed to grow taller, leaving space for the incorporation of components beneath its canopy. Farmers had strong preference for fruit species over timber yielding ones in homesteads of Bangladesh because of better growth and among fruit trees, mango was the most popular species. Control produces the best result due to the absence of shading effect that observed by Sayed *et al.* (2009).

Gebauer (2005) found that the long rotation fruit trees such as mango constitute dominant horticultural crop in tropical agroforestry systems.

Nath *et al.* (2006) concluded that in the locations having no supplemental irrigation and sloppy topography, mango + gamhar + stylosanthes model would be more effective. They also suggested that in the comparatively flat upland watersheds, mango + guava + french bean/rice can be the most suitable options.

Sreemannarayana *et al.*, 2007 observed that the mango based agri–horticulture system is an important agroforestry system in Andhra Pradesh state of India.

Ravitchandirane and Haripriya (2011) reported that mango intercropped with aloe and periwinkle recorded the highest yield of 15.71 and 10.91 kg tree–1 respectively with the supply of vermicompost @ 5 Mg ha–1 + groundnut oil cake @ 500Kg ha–1. All the organic manurial treatments for intercrops exerted a positive influence on the yield of main crop.

Mango based alley cropping is popular and widely followed in many parts of the world (Rahman et al, 2008). Since mango takes several years to grow to its full size, intercropping to utilize the interspaces is desirable. Mango trees are planted in rows. Paddy, wheat, sugarcane, papaya, banana, ginger, turmeric and different types of vegetables like potato, dolichos bean, and lady's finger are intercropped in between the hedge rows of mango trees to provide a cash flow – particularly in the early years after the mangoes have been planted but have yet to yield. Quiet often the alleys are wide enough (10 or 12m) to accommodate a variety of agricultural crops.

Singh *et al.*, 2008 reported that the farm families of Uttar Pradesh, India adopted the cultivation of wheat, lentil, chicory, oat (green fodder), potato and aborigine in association with mango. Potato, potato + pumpkin, pumpkin after potato, vegetable pea, pumpkin after vegetable pea, garlic and onion after potato in association with mango were also observed.

Swaminathan, (2001) identified casuarina and leucaena as two nitrogen fixing trees ideal for interplanting with the mango in early establishment period. The same author at a later stage observed a 12% reduction in the growth of mango when co– planted with casuarina or leucaena.

Rathore *et al.* (2013) reported that growing of leguminous crops inside the mango orchard had better in the fruit weight and fruit yield of mango under different mango based agri-horticultural models under rainfed condition of western Himalaya, India. Similar result was observed by Dhara and Sharma (2015), and they stated that mango yield improved under mango+ eucalyptus+ pigeonpea agroforestry system as compared with other agroforestery and monocropping systems.

Dhara and Sharma (2015) reported that mango with E. tereticornis along with lady's finger followed by mustard was showed highest gross return compared to other agroforestry system and lowest under sole plantation under different mango based agroforestry system in red laterite zone of West Bengal, India.

Singh *et al.* (2013) conducted a field experiments to investigate the suitability and profitably with different intercrops of cowpea, frenchbean, arhar, soyabean, lentil, blackgram and chickpea in mango orchard (cv. Himsagar). The age of the plant is 7 years old with a spacing of 10x10m which provide the utilization of land space between the plants as an intercrop. Pooled data reveals that the maximum number of fruits 192.41 / tree and yield 46.09 kg / tree were found in Mango + Cowpea whereas maximum fruit weight (254.16 g) in Mango + Lentil. Most of the physical parameters such as fruit length and breadth maximum were recorded (8.20 cm and 7.21 cm respectively) in Mango + Cowpea. But, in case of peel weight (35.67 g) was highest in Mango + Soyabean whereas the higher stone weight (35.79 g) was in sole crop (Mango) only. Again, pulp weight and pulp: stone ratio (193.53 g and 5.80) were observed in Mango + Frenchbean respectively. The quality parameters such as TSS, reducing sugar, vitamin c, acidity and shelf-life showed non-significant variation among the different treatments.

A mango based cropping study was conducted with ginger, turmeric, tomato, cowpea, French bean, ragi, niger and upland paddy by Swain (2014). The results of the study revealed that the mango + guava + cowpea combination exhibited better performance which has been reflected in the form of plant height, girth, canopy area, fruit weight and fruit yield of mango closely followed by mango + guava + French bean system. The mango plants, under study, however, did not exhibit any kind of variation in quality parameters in fruits. The leguminous intercrops, cowpea and French bean, were the most effective crop because of their desirable impact on improvement of nutrient status of soil and plant of mango orchard. Highest LER was obtained with mango + guava +cowpea combination (4.17) followed by mango + guava + French bean. The highest benefit, cost ratio (2.02) was recorded in the mango + guava + cowpea combination, which was almost similar to that of mango + guava + turmeric, mango + guava + French bean and mango + guava + tomato.

Sarker *et al.* (2014) conducted a comparative study with a total of 85 mango growing farmers by interviewing. They observed that Barind ecosystem (Rajshahi Region) is unfavourable for field crop production but suitable for production of fruits like mango, litchi and jujube etc.

Behera *et al.* (2014) stated that demand of food can probably be met through more intensive crop production with increase in productivity per unit area and time. Mango trees provide enough space even if they are fully grown as they do not cover much area. It is possible to grow a mixed fruit orchard, such as mango intercropped with other fruit crops, vegetables and spices during initial years of establishment. Intercropping in mango with suitable crops bring good income and improves the fertility of the soil. During the first few years, intercropping can be practiced with no shortage of irrigation. Intercropping of some vegetables and spices in plantation can be practiced if sufficient irrigation and manuring facilities are available.

Behera *et al.* (2014) also studied on development of mango based intercropping and observed that it is the need of hour to increase production along with increasing income of mango growers. Keeping the above facts in to consideration different intercrops like pineapple, turmeric and ginger were tried in mango orchard with and without application of biofertilizers. Growing of intercrops like ginger, turmeric and pineapple with biofertilizers and inorganic fertilizers in mango orchard revealed that maximum mango yield was recorded intercropping with turmeric with application of biofertilizers (36.87 quintal per hectare) followed by intercropping with ginger with application of biofertilizers (34.47 quintal per hectare) and minimum was recorded in control (22.07 quintal per hectare) where no intercrop was grown over the two years of investigation. The percentage increase of yield over control is 40 per cent. The application of biofertilizers also increased the yield over control and inorganic fertilizers to the ton of 48 per cent and 20 per cent, respectively.

The mango plants when planted at a spacing of 10 × 10m provide an ample scope for growing of short duration crops as intercrops during initial years. The inter row space in mango remains underutilized in the early growing period and during which short duration, location specific and market driven crops may be grown as intercrops and filler crops thus, allowing one to grow more than one crop and also to efficiently utilize the space and other natural resources. The intercrops under mango base Agroforestry not only generate an extra income but the practice also helps to check the soil erosion through ground coverage and improves the physio-chemical properties of the soil. Different crops cultivation base on fruit garden is one of the techniques of land utilization for optimum production (Bhattanagar *et al.* 2007). Experimental evidences have also proved that yield stability is grater with intercropping than sole cropping. Different other crops based on fruit forest can provide substantial yield advantages compared with sole cropping.

Long rotation fruit trees such as mango constitute dominant horticultural crop in tropical agroforestry systems (Gebauer, 2005). Mango based agri– horticultural systems consist of three main components viz. main crop, filler crop and inter crops which occupy three different tiers in space of the production system. The main crop (mango) in the system is planted at a wider spacing of 10m x 10m to 12m x 12 m providing enough space in the early period for incorporation of inter crops. Mango with its large crown constitutes the upper most layer of the multitier system. As mangoes seldom utilize the full site potential before 15–20 years, it can be safely intercropped with compatible crops upto 10 years. The filler crops are usually short statured crops with small crown and non–competitive nature. These crops have an early rotation, bear early fruits and provide an early economic return.

2.3 Chilli based agroforestry system

People have been planting it under the shade of natural, planted forest as well as under shade of other trees. In this practice, hot pepper is considered as the most potential cash crop. Grevillea is a fast growing multipurpose species, which can be grown easily on the sloppy erosion prone areas as it also binds soil, gives optimum shade, increases fertility, retains soil moisture, grows fast, and used as fuelwood and timber (Franzel and Scherr, 2001)

Chilli (*Capsicum annuum* L.) can be grown successfully in mahogany based horti-silviculture system in northern West Bengal. However, information regarding the stability of chilli genotypes under different growing systems is lacking. Hence, the present experiment was undertaken to study (West Bengal). The experimental soil was sandy loam in texture and course in nature with poor water holding capacity and the climate was humid tropical. Under both the growing systems, five week old chilli seedlings were transplanted during third week of November in a plot size of 3.00 m × 2.25 m with a spacing of 45 cm × 30 cm. The age of mahogany plantation was four years and spacing was 5.0 m × 3.5 m. Light intensity was recorded by digital Lux meter (Model TES-1332). Light intensity was recorded from the 4th week to 24th week after transplanting. Tree canopy reflected some light which could be indicated by estimating albedo, which is the ratio of reflected and received radiation. The crop was managed by recommended package of practices (Annonymous, 2003).

Sharma *et al.* (2009) observed that the enhancement of plant height of chilli at harvesting stage was proportional to increase of the distance from the tree base; although the least probability for reducing the performance of plant height of chilli in vegetative stage due to the minor or absence of shading effect of recently transplanted few days' old saplings.

Near the tree base competition for nutrients and moisture was present between the root system of chilli and drumstick as a result plant height little suppressed in this area. In agroforestry practices Shepherd, *et al.* (2008) also observed similar type of results where plant height of associated crops reduced surrounding the planted tree base.

Near the tree base competition for nutrients and moisture was present between the root system of chilli and drumstick as a result fruit weight little suppressed in this area. In agroforestry practices Islam *et al.* (2009) also observed similar type of results where fruit weight of associated crops reduced surrounding the planted tree base.

There was significant variation in fresh chilli yield per hectare due to different treatments grown under drumstick (*Moringa oleifera*) saplings. As evident from results, the highest yield of fresh chilli (4.36 t/ha) was obtained from treatment T0 (open field as control) which was statistically similar with the second nearly value (4.27 t/ha) produced under T3 (150 cm from tree base) followed by treatment T2 (4.12 t/ha) and the lowest yield of fresh chilli (3.97 t/ha) was found from treatment T1 (50 cm from tree base) Yield performance of chilli was better under open field condition compared to tree-crop base condition may be due to less completion for natural resources observed by Noman *et al.* (2018).

Noman *et al.* (2018) also observed that tree height, basal girth, number of branches per plant and number of leaves per of drumstick were observed before and after chilli cultivation period. It was found that regarding all studied parameters growth of drumstick tree was statistically almost similar with and without chilli combination but numerically bit higher value was found in without chilli condition.

Rahman *et al.*, (2004) reported that except plant height all others morphological characters viz. no. of branches plant-1 , no. of fruit plant-1 , fruit length, fruit diameter and fruit weight of three vegetables (Tomato, Brinjal, Chilli) were highest in open field condition. Among the different agroforestry system, highest yield was obtained in Horitoki - Lemon - Vegetable based agroforestry system.

Bithi *et al.* (2014) concluded that the different morphological parameters of brinjal and chilli were influenced by different patterns of Xylia dolabriformis trees. It was perceived that plant elevation of brinjal and chilli was suggestively enlarged with the increase of distance from the tree bases. Number of fruits per plant, fruit size and individual fruit weight are the most important yield contributing characteristics of chilli and brinjal, which was also significantly influenced by different distance from the tree and yield of brinjal and chilli were recorded as per plant, per plot and per hectare which was significantly influenced by lohakat tree in different distance from tree base. From these discussions, studies, it may clear that brinjal and chilli can be grown in combination with lohakat tree as agroforestry systems beyond 1m distance from the tree base.

Taleb *et al.* (2003) showed that plant height of the vegetables increased gradually with the decreased light levels. Due to litter fall, shade condition plant height of brinjal and chilli were reduced closest to lohakat tree bases. A significant variation was observed in case of number of leaves per plant due to different distance of brinjal and chilli plant from the tree.

Datta LS and Dey AN. 2009. Concluded that the eight chilli genotypes (*Capsicum annuum*) were evaluated for yield and yield parameters under open and mahogany (*Swietenia mahagoni*) based agroforestry system for stability analysis at northern West Bengal. Genotype and environment interactions for plant height, primary and secondary branches, plant spread, stem girth, fruit length and diameter and yield were significant indicating differential response of genotypes under different environments. Significant linear and nonlinear components of genotype - environments were recorded for plant height, fruit length and yield. The chilli genotype CA-5 may be adopted for cultivation under favorable (open) conditions in view of its stability. Though CA-12 and Bhaghya lakshmi recorded lower yield than the mean yield, these two genotypes were stable. Bhaghyalakshmi was stable under open and agroforestry condition and CA-12 was specifically adapted under agroforestry condition.

2.4 Effect of fertilizer doses on chilli cultivation

Patil *et al.* (2014) reported that the chilli crop respond well to the application of both organic manures and inorganic fertilizers. Organic manures supply the major nutrients minerals and improve many soil properties and soil health that maintain crop productivity.

Mishra *et al.* 2018. Concluded that the basis of experiment conducted in laboratory, we found that in eight given treatments T7 in combined and T2 in individual are better then and T0 lower than others. It is concluded that the effect of organics on seed quality of chilli (*Capsicum annum* L.) variety's (Suryamukhi and G-4) of chilli (50% Urea, 50% Vermicompost and 50% FYM) in combined and (Vermicompost @ 2.5 t ha-1) in individual given treatments showed better results compare to other treatments. If we have implement T7 and T2 treatments in India, so certainly will be reached optimum position.

Yuliana *et al.* (2019) concluded that the combination of fertilizer variety treatments significantly affects chili pepper on growth and yield. Both chili pepper varieties grow and produce fruit in all treatments. Organic fertilizer addition on the inorganic fertilizer base increase plant growth and yield. The addition of compost gave the highest growth and yield, followed by manure and control treatments. Lado F1 variety provides higher yields than PM999 F1 variety. The best treatment in this study was combination treatment of Lado F1 variety fertilized with urea 75 kg/ha + SP36 75 kg/ha + KCl 75 kg/ha with addition of 1.35 kg compost per planting hole with the result obtained at 253.35 g of fruit per plant.

Omogoye and Mubo (2015) also reported application vermicompost, FYM and other organic manures such as cowdung significantly influence the growth and development of chilli.

Ewulo *et al.* (2007) concluded from this study that CD ensured more availability of nutrients especially cations in soil and in pepper plant compared with NPK fertilizer especially when applied at 7.5 t ha^{-1}, the material is an effective source of N, P, K, Ca, Mg and OM for pepper plants and it served to reduce ph. It is recommended for use at 7.5 t ha^{-1}, which gave similar yield and growth parameters as recommended NPK fertilizer. Since the CD is abundant as waste in abattoirs located in urban centers in Nigeria and is often left as waste, it can be put to use as source of nutrients and manure to pepper in production.

Abid *et al.* (2014) stated the mineral nutrients had a good effect on growth of red chillies. As nitrogen is an essential part of chlorophyll, helps in protein synthesis. Increase in leaves number per plant may be due to sufficient amount of nitrogen provided an ideal environment and balanced nutrition to plants, which increased number of leaves. The results are to some extent in agreement with the findings of Deore *et al.* (2010) who obtained maximum number of leaves per plant with increasing nitrogen containing in liquid organic fertilizer.

Ewulo *et al.* (2015) abstracted in order to comparative the effect of Cow Dung (CD) manure on soil and leaf nutrient and yield of pepper, two field trials were conducted involving six treatment replicated three times in a randomized complete block design at Ondo, Southwest Nigeria. The six treatment were control, 2.5, 5.0, 7.5 and 10.0 t ha^{-1} CD and 250 kg ha^{-1} NPK fertilizer. Soil, leaf and cow dung N, P, K, Ca and Mg were determined, also soil pH, OM, texture plant number of leaves, branches, height, stem girth, number of fruits and fruits weight. OM, N, P, K, Ca and Mg and pH increased with rate of dung. Compare with cowdung treatments, NPK fertilizer gave less value of the soil pH, Ca and Mg. Cd increase leaf N, P, K. Ca, and Mg contents and leaf N and P increase with cow dung rate. The 10 t ha^{-1} dung increased leaf P, K, Ca and Mg compared with fertilizer. Growth and fruit yield parameters such as numbers of leaves and branches, plant height and girth and number and weight of fruits increased with level of CD up to 7.5 t ha^{-1}. Relative to control 2.5, 5.0, 7.5 and 10.0 t ha^{-1} dung and NPK fertilizer increased fruit weight by 4, 20, 35, 30 and 34 % respectively and increases in number of fruits were 12, 30, 106, 67 and 103%. Yield increased given by 7.5 t ha^{-1} dung and NPK fertilizer were similar.

Rahman *et al.* (2012) investigated the effects of bio compost, cow dung compost and NPK fertilizers on growth, yield and yield components of chili the experiment was conducted randomized block design with three replications at Botanical Garden of Rajshahi University Campus, Bangladesh during August 2008 to February 2009. There were 15 treatments viz. T_1 = bio compost (3 kg/pot) + NPK, T_2 = bio compost (2 kg/pot) + NPK, T_3 = bio compost (1.5 kg/pot) + NPK, T_4 = bio compost (3 kg/pot), T_5 = bio compost (2 kg/pot), T_6 = bio compost (1.5 kg/pot), T_7 = cow dung compost 3 kg/pot + NPK, T_8 = cow dung compost (2 kg/pot) + NPK, T_9 = cow dung compost (1.5 kg/pot) + NPK, T_{10} = cow dung compost (3 kg/pot), T11 = cow dung compost (2 kg/pot), T_{12} = cow dung compost (1.5 kg/pot), T_{13}= NPK, T_{14}= bacterial suspension, T_{15}= control (only soil). Bio compost and NPK significantly (p=0.05) influenced the growth and yield of chili. The treatment bio compost (3kg/pot) +NPK (T_1) produced the highest germination (%), vigor index, growth and yield of chili and the lowest yield and yield contributing parameters were recorded in control (T_{15}). The correlation matrix showed that yield per plant of chili had significant and positive correlation with plant height (r = 0.929**), leaf number (r = 0.808**), number of primary branch (r = 0.918**), secondary branch (r = 0.985**), root number (r = 0.953**), root length (r = 0.947**), total number of flower at maximum flowering time(r = 0.981**), total number of fruit (r = 0.966**), fruit length (r = 0.917**), fresh fruit weight (r = 0.990**), dry fruit weight (r = 0.800**), number of seed/ fruit (r = 0.861**) and hundred seed weight (r = 0.954**) and yield was significant and negative correlation (r = $^-$0.906**) with number of days required for first flower initiation. The results suggest that inorganic fertilizers (NPK) with bio compost (3kg/pot) is suitable for better production of chili that may increase soil fertility and this integrated approach could be contributed to improve crop production.

CHAPTER III

MATERIALS AND METHODS

In this chapter 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. Required materials and methodology are described under the following headings:

3.1 Description of the Experimental Site

3.1.1 Location

The experimental site was selected in the existing three different mango orchard Rani Pukur area under Mthapukur Upazila (Rangpur district) area 515.62 sq km, located in between 25°26' and 25°41' north latitudes and in between 89°06' and 89°27' east longitudes. It is bounded by Rangpur sadar and pirgachha upazilas on the north, pirganj and sadullapur upazilas on the south, Pirgachha and sundarganj upazilas on the east, badarganj and nawabganj (dinajpur) upazilas on the west.

Figure 3.1 Map of Mithapukur Upazila, Rangpur

3.1.2 Soil Characteristics

The experimental plot was situated in a medium high land belonging to the Old Himalayan Piedmont Plain Area (AEZ 01). Land was well-drained as drainage system was well developed. The soil texture was sandy loam in nature. The soil P^H was 5.8. The details soil properties are presented in Appendix-I.

3.1.3 Climate

The experimental site was situated under the tropical climate characterized by moderate rainfall from January to February and scanty rainfall the rest period of the year. Monthly maximum and minimum temperatures, rainfall and relative humidity recorded during the experimental period (January, 2020 to April, 2020) are included in the Appendix-II.

3.2 Experimental Period

Duration of the experiential period was from January, 2020 to April, 2020.

3.3 Seed Collections

Green fire (Hybrid variety) having high yielding potential and resistant from disease and insect attack chilli seeds were collected from Getco company ltd.

3.4 Raising of Seedlings

Seedling was raised in seedbed of Nassik plant and pot nursery. The soil was well pulverized and converted into loose fragile and dried mass by spading. All weeds and stubbles were removed from the soil. Forty grams of seeds of chilli were sown in the seed bed on 19 January, 2020. Seedlings germinated on 25 January, 2020.

3.5 Experimental Design

The experiment was laid out following a two factorial Randomized Complete Block Design (RCBD) with three replications. Total numbers of experimental plot were 36. The size of each unit plot was 6ft x 1.5ft. So the total area of each plot was $9ft^2$.

3.6 Experimental Treatments

The experiment consisted of two factors;

Factor –A: (Treatment)

V_1= BARI Amm-11

V_2= BARI Amm-4

V_3= Thai Baromasi

Factor- B (Fertilizer Applications)

F_1 = No fertilizer

F_2 = Cow-dung

F_3 = Chemical fertilizer

F_4 = Chemical fertilizer + Cow-dung

Treatments combinations:

V_1F_1	BARI Amm-11 + No fertilizer
V_1F_2	BARI Amm-11 + Cow-dung
V_1F_3	BARI Amm-11+ Recommended chemical fertilizer
V_1F_4	BARI Amm-11+ Chemical fertilizer + Cow-dung
V_2F_1	BARI Amm-4 + No fertilizer,
V_2F_2	BARI Amm-4+ Cow-dung
V_2F_3	BARI Amm-4 + Recommended chemical fertilizer
V_2F_4	BARI Amm-4 + Chemical fertilizer + Cow-dung
V_3F_1	Thai Baromasi + No fertilizer
V_3F_2	Thai Baromasi + Cow-dung
V_3F_3	Thai Baromasi + Recommended chemical fertilizer
V_3F_4	Thai Baromasi + Chemical fertilizer + Cow-dung

Here, Chilli was test crop.

3.7 Characteristics of Mango

Scientific name: *Mangifera indica L.*

Family: Anacardiaceae (cashew family)

Planting orientation : East-West

Mango variety : BARI Amm-11, BARI Amm-4 and Thai Baromasi

Age of mango tree : 2.5 years

Spacing : 8m x 8m

Average canopy diameter : 155.6cm

Source of collection: Mango orchard at Rani pukur in Methapukur Upazila, Rangpur

3.8 Land Preparation

The land of experimental plot was opened in the last first of January 2020 with a power tiller and it was made ready for planting on last week of February 2020. The corner of the land was spaded and visible larger clods were hammered to break into small pieces. All weeds and stubbles were removed from the field. The layout was done as per experimental design. All basal dosages of fertilizers as per schedule of the experiment were incorporated in the soil and finally the plots were made ready for planting.

3.9 Applications of Fertilizers and Manures

On last week of February 2020 fertilizers and manures were applied. The fertilizers and manures were applied as per the treatments. Cow-dung applications rate was 10t/ha respectively. Urea (N), TSP(P), MP(K) respectively were applied at the rate of urea 250kg/ha, TSP 200kg/ha, MOP 150kg/ ha (Fertilizer Recommendation Guide 2014) in the plots where chemical fertilizer applied. Half of the urea, full of TSP and MOP were mixed with the soil. The manures like cow dung as per the treatments were applied during land preparation.

3.10 Transplanting and Crop Management

25 days old healthy seedlings were uprooted from the nursery beds and were transplanted in the experimental plots during late afternoon on 31 January, 2020. In each plot there were 04 chilli plants. The spacing was 18cm x 30cm. immediately after planting, the seedlings were watered. Seedlings were also planted around the plot for gap filling and to check the border effect.

3.11 Intercultural Operations

For better growth and development of the plants the following intercultural operations were practiced:

3.11.1 Weeding and Mulching

Manual weeding was done as and when necessary to keep the plots completely free from all weeds. After irrigation, the soil was mulched by breaking the crust for aeration and to conserve soil moisture.

3.11.2 Gap Filling

When the chilli seedlings were well established, the soil around the base of each seedling was pulverized. Gap filling was done by healthy seedlings of the same stock material grown in nearby plot where initial planted seedlings was dead.

3.11.3 Staking

After 30 days of transplanting when the chilli plants were well established, staking was performed using bamboo sticks to keep the plants erect.

3.11.4 Irrigation

Three irrigations were provided throughout the growing period. The first one was done at 30 days after planting. Subsequently two irrigations were given at 20 days' interval.

3.12 Plant Protection Measures

Furadan 5G @ 10 kg/ha was applied during the final land preparation to control ant, mite, cutworm and other soil borne insects only the plot where chemical fertilizer was applied. As a preventive measure against chilli leaf curl disease imidacloprid 17.8 SL (0.003%) was also sprayed when needed in the plot where chemical fertilizer was applied. As a preventive measure against chilli fruit borer emamectin benzoate (Volvax) 5% SG @ 12g a.i was sprayed in the plot where chemical fertilizer was applied. But, all the chemical was avoided at the plots where cowdung were applied. In the plots of cowdung, neem oil (2%) was sprayed against pathogen infestation by hand sprayer during land preparation.

3.13 Harvesting Chilli Fruits

Fruits were harvested before ripening stage when they were fully matured. Harvesting was started on 31 March, 2020 and completed by 29 April 2020. Fruits were harvested by hand picking from each plant.

3.14 Sampling and Data Collection

The experimental plots were observed frequently to record various changes in plant characteristics at different stages of their growth. Four plants were selected at from each unit plot to collect experimental data. The observations were made on the following parameters during plant growth phase and harvest, which were noted for different treatments of the experiment.

3.14.1 Plant height (cm)

The heights were measured from the ground level to the tip of the longest shoot at an interval of 15 days starting from showing time, 15, 30 and 45 DAT. Height was measured by using centimeter scale from the soil surface to the tip of the plant.

3.14.2 Number of leaves per plant

It was counted with at an interval of 15 days starting from showing time, 15, 30 and 45 DAT.

3.14.3 First flowering days after transplanting

It was recorded by the counting first flowering days after transplanting.

3.14.4 First fruiting days after transplanting

It was recorded by the counting first fruiting days after transplanting.

3.14.5 Number of fruits per plant

It was counted at the time of final harvest. It was recorded as the average of the 04 plants from each plot selected at harvest from each unit plot.

3.14.6 Weight of fruits per plant (g)

It was weighted at the time of final harvest.

3.14.7 Total number of fruits per plot

It was observed at the time of final harvest.

3.14.8 Total weight of fruits per plot (kg)

It was weighted at the time of final harvest.

3.14.9 Fruit length (cm)

It was measured at the time of final harvest. It was recorded as the average of the 10 fruits selected at random at harvest from each unit plot.

3.14.10 Fruit diameter (cm)

It was also measured at the time of final harvest. It was recorded as the average of the 10 fruits selected at random at harvest from each unit plot.

3.14.11 Fresh Weight/Plant (g)

A sample weight of freshly harvested chilli plant was taken. It was recorded as the average of the 04 plant selected at random at harvest from each unit plot.

3.14.12 Dry Weight/Plant (g)

Freshly harvested chilli plant was taken and air-dried in the laboratory. Air-dried sample was then oven dried for 48 hours at 70^0C ± 2 ^{0} C in oven at HSTU agroforestry and environment laboratory. After drying it was weighted in an electric balance having a sensitivity of 0.1mg. It was also measured as the average of the 04 plant selected which was collected for fresh weight.

3.14.10 Yield of fruits (t/ha)

This trait was recorded from the harvested fruits of all plants of each plot including the sample plants. The yield of fruit plot $^{-1}$ was converted to the yield per hectare.

3.15 Total Cost of Production

The cost of cultivation of the mango was worked out on the basis of per hectare. The initial plantation cost of the mango sapling was included in this study. The management cost of mango tree was also included. The total cost included the cost items like human labour and mechanical power costs, materials cost (including cost of seeds, fertilizers and manures, pesticide, bamboos, ropes etc.), land use cost and interest on operating capital.

3.16 Gross Return

Gross return is the monetary value of total product and by-product. Per hectare gross returns from mango and chili was calculated by multiplying the total amount of production by their respective market prices.

3.17 Net Return

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

Net return = Gross return (Tk. ha^{-1}) – Total cost of production (Tk. ha^{-1})

3.18 Benefit-cost Ratio (BCR)

Benefit-cost ratio is the ratio of gross return with total cost of production. It was calculating by using the following formula:

Benefit-cost ratio = Gross return (Tk. ha^{-1}) / Total cost of production (Tk. ha^{-1})

3.19 Statistical Analysis

Data were statistically analyzed using the "Analysis of variance" (ANOVA) technique with the help of statistics 10 analysis software. The mean differences were adjusted by Tukey's HSD (Honestly Significant Difference) test.

CHAPTER IV

RESULTS AND DISCUSSIONS

In this chapter the results of the screening of chilli with fertilizer and manure applications under mango varieties based agroforestry system are presented in Table 4.1 to 4.22. The findings of the study and interpretation of the results under different critical sections comprising growth, yield contributing characteristics, yield, quality parameters and cost effective analysis are also presented and discussed in this chapter under the following sub-headings to achieve the objective of the study.

4.1 Main Effect of Mango Varieties on Growth, Yield Contributing Characters and Yield of Chilli

4.1.1 Plant height (cm)

By measuring plant height growth performance of a plant can be considered. Plant height of chilli was recorded from the ground surface to the tip of the leaf in 4 plants of all the treatments. At 30 and 45 days after transplanting (DAT), plant height of chilli was found significantly varied with different treatments and statistically similar recorded at showing and 15 days after transplanting (Table 4.1). At 00 DAT/ showing time/Immediate after transplanting plant height of chilli was 6.41 cm, 6.50 cm and 6.38 cm was recorded in BARI Amm-11 (V_1), BARI Amm-4 (V_2) and Thai Baromasi (V_3) mango varieties respectively and it increase significantly varied with the different treatments. At 15 DAT, the highest plant height (9.13 cm) was obtained from the BARI Amm-4 (V_2) treatments which was significantly followed by the BARI Amm-11 (V_1). On the other hand, lowest plant height (8.67 cm) was obtained from the Thai Baromasi (V_3) which were significantly not different. At 30 DAT, the highest plant height (17.53 cm) was obtained from the treatment BARI Amm-4 (V_2) which was significantly followed by the variety BARI Amm-11 (V_1) whereas the lowest plant height (16.07 cm) was observed from the Thai Baromasi (V_3). At 45 DAT, highest plant height (27.51 cm) was recorded from the BARI Amm-4 (V_2) treatment having minor shading effect on chilli and the lowest plant height (25.58 cm) was observed from the Thai Baromasi (V_3) treatment. The performance of plant height of chilli in vegetative stage due to the minor or absence of shading effect of recently transplanted few days' old saplings which was observed by Sharma *et al.* (2009).

Table 4.1 Effect of mango varieties on plant height of chilli at different day after transplanting (DAT)

Treatments	Plant height (cm)			
	00DAT	**15DAT**	**30DAT**	**45DAT**
V_1	6.41	8.89	16.75 ab	26.02 b
V_2	6.50	9.13	17.53 a	27.51 a
V_3	6.38	8.67	16.07 b	25.58 b
Significance Level	NS	NS	**	**
`CV (%)	7.82	6.34	5.08	2.58

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1 = BARI Amm-11; V_2 = BARI Amm-4 and V_3 = Thai Baromasi

***Significant at 1% probability level and * Significant at 5% probability level.*

4.1.2 Number of leaf/plant

Number of leaf/plant of chilli was found no significantly varied due to effects different mango varieties (Table 4.2), at 00 DAT, 15 DAT, 30 DAT and 45 DAT. At 00 DAT/ showing time/Immediate after transplanting number of leaf/plant was 6.58, 6.75 and 6.76 was recorded in BARI Amm-11 (V_1), BARI Amm-4 (V_2) and Thai Baromasi (V_3) production systems respectively. At 15 DAT, the highest number of leaf/plant (13.56) was obtained from the treatment Thai Baromasi (V_3). On the other hand, lowest number of leaf/plant (13.23) was recorded from the BARI Amm-1 (V_1). At 30 DAT, the highest number of leaf/plant (32.38) was obtained from the Thai Baromasi (V_3) treatment, whereas the lowest number of leaf/plant (31.10) was observed from the BARI Amm-11 (V_1). This might be due to higher sunlight was absorbed in full PAR so higher number of leaves were produced observed by Tania *et al.* 2018 in eggplant under mahogany based agroforestry system.

Table 4.2 Effect of mango varieties on number of leaf/plant of chilli at different day after transplanting (DAT)

Treatments	Number of leaf/plant			
	00DAT	**15DAT**	**30DAT**	**45DAT**
V_1	6.58	13.23	31.10	77.27
V_2	6.75	13.38	31.38	78.51
V_3	6.76	13.56	32.38	78.73
Significance Level	NS	NS	NS	NS
CV (%)	5.60	4.95	4.63	2.39

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1 = BARI Amm-11; V_2 = BARI Amm-4 and V_3 = Thai Baromasi

***Significant at 1% probability level and * Significant at 5% probability level.*

At 45 DAT, the highest number of leaf/plant (78.73) was recorded from the Thai Baromasi (V_3) treatment and the lowest number of leaf/plant (77.27) was observed from the BARI Amm-11 (V_1). In case of number of leaf per plant, the finding was in agreement with the findings of (Schoch *et al.* 1972) who stated that, cooler temperatures promote lower number of total leaf and numbers of branches.

4.1.2 First flowering days after transplanting

First flowering days after transplanting of chilli was found significantly varied with different variety treatments (Table 4.3). The fast first flowering days after showing (45.58 days) was obtained from the treatment BARI Amm-4 (V_2) due to small canopy and moderately first flowering days after transplanting (46.67 days) by the BARI Amm-11 (V_1) whereas the slow first flowering days after transplanting (46.83 days) was observed from the treatment Thai Baromasi (V_3). This happened due to different light intensity in production systems. The filler crops are usually short statured crops with small crown and non–competitive nature. These crops have an early rotation, bear early fruits and provide an early economic return reported by Gebauer. 2005.

Table 4.3 Effect of mango varieties on the growth contributing characters of chilli

Treatments	First flowering days after transplanting	First fruiting days after transplanting
V_1	46.67 a	56.58 a
V_2	45.58 b	54.92 b
V_3	46.83 a	56.41 a
Significance Level	**	**
CV (%)	1.04	1.02

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1 = BARI Amm-11; V_2 = BARI Amm-4 and V_3 = Thai Baromasi

***Significant at 1% probability level and * Significant at 5% probability level.*

4.1.3 First fruiting days after transplanting

First fruiting days after transplanting of chilli was found significantly varied with different variety treatments (Table 4.3). The fast first fruiting days after transplanting (54.92 days) was obtained from the treatment BARI Amm-4 (V_2) and moderately first fruiting days after transplanting (56.41 days) by the treatment Thai Baromasi (V_3) whereas the last first fruiting days after transplanting (56.58 days) was observed from the treatment BARI Amm-11 (V_1). The filler crops are usually short statured crops with small crown and non–competitive nature. These crops have an early rotation, bear early fruits and provide an early economic return reported by Gebauer. 2005.

4.1.4 Number of fruit/plant

The number of fruit/plant of chilli was found significantly varied with different treatments (Table 4.4). The maximum number of fruit/plant (89.52) was obtained from the treatment BARI Amm-4 (V_2).

Table 4.4 Effect of mango varieties on the yield contributing characters of chilli

Treatments	Number of fruit/plant	Weight of fruit/plant (g)	Total number of fruit/plot
V_1	78.15 b	275.43 b	312.59 b
V_2	89.52 a	314.17 a	358.35 a
V_3	54.19 c	178.42 c	216.89 c
Significance Level	*	*	*
CV (%)	6.73	1.01	6.65

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1 = BARI Amm-11; V_2 = BARI Amm-4 and V_3 = Thai Baromasi

***Significant at 1% probability level and * Significant at 5% probability level.*

On the other hand, minimum number of fruit/plant (54.19) was obtained from the treatment Thai Baromasi (V_3) due to negative allelopathy effect of this mango variety. This happened due to different shade levels in different varietal production system.

4.1.5 Weight of fruit/plant (g)

The Weight of fruit/plant of chilli was found significantly varied with different treatments (Table 4.4). The highest weight of fruit/plant (314.17 g) was observed from the treatment BARI Amm-4 (V_2). On the other hand, lowest weight of fruit/plant (178.42 g) was obtained from the treatment Thai Baromasi (V_3). This significantly varied result recorded due to different light intensity among the mango varieties. In agroforestry practices Islam *et al.* (2009) also observed similar type of results where fruit weight of associated crops reduced surrounding the planted tree base.

4.1.6 Total Number of fruit/plot

The total number of fruit/plot of chilli was found significantly varied with different treatments (Table 4.4). The maximum total number of fruit/plot (358.35) was obtained from the BARI Amm-4 (V_2) treatment. On the other hand, minimum total number of fruit/plot (216.89) was obtained from the treatment Thai Baromasi (V_3). Indeed, at the floor of Thai Baromasi mango tree, the chilli plant receive minimum amount of light and also there is intense competition for plant nutrients. So, number of fruits were varied under different light intensity. This present investigation was supported by Aldazabal and Zamora, 2000 in tomato.

Table 4.5 Effect of mango varieties on the yield contributing characters of chilli

Treatments	Total weight of fruit/plot (kg)	Fruit length (cm)	Fruit Diameter (cm)
V_1	1.30 b	6.58 b	2.37 a
V_2	1.50 a	6.84 a	2.39 a
V_3	0.94 c	6.41 c	2.28 b
Significance Level	*	*	**
CV (%)	7.61	2.29	3.01

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1 = BARI Amm-11; V_2 = BARI Amm-4 and V_3 = Thai Baromasi

***Significant at 1% probability level and * Significant at 5% probability level.*

4.1.9 Total weight of fruit/plot (kg)

The total weight of fruit/plot of chilli was found significantly varied with different treatments (Table 4.5). The highest total weight of fruit/plot (1.50 kg) was observed from the treatment BARI Amm-4 (V_2). On the other hand, lowest total weight of fruit/plot (0.94 kg) was obtained from the Thai Baromasi (V_3) treatment. This significantly varied result recorded due to different light intensity among the three variety of mango tree treatment.

4.1.10 Fruit length (cm)

Fruit length of chilli was found significantly varied with different production systems (Table 4.5). The highest fruit length (6.84 cm) was obtained from the BARI Amm-4 (V_2) treatment. On the other hand, lowest fruit length (6.41 cm) was recorded from the Thai Baromasi (V_3) treatment, which was significantly followed by the BARI Amm-11 (V_1)

treatment. This happened due to the different canopy orientation in production systems. BARI Amm-4 (V_2) got maximum light, highly litter fall and minimum competition. Therefore, it gave highest fruit length that observed by Sayed et al. (2009).

4.1.11 Fruit diameter (cm)

Fruit diameter of chilli was found significantly no difference in different production systems (Table 4.5). The highest fruit diameter (2.39 cm) was obtained from the BARI Amm-4 (V_2) treatment which was significantly followed by the BARI Amm-11 (V_1) treatment. On the other hand, lowest fruit diameter (2.28 cm) was recorded from the Thai Baromasi (V_3) treatment. This happened due to the different canopy orientation of different MPTs under different agroforestry production systems.

4.1.12 Fresh Weight/Plant (g)

The fresh weight/plant was significantly varied by the different production systems (Table 4.6). The highest fresh weight/plant (361.14 g) was recorded from the BARI Amm-4 (V_2) treatment. The second highest fresh weight/plant (352.58 g) in BARI Amm-11 (V_1) treatment. On the other hand, lowest fresh weight/plant (339.69 g) was obtained from the Thai Baromasi (V_3) based agroforestry system. This might be due to the different light intensity among the production system. Actually, The BARI Amm-4 (V_2) got maximum light due to lower canopy spreading and minimum competition for different natural plant growth resources. Therefore, this sole cropping production system gave maximum chilli fresh weight/plant. Chilli is a fruity spices and it required sufficient amount of light for proper production.

Table 4.6 Effect of mango varieties on the yield contributing characters of chilli

Treatments	Fresh Weight/Plant (g)	Dry Weight/Plant (g)
V_1	352.58 b	70.12 b
V_2	361.14 a	75.60 a
V_3	339.69 c	57.96 c
Significance Level	*	*
CV (%)	1.81	5.98

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1 = BARI Amm-11; V_2 = BARI Amm-4 and V_3 = Thai Baromasi

***Significant at 1% probability level and * Significant at 5% probability level.*

4.1.13 Dry Weight/Plant (g)

The dry weight of fruit of chilli was found significantly affected due to the impact of different production system (Table 4.6). The maximum dry weight of chilli fruit (75.60 g) was obtained from the BARI Amm-4 (V_2 treatment. On the other hand, minimum dry weight (57.96 g) was obtained from the Thai Baromasi (V_3) treatment. Under partial shade condition, the chilli plant did not receive enough light to accumulate minerals and other dry matter in fruit. On the other hand, in BARI Amm-4 (V_2) treatment, chilli plant get adequate light to produce minerals and other dry matter inside fruit. Therefore BARI Amm -4 (V_2) treatment gave maximum dry weight of fruit.

4.1.10 Yield (t/ha)

The yield of chilli as ton per hector was significantly varied by the different production systems (fig. 4.1). The highest fruit yield (4.97 t/ha) was recorded from the BARI Amm-4 (V_2) treatment. The second highest yield (4.34 t/ha) was obtained in BARI Amm-11 (V_1) treatment. On the other hand, lowest fruit yield (3.12 t/ha) was obtained from the Thai Baromasi (V_3) treatment. This might be due to the different light intensity among the mango varieties treatment. Actually, the BARI Amm-4 (V_2) field got maximum light, favorable root nature and minimum competition for different natural plant growth resources. Therefore, this BARI Amm-4 (V_2) treatment gave maximum chilli yield. Chilli is a fruity spices and it required sufficient amount of light for proper production. The crop growth is mainly affected by light and nutrient availability. Leaf litter inputs from agro-forestry trees could provide sufficient nutrients and organic matter to sustain crop growth that may improve crop yield. Similar results were observed by (Lehmann *et al.*, 2002).

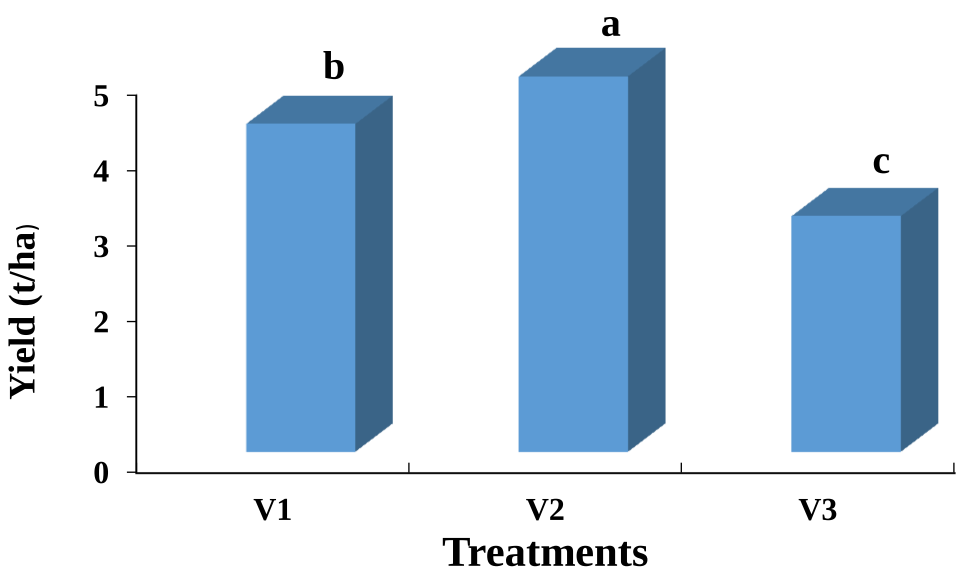

Figure 4.1: Effect of mango variety on of Yield (t/ha) of chilli

Here, V_1 = BARI Amm-11; V_2 = BARI Amm-4 and V_3 = Thai Baromasi

4.2 Main Effect of Fertilizer Applications on Growth, Yield Contributing Characters and Yield of Chilli

4.2.1 Plant height (cm)

By measuring plant height growth performance of a plant can be considered. Plant height of chilli was recorded from the ground surface to the tip of the leaf in 4 plants of all the treatments. At different days after transplanting (DAT), plant height of chilli was found significantly affected due to the applications of different fertilizer and manure accept showing time (Table 4.7). At 00 DAT/ showing time, there is no significantly varied among treatment due to no additional applications of different fertilizer and manure. At 15 DAT, the highest plant height (9.94 cm) was recorded from the plot where chemical fertilizer (F_3) was applied. Whereas, lowest plant height (8.11 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 30 DAT, the highest plant height (18.93 cm) was obtained from the plot where chemical fertilizer (F_3) was applied and lowest plant height (14.47 cm) was obtained from the plot where no fertilizer (F_1) was applied which was control treatment. At 45 DAT, the highest plant height (29.45 cm) was obtained from the plot where chemical fertilizer (F_3) was applied and lowest plant height (23.10 cm) was obtained from the plot where no fertilizer (F_1) was applied. The maximum plant height was obtained from the plot where chemical fertilizer was applied. Because chemical fertilizer has instant capability to release nutrient than organic manure. Plant need high concentration of this primary nutrient as any deficiency of these essential nutrients will prevent good plant growth (Gholizadeh *et al.* 2009). Thus, sufficient nitrogen, phosphorus and potassium supplied by organic fertilizer help in producing sturdy and taller chilli plant.

Table 4.7 Effect of fertilizer applications on plant height of chilli plant at different days after transplanting (DAT)

Treatments (fertilizer applications)	Plant height (cm)			
	00DAT	15DAT	30DAT	45DAT
F_1	6.35	8.11 c	14.47 c	23.10 d
F_2	6.22	8.50 bc	16.47 b	25.97 c
F_3	6.58	9.94 a	18.93 a	29.35 a
F_4	6.54	9.05 b	17.26 b	27.07 b
Significance Level	NS	**	**	**
CV (%)	7.82	6.34	5.08	2.58

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, F_1 = No fertilizer; F_2 = Cow-dung; F_3 = Chemical fertilizer and F_4 = Chemical fertilizer + Cow-dung

***Significant at 1% probability level and * Significant at 5% probability level.*

4.2.2 Number of leaf/plant

Number of leaf/shoot of chilli was found significantly affected due to the applications of different fertilizer (Table 4.8). At showing time, the number of leaf/plant 6.60, 7.06, 6.56 and 6.58 was recorded from F_1, F_2, F_3 and F_4 treatments respectively which were significantly affected due to the applications of different fertilizer and manure. At 15 DAT, the highest number of leaf/shoot (13.83) was obtained from both the plot where chemical fertilizer (F_3) and cow-dung (F_3) was applied. On the other hand, lowest number of leaf/shoot (12.89) was obtained from the plot where no fertilizer (F_1) was applied. At 30 DAT, the highest number of leaf/shoot (34.56) was recorded from the plot where chemical fertilizer (F_3) was applied. Whereas, lowest number of leaf/shoot (28.69) was obtained from the plot where no fertilizer (F_1) was applied. At 45 DAT, the highest number of leaf/plant (87.96) was obtained from the plot where chemical fertilizer (F_3) was applied and lowest number of leaf/shoot (69.92) was obtained from the plot where no fertilizer (F_1) was applied. Abid *et al.* (2014) stated the mineral nutrients had a good effect on growth of red chillies. As nitrogen is an essential part of chlorophyll, helps in protein synthesis. Increase in leaves number per plant may be due to sufficient amount of nitrogen provided an ideal environment and balanced nutrition to plants, which increased number of leaves. The results are to some extent in agreement with the findings of Deore *et al.* (2010) who obtained maximum number of leaves per plant with increasing nitrogen containing in liquid organic fertilizer.

Table 4.8 Effect of fertilizer applications on number of leaf of chilli plant at different days after transplanting (DAT)

Treatments (fertilizer applications)	Number of leaf/plant			
	00DAT	**15DAT**	**30DAT**	**45DAT**
F_1	6.60 ab	12.89 b	28.69 c	69.92 c
F_2	7.06 a	13.83 a	32.00 b	77.25 b
F_3	6.56 b	13.83 a	34.56 a	87.96 a
F_4	6.58 ab	13.00 ab	31.22 b	77.56 b
Significance Level	**	**	*	*
CV (%)	5.60	4.95	4.63	2.93

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, F_1 = No fertilizer; F_2 = Cow-dung; F_3 = Chemical fertilizer and F_4 = Chemical fertilizer + Cow-dung

***Significant at 1% probability level and * Significant at 5% probability level.*

4.2.3 First flowering days after transplanting

The variation in first flowering days after transplanting of chilli was found to be statistically significant due to the applications of different fertilizer (Table 4.9). The fast first flowering days after transplanting (44.67) observed from the plot where chemical fertilizer (F_1) was applied and last first flowering days after transplanting (48.44) recorded from the plot where no fertilizer was (F_1) applied.

4.2.4 First fruiting days after transplanting

First fruiting days after transplanting per chilli plant was found significantly influenced due to different fertilizer application which shown in Table 4.9. The fast first fruiting days after transplanting (54.33) observed from the plot where chemical fertilizer (F_1) was applied and last first fruiting days after transplanting (58.11) recorded from the plot where no fertilizer was (F_1) applied.

Table 4.9 Effect of fertilizer applications on the growth contributing characters of chilli plant

Treatments (fertilizer applications)	First flowering days after transplanting	First fruiting days after transplanting
F_1	48.44 a	58.11 a
F_2	46.67 b	56.22 b
F_3	44.67 d	54.33 d
F_4	45.67 c	55.22 c
Significance Level	*	*
CV (%)	1.04	1.02

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, F_1 = No fertilizer; F_2 = Cow-dung; F_3 = Chemical fertilizer and F_4 = Chemical fertilizer + Cow-dung

***Significant at 1% probability level and * Significant at 5% probability level.*

4.2.5 Number of fruit/ plant

Number of fruit per chilli plant was found significantly influenced due to different fertilizer application which shown in (Table 4.10).The largest number of fruit/plant (83.39) was found where chemical fertilizer (F_3) and on the other hand, the smallest number of fruit/plant (64.45) was found where no fertilizer applied (F_1). Treatments were ranked followed in the order of $F_3 > F_4 > F_2 > F_1$. The results are in agreement with those of Roychaudhury *et al.* (1995) who reported that the number of fruit per plant increased with increasing nitrogen application.

Table 4.10 Effect of fertilizer applications on the yield contributing characters of chilli

Treatments (fertilizer applications)	Number of fruit/plant	Weight of fruit/plant (g)	Total number of fruit/plot
F_1	64.45 c	251.48 c	257.78 c
F_2	73.40 b	255.32 b	293.61 b
F_3	83.39 a	259.51 a	334.06 a
F_4	74.58 b	257.73 ab	298.32 b
Significance Level	**	**	**
CV (%)	6.73	1.01	6.65

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, F_1 = No fertilizer; F_2 = Cow-dung; F_3 = Chemical fertilizer and F_4 = Chemical fertilizer + Cow-dung

***Significant at 1% probability level and * Significant at 5% probability level.*

4.2.6 Weight of fruit/plant (g)

The weight of fruit as gram per plant was significantly different due to the applications of different fertilizer (Table 4.10). The highest weight of fruit (259.51 g/plant) was recorded from the plot where chemical fertilizer (F_3) was applied. On the other hand, lowest weight of fruit (251.48 g/plant) was obtained from the plot where no fertilizer (F_3) was applied. The maximum weight of fruit was obtained from the plot where chemical fertilizer was applied because chemical fertilizer has instant capability to release nutrient than organic manure. Similar results were obtained by Abid *et al.* (2014) in chilli plants treated with organic fertilizers. Despite its limitation for short term correction of soil fertility, mango leaves can be used for long–term buildup of soil organic matter (Mubarak *et al.,* 2008).

4.2.7 Total number of fruit/plot

The total number of fruit per chilli plant was found significantly influenced due to different fertilizer application which shown in (Table 4.10).The largest total number of fruit/plot (334.06) was found where chemical fertilizer (F_3) and on the other hand, the smallest number of fruit/plot (257.78) was found where no fertilizer applied (F_1). Treatments were ranked followed in the order of $F_3 > F_4 > F_2 > F_1$.

4.2.8 Total weight of fruit/plot (kg)

The total weight of fruit as kilogram per plot was significantly different due to the applications of different fertilizer (Table 4.11). The highest total weight of fruit/plot (1.41 kg/plot) was recorded from the plot where chemical fertilizer (F_3) was applied. On the other hand, lowest total weight of fruit/plot (1.09 kg/plot) was obtained from the plot where no fertilizer (F_3) was applied. The maximum weight of fruit was obtained from the plot where chemical fertilizer was applied because chemical fertilizer has instant capability to release nutrient than organic manure.

4.2.9 Fruit length (cm)

Fruit length of chilli was recorded from the base of the fruit to the tip of the fruit in all the treatments. The fruit length of chilli was found significantly varied due to the applications of different fertilizer (Table 4.11). The maximum fruit length (7.30 cm) was obtained from the plot where chemical fertilizer (F_3) was applied, which was significantly followed by plot where cow-dung (F_4) was applied. On the other hand, minimum fruit length (5.97 cm) was obtained from the plot where no fertilizer (F_1) was applied. The order recorded according to the highest to the lowest fruit length was $F_3 > F_4 > F_2 > F_1$. The results are to some extent in agreement with Roychaudhury *et al.* (1995) who observed an improvement in fruit length with increasing nitrogen contents in organic fertilizer.

Table 4.11 Effect of fertilizer applications on the yield contributing characters of chilli

Treatments (fertilizer applications)	Total weight of fruit/plot (kg)	Fruit length (cm)	Fruit Diameter (cm)
F_1	1.09 c	5.97 d	2.25 c
F_2	1.23 b	6.35 c	2.32 bc
F_3	1.41 a	7.30 a	2.44 a
F_4	1.25 b	6.82 b	2.37 ab
Significance Level	**	**	**
CV (%)	7.61	2.29	3.01

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, F_1 = No fertilizer; F_2 = Cow-dung; F_3 = Chemical fertilizer and F_4 = Chemical fertilizer + Cow-dung

***Significant at 1% probability level and * Significant at 5% probability level.*

4.2.10 Fruit diameter (cm)

The variation in diameter of fruit was found to be statistically significant due to the applications of different fertilizer and manure (Table 4.11). The maximum fruit diameter (2.44 cm) was obtained from the plot where chemical fertilizer (F_3) was applied. On the other hand, minimum fruit diameter (2.25 cm) was obtained from the plot where no fertilizer (F_1) was applied. The result was ranked from the maximum to the minimum diameter of fruit was $F_3 > F_4 > F_2 > F_1$. Roychaudhury *et al.* (1995) who also observed an improvement in fruit dianeret with increasing nitrogen contents in organic fertilizer.

4.2.11 Fresh weight/plant (g)

The fresh weight/plant as gram of chilli was found significantly affected due to the applications of different fertilizer (Table 4.12). The maximum fresh weight/plant (362.83 g) was obtained from the plot where chemical fertilizer (F_3) was applied. On the other hand, minimum fresh weight/plant (339.71 g) was obtained from the plot where no fertilizer (F_1) was applied.

4.2.12 Dry weight/plant (g)

The dry weight/plant as gram of chilli was found significantly affected due to the applications of different fertilizer (Table 4.12). The maximum fresh weight/plant (74.61 g) was obtained from the plot where chemical fertilizer (F_3) was applied. On the other hand, minimum fresh weight/plant (61.54 g) was obtained from the plot where no fertilizer (F_1) was applied.

Table 4.12 Effect of fertilizer applications on the yield contributing characters of chilli plant

Treatments (fertilizer applications)	Fresh Weight/Plant (g)	Dry Weight/Plant (g)
F_1	339.71 c	61.54 c
F_2	349.23 b	66.65 bc
F_3	362.83 a	74.61 a
F_4	352.77 b	68.78 b
Significance Level	**	**
CV (%)	1.81	5.98

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, F_1 = No fertilizer; F_2 = Cow-dung; F_3 = Chemical fertilizer and F_4 = Chemical fertilizer + Cow-dung

***Significant at 1% probability level and * Significant at 5% probability level.*

4.2.13 Yield (t/ha)

The yield of chilli as ton per hector was significantly affected due to the applications of different fertilizer and manure (Figure 4.2). The highest fruit yield (4.69 t/ha) was recorded from the plot where chemical fertilizer (F_3) was applied. On the other hand, lowest fruit yield (3.62 t/ha) was obtained from the plot where no fertilizer (F_1) was applied. The yield (t/ha) was no statistically varied observed in F_2 and F_4 treatment that was cow-dung and chemical fertilizer + cow-dung respectively. The maximum yield was obtained from the plot where chemical fertilizer was applied because chemical fertilizer has instant capability to release nutrient than organic manure. The results are agreement with the findings of Rahman *et al.* (2010). In a study by Alam *et al.* (2007) reported that growth and yield of red amaranth were significantly increased with the application of

NPKS and that was significantly and positively correlated with total dry matter, plant height, leaf length and stem length.

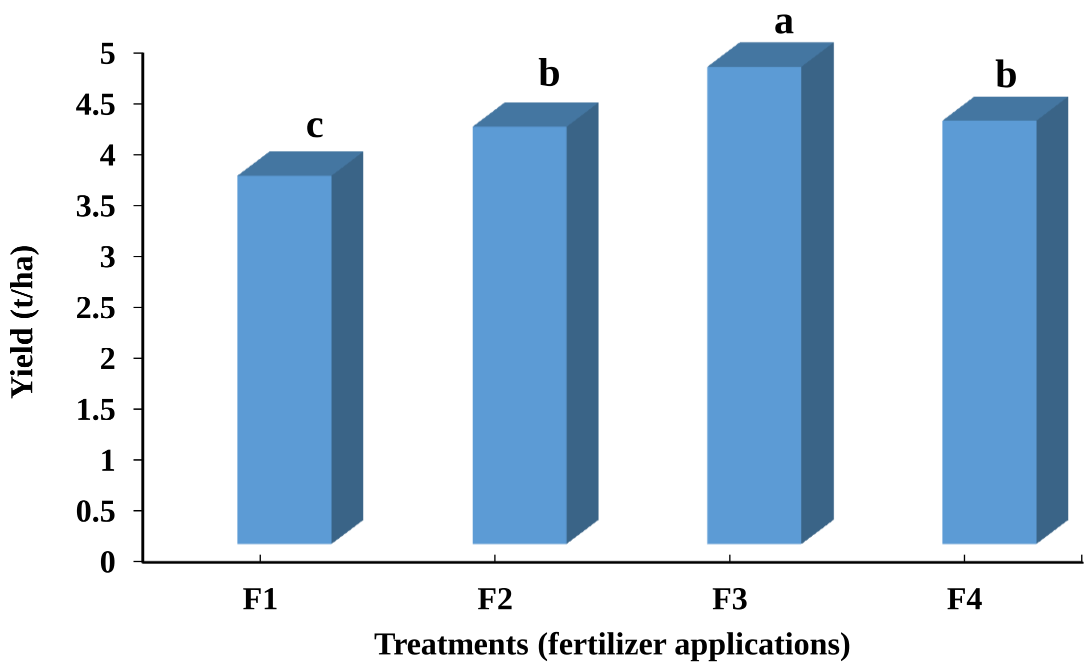

Figure 4.2 Effect of fertilizer applications on yield (t/ha) of chilli

Here, F_1 = No fertilizer; F_2 = Cow-dung; F_3 = Chemical fertilizer and F_4 = Chemical fertilizer + Cow-dung

4.3 Interaction Effect of Mango Varieties and Fertilizer Applications on Growth, Yield Contributing Characters and Yield of Chilli

4.3.1 Plant height (cm)

The interaction effect of mango varieties and fertilizer applications on the plant height of chilli was found significantly different at different days after planting (Table 4.13). At 00 DAT/ showing time, there is no significantly varied among treatment due to no interaction effect of three mango varieties and fertilizer applications as raw data. At 15 DAT, the highest plant height (10.48 cm) was obtained from the combine treatment V_2F_3 (BARI Amm-4 + chemical fertilizer) which is significantly followed by V_3F_3 (Thai Baromasi + Chemical fertilizer). On the other hand, lowest plant height (7.73 cm) was obtained from the treatment V_3F_1 (Thai Baromasi + no fertilizer). At 30 DAT, the highest plant height (19.90 cm) was recorded from the treatment V_2F_3 (BARI Amm-4

+nchemical fertilizer) which is significantly followed by V_1F_3 (BARI Amm-11 + chemical fertilizer) and V_3F_3 (Thai Baromasi + chemical fertilizer). Whereas, lowest plant height (13.53 cm) was obtained from the treatment V_3F_1 (Thai Baromasi + no fertilizer).

Table 4.13 Interaction effect of mango varieties and fertilizer applications on plant height of chilli plant at different DAT

Treatments (Combination)	Plant height (cm)			
	00DAT	**15DAT**	**30DAT**	**45DAT**
V_1F_1	6.67	8.47 bcd	14.76 cd	22.77 fg
V_1F_2	6.65	8.79 bcd	17.21 bc	26.18 cde
V_1F_3	6.26	9.52 abc	18.48 ab	28.77 ab
V_1F_4	6.05	8.77 bcd	16.54 bc	26.35 cde
V_2F_1	6.21	8.13 cd	15.12 cd	24.43 ef
V_2F_2	5.98	8.41 bcd	16.75 bc	27.00 bc
V_2F_3	6.95	10.48 a	19.90 a	30.42 a
V_2F_4	6.87	9.50 abc	18.33 ab	28.17 bc
V_3F_1	6.17	7.73 d	13.53 d	22.10 g
V_3F_2	6.10	8.29 bcd	15.45 cd	24.71 def
V_3F_3	6.53	9.81 ab	18.40 ab	26.67 cd
V_3F_4	6.70	8.87 abcd	16.91 bc	28.85 ab
Significance Level	NS	*	**	*
CV (%)	7.82	6.34	5.08	2.58

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1F_1 = BARI Amm-*11+ No fertilizer, V_1F_2= BARI* Amm-*11 + Cow-dung, V_1F_3= BARI* Amm-*11+ Recommended chemical fertilizer, V_1F_4= BARI* Amm-*11+ Chemical fertilizer + Cow-dung, V_2F_1 = BARI* Amm-*4 + No fertilizer, V_2F_2= BARI* Amm-*4+ Cow-dung, V_2F_3= BARI* Amm-*4 + Recommended chemical fertilizer, V_2F_4= BARI* Amm-*4 + Chemical fertilizer + Cow-dung, V_3F_1 = Thai Baromasi + No fertilizer, V_3F_2= Thai Baromasi + Cow-dung, V_3F_3= Thai Baromasi + Recommended chemical fertilizer, V_3F_4= Thai Baromas + Chemical fertilizer + Cow-dung.*

***Significant at 1% probability level and * Significant at 5% probability level.*

At 45 DAT, the highest plant height (30.42 cm) was obtained from the treatment V_2F_3 (BARI-4 +chemical fertilizer) which is significantly followed by V_1F_3 (BARI Amm -11 + chemical fertilizer). And lowest plant height (22.10 cm) was obtained from the treatment V_3F_1 (Thai Baromasi + no fertilizer) which was nearly similar with V_1F_1 (BARI Amm -11 + No fertilizer).

4.3.2 Number of leaf/plant

The interaction effect of mango varieties and fertilizer applications on the number of leaf/plant of chilli was found no significantly different at showing time and 15 days after planting (DAT) and found significantly different at 30 and 45 days after planting (DAT) (Table 4.14).

Table 4.14 Interaction effect of mango varieties and fertilizer applications on number of leaf of chilli plant at different DAT

Treatments (Combination)	Number of leaf/plant			
	00DAT	**15DAT**	**30DAT**	**45DAT**
V_1F_1	6.42	12.67	28.33 d	69.25 d
V_1F_2	7.08	13.83	31.67 abcd	76.17 bc
V_1F_3	6.33	13.50	34.08 abc	86.92 a
V_1F_4	6.50	12.92	30.33 bcd	76.75 bc
V_2F_1	6.58	12.58	27.83 d	71.25 cd
V_2F_2	7.17	13.58	31.50 abcd	77.33 b
V_2F_3	6.50	14.08	34.42 ab	87.72 a
V_2F_4	6.75	13.25	31.75 abcd	77.75 b
V_3F_1	6.80	13.42	29.92 cd	69.25 d
V_3F_2	6.92	14.08	32.83 abc	78.25 b
V_3F_3	6.83	13.92	35.17 a	89.25 a
V_3F_4	6.50	12.83	31.58 abcd	78.17 b
Significance Level	NS	NS	*	**
CV (%)	5.60	4.95	4.63	2.39

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1F_1 = BARI Amm-*11+ No fertilizer, V_1F_2= BARI* Amm-*11 + Cow-dung, V_1F_3= BARI* Amm-*11+ Recommended chemical fertilizer, V_1F_4= BARI* Amm-*11+ Chemical fertilizer + Cow-dung, V_2F_1 = BARI* Amm-*4 + No fertilizer, V_2F_2= BARI* Amm-*4+ Cow-dung, V_2F_3= BARI* Amm-*4 + Recommended chemical fertilizer, V_2F_4= BARI* Amm-*4 + Chemical fertilizer + Cow-dung, V_3F_1 = Thai Baromasi + No fertilizer, V_3F_2= Thai Baromasi + Cow-dung, V_3F_3= Thai Baromasi + Recommended chemical fertilizer, V_3F_4= Thai Baromas + Chemical fertilizer + Cow-dung.*

***Significant at 1% probability level and * Significant at 5% probability level.*

At 30 DAT, the highest number of leaf/plant (35.17) was recorded from the treatment V_3F_3 (Thai Baromasi + chemical fertilizer). Whereas, lowest number of leaf/plant (27.83) was obtained from the treatment V_2F_1 (BARI Amm -4 + no fertilizer) which is significantly followed by V_1F_1 (BARI Amm -11 + no fertilizer). And at 45 DAT, the highest plant height (89.25) was obtained from the treatment V_3F_3 (Thai Baromasi +

chemical fertilizer) which is significantly followed by V_2F_3 (BARI Amm -4 +chemical fertilizer) and V_1F_3 (BARI Amm -11 + chemical fertilizer) and lowest plant height (69.25) was obtained from the treatment V_1F_1 (BARI Amm -11 + no fertilizer) which was similar with V_3F_1 (Thai Baromasi + No fertilizer).

4.3.3 First flowering days after transplanting

The first flowering days after transplanting of chilli was found significantly affected among combine treatments due to the interaction effect of mango varieties and fertilizer applications (Table 4.15). Early first flowering days after transplanting (44.00 days) observed from the combine treatment V_2F_3 (BARI Amm -4 +chemical fertilizer). Whereas the late first flowering days (49.33) recorded from the V_3F_1 (Thai Baromasi + No fertilizer) combine treatment.

Table 4.15 Interaction effect of mango varieties and fertilizer applications on growth contributing characters of chilli plant

Treatments (Combination)	First flowering days after transplanting	First fruiting days after transplanting
V_1F_1	48.67 ab	58.67 a
V_1F_2	46.67 cd	56.67 bc
V_1F_3	45.00 ef	55.00 cdef
V_1F_4	46.33 cde	56.00 bcd
V_2F_1	47.33 bc	57.00 ab
V_2F_2	46.00 cde	55.00 cdef
V_2F_3	44.00 f	53.67 f
V_2F_4	45.00 ef	54.00 ef
V_3F_1	49.33 a	58.67 a
V_3F_2	47.33 bc	57.00 ab
V_3F_3	45.00 ef	54.33 def
V_3F_4	45.67 de	55.67 bcde
Significance Level	**	*
CV (%)	1,04	1.02

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1F_1 *= BARI* Amm-*11+ No fertilizer,* V_1F_2*= BARI* Amm-*11 + Cow-dung,* V_1F_3*= BARI* Amm-*11+ Recommended chemical fertilizer,* V_1F_4*= BARI* Amm-*11+ Chemical fertilizer + Cow-dung,* V_2F_1 *= BARI* Amm-*4 + No fertilizer,* V_2F_2*= BARI* Amm-*4+ Cow-dung,* V_2F_3*= BARI* Amm-*4 + Recommended chemical fertilizer,* V_2F_4*= BARI* Amm-*4 + Chemical fertilizer + Cow-dung,* V_3F_1 *= Thai Baromasi + No fertilizer,* V_3F_2*= Thai Baromasi + Cow-dung,* V_3F_3*= Thai Baromasi + Recommended chemical fertilizer,* V_3F_4*= Thai Baromas + Chemical fertilizer + Cow-dung.*
***Significant at 1% probability level and * Significant at 5% probability level.*

4.3.4 First fruiting days after transplanting

The first fruiting days after transplanting of chilli was found significantly affected among combine treatments due to interaction effect of mango varieties and fertilizer applications (Table 4.15). Early first fruiting days after transplanting (53.67 days) observed from the combine treatment V_2F_3 (BARI Amm -4 + Chemical fertilizer) which was followed by V_2F_4 (BARI Amm -4 + Chemical fertilizer+ cow-dung) combine treatment. Whereas the late first fruiting days (58.97) recorded from both of the combination treatment V_3F_1 (Thai BaromasC + No fertilizer) and V_1F_1 (BARI Amm -11 + No fertilizer).

4.3.5 Number of fruit/plant

The interaction effect of mango varieties and fertilizer applications on the number of fruit/plant of chilli was found significantly different (Table 4.16). The maximum number of fruit/plant (100.82) was obtained from the treatment V_2F_3 (BARI Amm -4 + Chemical fertilizer). On the other hand, minimum number of fruit/plant (47.85) was obtained from the treatment V_3F_1 (Thai Baromasi + No fertilizer).

4.3.6 Weight of fruit/plant (g)

The Interaction effect of mango varieties and fertilizer applications on the weight of fruit/plant of chilli as gram was found significantly different (Table 4.16). The maximum weight of fruit/plant (317.48 g) was obtained from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) which was followed by V_2F_4 (BARI Amm-4 + Chemical fertilizer + Cow-dung), V_2F_2 (BARI Amm-4 + Cow-dung) and V_2F_4 (BARI Amm-4 + No fertilizer) combine treatments .On the other hand, minimum weight of fruit/plant (172.47 g) was obtained from the treatment V_3F_1 (Thai Baromasi + No fertilizer).

4.3.7 Total number of fruit/plot

The total number of chilli fruit/plot was found significantly affected among combination treatments due to the interaction effect of mango varieties and fertilizer applications (Table 4.16). The highest number of fruit/plot (403.27) was observed from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) due to 60% light intensity and applied systematic fertilizer. On the other hand, lowest number of fruit/plant (191.40) was observed from the treatment V_3F_1 (Thai Baromasi + No fertilizer) due to 40% light intensity and without fertilizer.

Table 4.16 Interaction effect of mango varieties and fertilizer applications on yield contributing characters of chilli

Treatments (Combination)	Number of fruit/plant	Weight of fruit/plant (g)	Total number of fruit/plot
V_1F_1	68.02 cd	272.07 b	271.01 cd
V_1F_2	76.93 bc	274.16 b	307.72 bc
V_1F_3	88.56 ab	278.67 b	355.23 ab
V_1F_4	79.10 bc	276.83 b	316.39 bc
V_2F_1	77.47 bc	309.90 a	310.93 bc
V_2F_2	89.64 ab	313.75 a	358.57 ab
V_2F_3	100.82 a	317.48 a	403.27 a
V_2F_4	90.16 ab	315.57 a	360.63 ab
V_3F_1	47.85 e	172.47 d	191.40 e
V_3F_2	53.64 de	178.04 cd	214.55 de
V_3F_3	60.80 de	182.40 c	243.68 de
V_3F_4	54.48 de	180.78 c	217.93 de
Significance Level	**	**	*
CV (%)	6.73	1.01	6.65

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1F_1 = BARI Amm-*11+ No fertilizer, V_1F_2= BARI* Amm-*11 + Cow-dung, V_1F_3= BARI* Amm-*11+ Recommended chemical fertilizer, V_1F_4= BARI* Amm-*11+ Chemical fertilizer + Cow-dung, V_2F_1 = BARI* Amm-*4 + No fertilizer, V_2F_2= BARI* Amm-*4+ Cow-dung, V_2F_3= BARI* Amm-*4 + Recommended chemical fertilizer, V_2F_4= BARI* Amm-*4 + Chemical fertilizer + Cow-dung, V_3F_1 = Thai Baromasi + No fertilizer, V_3F_2= Thai Baromasi + Cow-dung, V_3F_3= Thai Baromasi + Recommended chemical fertilizer, V_3F_4= Thai Baromas + Chemical fertilizer + Cow-dung.*

***Significant at 1% probability level and * Significant at 5% probability level.*

4.3.8 Total weight of fruit/plot (kg)

The interaction effect of variety and fertilizer & manure applications on the total weight of fruit/plot of chilli as kilogram was found significantly different (Table 4.17). The maximum total weight of fruit/plot (1.69 kg) was obtained from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment. On the other hand, minimum total weight of fruit/plot (0.82 kg) was obtained from the treatment V_3F_1 (Thai Baromasi + No fertilizer).

4.3.9 Fruit length (cm)

The interaction effect of mango varieties and fertilizer applications on the fruit length of chilli was found significantly different (Table 4.17). The highest fruit length (7.57 cm) was recorded from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment due to 60% light intensity and applied chemical fertilizer. On the other hand, lowest fruit length (5.69 cm) was recorded from the treatment V_3F_1 (Thai Baromasi + No fertilizer) due to 40% light intensity and without fertilizer.

Table 4.17 Interaction effect of mango varieties and fertilizer applications on yield contributing characters of chilli

Treatments (Combination)	Total weight of fruit/plot (kg)	Fruit length (cm)	Fruit Diameter (cm)
V_1F_1	1.13 cd	6.02 gh	2.28 abc
V_1F_2	1.27 bc	6.30 efg	2.34 abc
V_1F_3	1.49 ab	7.25 ab	2.45 ab
V_1F_4	1.32 bc	6.76 cd	2.40 ab
V_2F_1	1.30 bc	6.20 fg	2.31 abc
V_2F_2	1.49 ab	6.60 def	2.37 abc
V_2F_3	1.69 a	7.57 a	2.47 a
V_2F_4	1.50 ab	7.01 bcd	2.40 ab
V_3F_1	0.82 e	5.69 h	2.16 c
V_3F_2	0.93 de	6.17 fg	2.25 bc
V_3F_3	1.05 cde	7.07 bc	2.40 ab
V_3F_4	0.94 de	6.70 cde	2.32 abc
Significance Level	**	*	*
CV (%)	7.61	2.29	3.01

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1F_1 *= BARI* Amm-*11+ No fertilizer,* V_1F_2*= BARI* Amm-*11 + Cow-dung,* V_1F_3*= BARI* Amm-*11+ Recommended chemical fertilizer,* V_1F_4*= BARI* Amm-*11+ Chemical fertilizer + Cow-dung,* V_2F_1 *= BARI* Amm-*4 + No fertilizer,* V_2F_2*= BARI* Amm-*4+ Cow-dung,* V_2F_3*= BARI* Amm-*4 + Recommended chemical fertilizer,* V_2F_4*= BARI* Amm-*4 + Chemical fertilizer + Cow-dung,* V_3F_1 *= Thai Baromasi + No fertilizer,* V_3F_2*= Thai Baromasi + Cow-dung,* V_3F_3*= Thai Baromasi + Recommended chemical fertilizer,* V_3F_4*= Thai Baromas + Chemical fertilizer + Cow-dung.*

***Significant at 1% probability level and * Significant at 5% probability level.*

4.3.10 Fruit Diameter (cm)

The interaction effect of mango varieties and fertilizer applications on the fruit diameter of chilli was found significantly different (Table 4.17). The highest fruit diameter (2.47 cm) was measured from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment. On the other hand, lowest fruit diameter (2.16 cm) was measured from the treatment V_3F_1 (Thai Baromasi + No fertilizer) due to without fertilizer.

4.3.11 Fresh Weight/Plant (g)

The fresh weight/plant as gram of chilli was found significantly affected due to the interaction effect of mango varieties and applications of fertilizer (Table 4.18). The maximum fresh weight/plant (374.33 g) was obtained from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment. On the other hand, minimum fresh weight/plant (328.87 g) was obtained from the treatment V_3F_1 (Thai Baromasi + no fertilizer) due to without fertilizer.

Table 4.18 Interaction effect of mango varieties and fertilizer applications on yield contributing characters and yield of chilli

Treatments (Combination)	Fresh Weight/Plant (g)	Dry Weight/Plant (g)
V_1F_1	340.70 de	62.87 cdef
V_1F_2	349.87 bcd	69.91 bcd
V_1F_3	365.80 ab	76.61 ab
V_1F_4	353.93 bcd	71.10 abcd
V_2F_1	349.57 bcd	70.10 abcd
V_2F_2	360.23 abc	74.74 abc
V_2F_3	374.33 a	82.00 a
V_2F_4	360.43 abc	75.55 ab
V_3F_1	328.87 e	51.65 f
V_3F_2	337.60 de	55.31 ef
V_3F_3	348.37 bcd	65.21 bcde
V_3F_4	343.93 cde	59.69 def
Significance Level	*	*
CV (%)	1.81	5.98

In a column, figures having similar letter (s) do not differ significantly. On the other hand, figures bearing different letter (s) differ significantly (as per Tukey HSD) at 5% level of probability.

Here, V_1F_1 = BARI Amm-*11+ No fertilizer, V_1F_2= BARI* Amm-*11 + Cow-dung, V_1F_3= BARI* Amm-*11+ Recommended chemical fertilizer, V_1F_4= BARI* Amm-*11+ Chemical fertilizer + Cow-dung, V_2F_1 = BARI* Amm-*4 + No fertilizer, V_2F_2= BARI* Amm-*4+ Cow-dung, V_2F_3= BARI* Amm-*4 + Recommended chemical fertilizer, V_2F_4= BARI* Amm-*4 + Chemical fertilizer + Cow-dung, V_3F_1 = Thai Baromasi + No fertilizer, V_3F_2= Thai Baromasi + Cow-dung, V_3F_3= Thai Baromasi + Recommended chemical fertilizer, V_3F_4= Thai Baromas + Chemical fertilizer + Cow-dung.*

***Significant at 1% probability level and * Significant at 5% probability level.*

4.3.12 Dry Weight/Plant (g)

The dry weight/plant as gram of chilli was found significantly affected due to the interaction effect of mango varieties and fertilizer applications (Table 4.18). The maximum dry weight/plant (82.00 g) was obtained from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment. On the other hand, minimum dry weight/plant (51.65 g) was obtained from the treatment V_3F_1 (Thai Baromasi + No fertilizer) due to without fertilizer.

4.3.13 Yield (t/ha)

The interaction effect of mango varieties and fertilizer applications on the yield as ton per hector of chilli was found significantly different (Figure 4.3). The highest yield (5.62 t/ha) was observed from V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment due to low allelopathy effect and applied systematic fertilizer. On the other hand, lowest yield (2.74 t/ha) was observed from the V_3F_1 (Thai Baromasi + No fertilizer) due to without fertilizer.

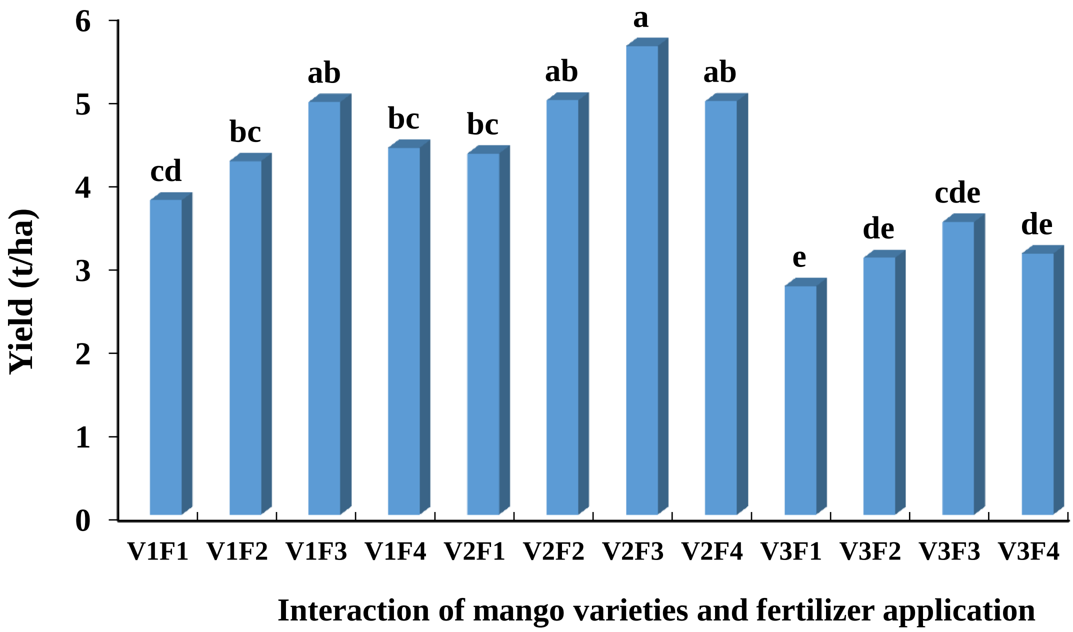

Figure 4.3: Interaction effect of mango varieties and fertilizer on yield (t/ha) of chilli

Here, V_1F_1 *= BARI* Amm-*11+ No fertilizer,* V_1F_2*= BARI* Amm-*11 + Cow-dung,* V_1F_3*= BARI* Amm-*11+ Recommended chemical fertilizer,* V_1F_4*= BARI* Amm-*11+ Chemical fertilizer + Cow-dung,* V_2F_1 *= BARI* Amm-*4 + No fertilizer,* V_2F_2*= BARI* Amm-*4+ Cow-dung,* V_2F_3*= BARI* Amm-*4 + Recommended chemical fertilizer,* V_2F_4*= BARI* Amm-*4 + Chemical fertilizer + Cow-dung,* V_3F_1 *= Thai Baromasi + No fertilizer,* V_3F_2*= Thai Baromasi + Cow-dung,* V_3F_3*= Thai Baromasi + Recommended chemical fertilizer,* V_3F_4*= Thai Baromas + Chemical fertilizer + Cow-dung*

4.4 Economic Analysis

Profitability of growing chilli as inter-crop in mango varieties based agroforestry system was calculated based on local market rate prevailed during experimentation. The return of produce and the profit per taka i.e. Benefit Cost Ratio (BCR) have also been presented in Table 4.19.

4.4.1 Total cost of production

The values in Table 4.19 indicate that the total cost of production was maximum (177996 Tk. /ha) in those plots where chilli was cultivated with using BARI-4 + Cow-dung (F_2) whereas the minimum cost of production (158710 Tk. /ha) was recorded from those plots where Thai Baromasi + no fertilizer (F_1) was applied.

Table 4.19: Economics of chilli production under three mango variety based agroforestry system

Treatments	Return (Tk. ha^{-1})		Gross Return (Tk. ha^{-1})	Total cost of production (Tk. ha^{-1})	Net Return (Tk. ha^{-1})	BCR
	Mango	Chilli				
V_1F_1	24375	301600	325975	160573	165402	2.03
V_1F_2	24375	339200	363575	172845	190730	2.10
V_1F_3	24375	396000	420375	164245	256130	2.56
V_1F_4	24375	352000	376375	168545	207830	2.23
V_2F_1	29250	346400	375650	165724	209926	2.27
V_2F_2	29250	397600	426850	177996	248854	2.40
V_2F_3	29250	449600	478850	169396	309481	2.83
V_2F_4	29250	396800	426050	173696	252354	2.45
V_3F_1	19500	219200	298700	158710	139990	1.88
V_3F_2	19500	246400	265900	170981	94919	1.56
V_3F_3	19500	280800	300300	162383	137917	1.85
V_3F_4	19500	250400	269900	166682	103218	1.62

Note: Chilli 80 Tk kg^{-1}, BARI-11, BARI-4 and Thai Baromasi 2500, 3000 and 2000 Tk per Tree per Year respectively.

Here, V_1F_1 = *BARI* Amm-*11+ No fertilizer,* V_1F_2= *BARI* Amm-*11 + Cow-dung,* V_1F_3= *BARI* Amm-*11+ Recommended chemical fertilizer,* V_1F_4= *BARI* Amm-*11+ Chemical fertilizer + Cow-dung,* V_2F_1 = *BARI* Amm-*4 + No fertilizer,* V_2F_2= *BARI* Amm-*4+ Cow-dung,* V_2F_3= *BARI* Amm-*4 + Recommended chemical fertilizer,* V_2F_4= *BARI* Amm-*4 + Chemical fertilizer + Cow-dung,* V_3F_1 = *Thai Baromasi + No fertilizer,* V_3F_2= *Thai Baromasi + Cow-dung,* V_3F_3= *Thai Baromasi + Recommended chemical fertilizer,* V_3F_4= *Thai Baromas + Chemical fertilizer + Cow-dung.*

4.4.2 Gross return

Gross return is an important indicator whether crop cultivation is profitable or not. It is varying with the chilli and three mango tree variety based production system of chilli. The values in Table 4.19 indicate that the highest value of gross return (478850 Tk. /ha) was obtained in those plots where BARI Amm-4 + Chemical fertilizer (F_3) was applied. On the other hand, the lowest value of gross return (265900 Tk. /ha) was obtained in those plots where Thai Baroasi + Cow-dung (F_2) was applied.

4.4.3 Net return

Results presented in the Table 4.19 show that net return (309481 Tk. /ha) was comparatively higher in producing chilli under BARI Amm-4 + chemical fertilizer (F_3). At the same time, the lowest net return (94919 Tk. /ha) was received from those plot where Thai Baroasi + Cow-dung (F_2) was applied.

4.4.4 Benefit-cost ratio (BCR)

The values in Table 4.19 indicate that the highest benefit-cost ratio (2.83) was recorded from the treatment BARI Amm-4 + Chemical fertilizer (V_2F_3). On the other hand, the lowest benefit-cost ratio (1.56) was observed in those plots where chilli was grown under Thai Baromasi mango tree variety with cow-dung (F_1) application.

CHAPTER V

SUMMARY CONCLUSIONAND RECOMMENDATIONS

5.1 Summary

A field experiment was carried out at the Mithapukur upazila, Rangpur, during January, 2020 to April, 2020 to evaluate the performance of chilli production under three different mango variety (BARI-11, BARI-11 and Thai Baromasi) based agroforestry system. The experiment was laid out in two factorial RCBD with 3 (three) replications. Factor A (Varietal treatments) viz. V_1= BARI Amm-11, V_2= BARI Amm-4 and V_3= Thai Baromasi and Factor B (fertilizer applications) viz. F_1= No Fertilizer, F_2= Cow-dung, F_3= Chemical fertilizer and F_4= Chemical fertilizer + Cow-dung. The total numbers of experimental plots were 36 and each plot size 6ft x 1.5ft. The land of experimental plot was opened in the first week of January, 2020 with a power tiller and it was made ready for planting on first week of January 2020. 25 days old healthy seedlings were uprooted from the nursery beds and were transplanted in the experimental plots during late afternoon on 31 January, 2020. In all mango variety orchard, each plot there were 4 plants and the spacing was 18 cm x 30 cm, the seedlings were watered. Seedlings were also planted around the plot for gap filling and to check the border effect. The data were recorded on two broad heads, i) growth stage ii) harvesting stage. Data were statistically analyzed using the "Analysis of variance" (ANOVA) technique with the help of statistics 10 analysis software. The mean differences were adjudged by Tukey HSD (honestly significant difference) test.

In case of the main effect of three different mango variety based production system on growth, yield contributing characters and yield of Chilli, the result was found significant in respect of plant height (00, 15, 30 and 45 DAT), number of leaf/plant (00, 15, 30 and 45 DAT), first flowering days after transplanting, first fruiting days after transplanting, number of fruit/plant, weight of fruit/plant (g), total Number of fruit/plot, total weight of fruit/plot (kg), fruit length (cm), fruit diameter (cm), fresh weight/Plant (g), dry weight/Plant (g) and yield (t/ha). The tallest plant height (27.51 cm) at 45 DAT was recorded from the BARI Amm-4 (V2) treatment. On the other hand, the shortest plant height (25.58 cm) at 45 DAT was recorded from the Thai Baromasi (V3) treatment. Number of leaf/plant of chilli was significant due to different mango variety based agroforestry system. However, highest number of leaf/plant (78.73) at 45 DAT was recorded from the Thai Baromasi (V3) treatment. On the other hand, the lowest number of leaf/plant (77.27) at 45 DAT was recorded from the BARI Amm-11 (V1) treatment. The fast first flowering days after transplanting (45.58 days) was obtained from the treatment BARI Amm-4 (V_2) due to more light intensity and moderately first flowering days after transplanting (46.67 days) by the BARI Amm-11 (V_1) whereas the slow first flowering days after transplanting (46.83 days) was observed from the treatment Thai Baromasi (V_3). Numerically, The fast first fruiting days after transplanting (54.92 days) was obtained from the treatment BARI Amm-4 (V_2) and moderately first fruiting days after transplanting (56.41 days) by the treatment Thai Baromasi (V_3) whereas the slow first fruiting days after transplanting (56.58 days) was observed from the treatment BARI Amm-11 (V_1). The maximum number of fruit/plant (89.52) was obtained from the treatment BARI Amm-4 (V_2). On the other hand, minimum number of fruit/plant (54.19) was obtained from the treatment Thai Baromasi (V_3). Similarly, the highest weight of fruit/plant (314.17 g) was observed from the treatment BARI Amm-4 (V_2). On the other hand, lowest weight of fruit/plant (178.42 g) was obtained from the treatment Thai Baromasi (V_3). Again, the maximum total number of fruit/plot (358.35) was obtained from the BARI Amm-4 (V_2) treatment. On the other hand, minimum total number of fruit/plot (216.89) was obtained from the treatment Thai Baromasi (V_3). As well as, the highest total weight of fruit/plot (1.50 kg) was observed from the treatment BARI Amm-4 (V_2). On the other hand, lowest total weight of fruit/plot (0.94 kg) was obtained from the Thai Baromasi (V_3). However, the maximum fruit length (6.84 cm) was recorded from Thai Baromasi (V_3) based agroforestry system. On the other hand, minimum fruit length (6.41 cm) was recorded from the Thai Baromasi (V_3) treatment. The highest fruit diameter (2.39 cm) was obtained from the BARI Amm-4 (V2) treatment. On the other hand, lowest fruit diameter (2.28 cm) was recorded from the Thai Baromasi (V_3) treatment. The highest fresh weight/plant (361.14 g) was recorded from the treatment BARI Amm-4 (V_2). . On the other hand, lowest fresh weight/plant (339.69 g) was obtained from the treatment Thai Baromasi (V_3). As we as, the maximum dry weight of chilli fruit (75.60 g) was obtained from the BARI Amm-4 (V_2) treatment. On the other hand, minimum dry weight (57.96 g) was obtained from the treatment Thai Baromasi (V_3). The yield of chilli as ton per hector was significantly varied by the different varietal treatment. The highest fruit yield (4.97 t/ha) was recorded from the BARI Amm-4 (V_2) treatment. The second highest yield (4.34 t/ha) was obtained in BARI Amm-11 (V_1)

treatment. On the other hand, lowest fruit yield (3.12 t/ha) was obtained from the treatment Thai Baromasi (V_3).

Again, the result of the research were showed that the main effect of fertilizer and manure were significant in respect of plant height (00, 15, 30 and 45 DAT), number of leaf/plant (00, 15, 30 and 45 DAT), first flowering days after transplanting, first fruiting days after transplanting, number of fruit/plant, weight of fruit/plant (g), total Number of fruit/plot, total weight of fruit/plot (kg), fruit length (cm), fruit diameter (cm), fresh weight/Plant (g), dry weight/Plant (g) and yield (t/ha). The tallest plant height (29.35 cm) at 45 DAT was recorded from Chemical fertilizer (F_3). On the other hand, the shortest plant height (23.10 cm) at 45 DAT was observed in those plots where no fertilizer was applied (F_1). The maximum number of leaf/plant (87.96) at 45 DAT was recorded from Chemical fertilizer (F_3). On the other hand, minimum number of leaf/plant (69.92) at 45 DAT was observed in those plots where no fertilizer was applied (F_1). The fast first flowering days after transplanting (44.67) observed from the plot where chemical fertilizer (F_1) was applied and last first flowering days after transplanting (48.44) recorded from the plot where no fertilizer was (F_1) applied. As well as, the fast first fruiting days after transplanting (54.33) observed from the plot where chemical fertilizer (F_1) was applied and last first fruiting days after transplanting (58.11) recorded from the plot where no fertilizer was (F_1) applied. The largest number of fruit/plant (83.39) was found where chemical fertilizer (F_3) and on the other hand, the smallest number of fruit/plant (64.45) was found where no fertilizer applied (F_1) and the highest weight of fruit (259.51 g/plant) was recorded from the plot where chemical fertilizer (F_3) was applied. On the other hand, lowest weight of fruit (251.48 g/plant) was obtained from the plot where no fertilizer (F_3) was applied. Similarly, the largest total number of fruit/plot (334.06) was found where chemical fertilizer (F_3) and on the other hand, the smallest number of fruit/plot (257.78) was found where no fertilizer applied (F_1) and the highest total weight of fruit/plot (1.41 kg/plot) was recorded from the plot where chemical fertilizer (F_3) was applied. On the other hand, lowest total weight of fruit/plot (1.09 kg/plot) was obtained from the plot where no fertilizer (F_3) was applied. The fruit length and fruit diameter of chilli was found significantly varied due to the applications of different fertilizer and manure. The maximum fruit length (7.30 cm) was obtained from the plot where chemical fertilizer (F_3) was applied. On the other hand, minimum fruit length (5.97 cm) was obtained from the plot where no fertilizer (F_1) was applied.

And the maximum fruit diameter (2.44 cm) was obtained from the plot where chemical fertilizer (F_3) was applied. On the other hand, minimum fruit diameter (2.25 cm) was obtained from the plot where no fertilizer (F_1) was applied. The maximum fresh weight/plant (362.83 g) was obtained from the plot where chemical fertilizer (F_3) was applied. On the other hand, minimum fresh weight/plant (339.71 g) was obtained from the plot where no fertilizer (F_1) was applied as same as the maximum fresh weight/plant (74.61 g) was obtained from the plot where chemical fertilizer (F_3) was applied. On the other hand, minimum fresh weight/plant (61.54 g) was obtained from the plot where no fertilizer (F_1) was applied. The yield of chilli as ton per hector was significantly affected due to the applications of different fertilizer. The highest fruit yield (4.69 t/ha) was recorded from the plot where chemical fertilizer (F_3) was applied. On the other hand, lowest fruit yield (3.62 t/ha) was obtained from the plot where no fertilizer (F_1) was applied.

In case of, the interaction effect of three different mango variety treatment and fertilizer applications of chilli had significant effect of growth, yield contributing characters and yield of chilli. The tallest plant height (30.42 cm) at 45 DAT was recorded from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) which is significantly followed by V_1F_3 (BARI Amm-11 + Chemical fertilizer). And lowest plant height (22.10 cm) was obtained from the treatment V_3F_1 (Thai Baromasi + no fertilizer). And at 45 DAT, the highest plant height (89.25) was obtained from the treatment V_3F_3 (Thai Baromasi + Chemical fertilizer) which is significantly followed by V_2F_3 (BARI Amm-4 + Chemical fertilizer) and V_1F_3 (BARI Amm-11 + chemical fertilizer) and lowest plant height (69.25) was obtained from the treatment V_1F_1 (BARI Amm-11 + No fertilizer) which was similar with V_3F_1 (Thai Baromasi + No fertilizer). The Early first flowering days after transplanting (44.00 days) observed from the combine treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer). Whereas the late first flowering days (49.33) recorded from the V_3F_1 (Thai Baromasi + No fertilizer) combine treatment and early first fruiting days after transplanting (53.67 days) observed from the combine treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) which was followed by V_2F_4 (BARI Amm-4 + Chemical fertilizer + Cow-dung) combine treatment. Whereas the late first fruiting days (58.97) recorded from both of the combination treatment V_3F_1 (Thai Baromasi + No fertilizer) and V_1F_1 (BARI Amm-11 + No fertilizer).

The maximum number of fruit/plant (100.82) was obtained from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer). On the other hand, minimum number of fruit/plant (47.85) was obtained from the treatment V_3F_1 (Thai Baromasi + No fertilizer) and the maximum weight of fruit/plant (317.48 g) was obtained from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer).On the other hand, minimum weight of fruit/plant (172.47 g) was obtained from the treatment V_3F_1 (Thai Baromasi + No fertilizer). So, the highest number of fruit/plot (403.27) was observed from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) due to 60% light intensity and applied systematic fertilizer. On the other hand, lowest number of fruit/plant (191.40) was observed from the treatment V_3F_1 (Thai Baromasi + chilli + no fertilizer) due to 40% light intensity and without fertilizer and the maximum total weight of fruit/plot (1.69 kg) was obtained from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment. On the other hand, minimum total weight of fruit/plot (0.82 kg) was obtained from the treatment V_3F_1 (Thai Baromasi + No fertilizer). The maximum fruit length (7.57 cm) was obtained from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment. On the other hand, minimum fruit length (5.69 cm) was obtained from the treatment V_3F_1 (Thai Baromasi + No fertilizer). The maximun fruit diameter (2.47 cm) was measured from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment. On the other hand, minimum fruit diameter (2.16 cm) was measured from the treatment V_3F_1 (Thai Baromasi + No fertilizer). The maximum fresh weight/plant (374.33 g) was obtained from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment. On the other hand, minimum fresh weight/plant (328.87 g) was obtained from the treatment V_3F_1 (Thai Baromasi + No fertilizer) and the maximum dry weight/plant (82.00 g) was obtained from the treatment V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment. On the other hand, minimum dry weight/plant (51.65 g) was obtained from the treatment V_3F_1 (Thai Baromasi + No fertilizer) due to without fertilizer. The interaction effect of production system and fertilizer & manure applications on the yield as ton per hector of chilli was found significantly different. The highest yield (5.62 t/ha) was observed from V_2F_3 (BARI Amm-4 + Chemical fertilizer) combination treatment due to low allelopathy effect and applied systematic fertilizer.

In case of economic analysis, indicate that the total cost of production was maximum (177996 Tk. /ha) in those plots where chilli was cultivated with using BARI Amm-4 + Cow-dung (F_2) whereas the minimum cost of production (158710 Tk. /ha) was recorded from those plots where Thai Baromasi + no fertilizer (F_1) was applied. The highest value of gross return (478850 Tk. /ha) was obtained in those plots where BARI Amm-4 + chemical fertilizer (F_3) was applied. On the other hand, the lowest value of gross return (265900 Tk. /ha) was obtained in those plots where Thai Baromasi + Cow-dung (F_2) was applied. Net return (309481 Tk. /ha) was comparatively higher in producing chilli under BARI Amm-4 + Chemical fertilizer (F_3). At the same time, the lowest net return (94919 Tk. /ha) was received from those plot where Thai Baroasi + Cow-dung (F_2) combine treatment was applied. The highest benefit-cost ratio (2.83) was recorded from the treatment BARI Amm-4 + Chemical fertilizer (V_2F_3). On the other hand, the lowest benefit-cost ratio (1.56) was observed in those plots where chilli was grown under Thai Baromasi mango tree variety with cow-dung (F_1) application.

5.2 Conclusion

The findings of the present investigation indicate that diversification of farming system and growing chilli as ground layers crops in three different variety of mango tree orchard is a viable option for increasing income of farmers. Among the three different mango variety, BARI Amm-4 (V_2) gave best performance in terms of total yield of chilli which followed by BARI Amm-11 (V_1). Again, among the four fertilizer application packages, chemical fertilizer gave best yield and also cowdung used as organic fertilizer gave better yield. Moreover, in case of economic return, chilli cultivation at the floor of BARI Amm-4 mango tree with the application of full chemical fertilizer gave maximum BCR. However, the suitability of the cultivation of chilli under three different mango based agroforestry systems may be ranked as $V_2F_3 > V_1F_3 > V_2F_4 > V_2F_2 > V_2F_1 > V_1F_4 > V_1F_2 > V_1F_1 > V_3F_1 > V_3F_3 > V_3F_4 > V_3F_2$. Finally it may be concluded that, BARI Amm-4 would be the best variety to be chilli cultivation.

5.3 Recommendations

1. BARI Amm-4 is economically viable for growing chilli as ground layers crops. So, it can be suggested to the farmers to practice it extensively. Moreover, it will help to improve family health, farm economics and/or self-reliance. Farmers will be economically more benefited and healthy safe food for family nutrition will be also ensured.

2. Integrated application of cowdung or combination of cowdung and NPK showed better performance and gave the profitable yield. So, cowdung can play a vital role in depletion of chemical fertilizer or increasing of soil fertility and this integrated approach can contribute to improve crop production.

3. This study should be repeated in different location of the country using different aged BARI Amm-4 and BARI Amm-11 mango orchard to obtained valid recommendation.

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APPENDICES

Appendix-I: The physical and chemical properties of soil in Agroforestry & Environment farm HSTU, Dinajpur

Soil characters	Physical and chemical properties
Texture	
Sand (%)	65
Silt (%	25
Clay(%	10
Textural class	Sandy loam
CEC (meq/ 100g)	9.17
pH	5.8
Organic matter (%)	0.99
Total nitrogen (%)	0.10
Sodium (meq/ 100g)	0.15
Calcium (meq/ 100g)	1.30
Magnesium (meq/ 100g)	0.60
Potassium (meq/ 100g)	1.26
Phosphorus (μg/g)	22.0
Sulphur (μg/g)	3.2
Boron (μg/g)	0.27
Iron (μg/g)	5.60
Zinc (μg/g)	1.01

Source: Soil Resources Development Institute, Dinajpur (2019)

Appendix II. Weather data of the experimental site during the period from February 2020 to April 2020

Months	* Air Temperature (^0C)			* Minimum Rainfall (mm)	* Relative Humidity (%)
	Maximum	Minimum	Average		
January 2020	13.5	7	10.25	9.9	89
February 2020	15.1	8.1	11.6	16.4	81
March 2020	15.9	9.2	12.55	10.2	75
April 2020	25.2	8.5	16.85	14.9	75

Note * Monthly average

Source: Bangladesh Meteorological Station, Rangpur

Appendix III: Schedule of cultural operation in the experiment

Serial No.	Cultural preparation	Date
1	Opening of the land	18.01.2020
2	Ploughing and cross ploughing	29.01.2020
3	Breaking of clods, laddering and weeding	29.01.2020
4	Layout of the experimental pit and plot	30.01.2020
5	Applications of 2/3rd of urea and entire of other fertilizer	30.01.2020
6	Sowing of seed	31.01.2020
7	1st Irrigation	31.01.2020
8	1st Weeding	22.02.2020
9	2nd Weeding	09.03.2020
10	2nd Irrigation	10.03.2020
11	3rd Irrigation	17.03.2020
12	Insect and Disease control by hand picking	20.03.2020
13	1st Harvesting	31.03.2020
14	2nd Harvesting	07.04.2020
15	3rd Harvesting	14.04.2020
16	Data analysis	29.04.2020
17	Thesis writing	15.07.2020

Appendix IV. Factorial ANOVA tables.

Source	DF	SS	MS	F-Value	Pr(>F)
1.Plant height (cm) at 00 DAT/Showing time					
Replication	2	0.9798	0.48991		
Factor A	2	0.1014	0.05068	0.20	0.8199
Factor B	3	0.6893	0.22976	0.91	0.4531
A×B	6	2.9874	0.49790	1.97	0.1142
Error	22	5.5655	0.25298		
Total	35	10.3234			
2.Plant height (cm) at 15 DAT					
Replication	2	1.1673	0.58367		
Factor A	2	1.2527	0.62634	1.97	0.1635
Factor B	3	16.9881	5.66269	17.80	0.0000
A×B	6	2.3753	0.39588	1.24	0.3225
Error	22	6.9988	0.31813		
Total	35	28.7822			
3.Plant height (cm) at 30 DAT					
Replication	2	2.439	1.2195		
Factor A	2	12.707	6.3536	8.75	0.0016
Factor B	3	92.606	30.8686	42.49	0.0000
A×B	6	6.116	1.0194	1.40	0.2577
Error	22	15.982	0.7264		
Total	35	129.850			
4. Plant height (cm) at 45 DAT					
Replication	2	4.749	2.3743		
Factor A	2	24.491	12.2456	26.45	0.0000
Factor B	3	181.903	60.6343	130.96	0.0000
A×B	6	3.164	0.5274	1.14	0.3731
Error	22	10.186	0.4630		
Total	35	224.492			

Source	DF	SS	MS	F-Value	Pr(>F)
5. Number of leaf /plant at 00 DAT/Showing time					
Replication	2	0.06514	0.03257		
Factor A	2	0.24014	0.12007	0.85	0.4392
Factor B	3	1.53799	0.51266	3.65	0.0283
A×B	6	0.59264	0.09877	0.70	0.6504
Error	22	3.09153	0.14052		
Total	35	5.52743			
6. Number of leaf /plant at 15 DAT					
Replication	2	1.3785	0.68924		
Factor A	2	0.6701	0.33507	0.76	0.4783
Factor B	3	7.1667	2.38889	5.44	0.0059
A×B	6	1.8021	0.30035	0.68	0.6646
Error	22	9.6632	0.43924		
Total	35	20.6806			
7. Number of leaf /plant at 30 DAT					
Replication	2	70.733	35.3663		
Factor A	2	10.753	5.3767	2.51	0.1045
Factor B	3	157.311	52.4369	24.45	0.0000
A×B	6	4.955	0.8258	0.39	0.8806
Error	22	47.184	2.1447		
Total	35	290.936			
8. Number of leaf /plant at 45 DAT					
Replication	2	36.02	18.010		
Factor A	2	14.86	7.431	2.13	0.1421
Factor B	3	1486.87	495.622	142.39	0.0000
A×B	6	11.30	1.883	0.54	0.7715
Error	22	76.58	3.481		
Total	35	1625.62			

Source	DF	SS	MS	F-Value	Pr(>F)
9. First Flowering Days after transplanting					
Replication	2	1.5556	0.7778		
Factor A	2	11.0556	5.5278	23.79	0.0000
Factor B	3	70.0833	23.3611	100.55	0.0000
A×B	6	2.5000	0.4167	1.79	0.1470
Error	22	5.1111	0.2323		
Total	35	90.3056			
10. First Fruiting Days after transplanting					
Replication	2	2.889	1.4444		
Factor A	2	20.222	10.1111	31.28	0.0000
Factor B	3	70.972	23.6574	73.19	0.0000
A×B	6	1.778	0.2963	0.92	0.5017
Error	22	7.111	0.3232		
Total	35	102.972			
11. Number of Fruit per Plant					
Replication	2	17.6	8.78		
Factor A	2	7806.5	3903.25	157.54	0.0000
Factor B	3	1620.9	540.30	21.81	0.0000
A×B	6	91.2	15.20	0.61	0.7172
Error	22	545.1	24.78		
Total	35	10081.2			
12. Weight of Fruit per Plant					
Replication	2	176	88.2		
Factor A	2	117359	58679.6	8748.26	0.0000
Factor B	3	326	108.7	16.20	0.0000
A×B	6	15	2.4	0.36	0.8932
Error	22	148	6.7		
Total	35	118024			

Source	DF	SS	MS	F-Value	Pr(>F)
13. Total Number of Fruit/plot					
Replication	2	294	146.8		
Factor A	2	125052	62526.1	161.57	0.0000
Factor B	3	26280	8760.1	22.64	0.0000
A×B	6	1409	234.8	0.61	0.7222
Error	22	8514	387.0		
Total	35	161549			
14. Total weight of Fruit/plot					
Replication	2	0.16740	0.08370		
Factor A	2	1.93167	0.96583	107.64	0.0000
Factor B	3	0.47308	0.15769	17.57	0.0000
A×B	6	0.02216	0.00369	0.41	0.8634
Error	22	0.19740	0.00897		
Total	35	2.79170			
15. Fruit length (cm)					
Replication	2	0.5784	0.28920		
Factor A	2	1.1498	0.57490	25.18	0.0000
Factor B	3	8.9453	2.98177	130.59	0.0000
A×B	6	0.0761	0.01268	0.56	0.7608
Error	22	0.5023	0.02283		
Total	35	11.2519			
16. Fruit diameter (cm)					
Replication	2	0.02954	0.01477		
Factor A	2	0.07421	0.03710	7.43	0.0034
Factor B	3	0.17392	0.05797	11.62	0.0001
A×B	6	0.00704	0.00117	0.24	0.9603
Error	22	0.10979	0.00499		
Total	35	0.39450			

Source	DF	SS	MS	F-Value	Pr(>F)
17. Fresh weight/plant					
Replication	2	135.58	67.79		
Factor A	2	2797.88	1398.94	34.58	0.0000
Factor B	3	2462.71	820.90	20.29	0.0000
A×B	6	84.97	14.16	0.35	0.9022
Error	22	890.00	40.45		
Total	35	6371.14			
18. Dry weight/plant					
Replication	2	21.37	10.684		
Factor A	2	1955.56	977.778	59.36	0.0000
Factor B	3	789.69	263.230	15.98	0.0000
A×B	6	20.35	3.392	0.21	0.9712
Error	22	362.38	16.472		
Total	35	3149.34			
19. Yield (t/ha)					
Replication	2	1.8728	0.9364		
Factor A	2	21.3416	10.6708	106.93	0.0000
Factor B	3	5.2385	1.7462	17.50	0.0000
A×B	6	0.2529	0.0422	0.42	0.8561
Error	22	2.1954	0.0998		
Total	35	30.9013			

Appendix- V: Production cost analysis of chilli cultivation under mango based agroforestry system.

Treatment	Input cost										Total input cost (tk/ha)	Overhead cost			Total cost of production (tk/ha)
	Non material cost (Tk/ha)			Material cost (Tk/ha)								Interest of input cost @ 8% for the crop season (tk/ha)	Interes of the value of land(tk. 300000/ha /ha) @ 8% for the crop season (tk/ha)	Miscellaneous cost @ 5% of the input cost (tk/ha)	
	Three mango variety	Chilli	Total nonmaterial cost	Seed	Fertilizer and Manure	Pesticide	Irrigation	Maintenance cost of trees	Initial plantation cost of trees	Total material cost (tk/ha)					
V_1F_1	38242	28650	66892	12010	0	8000	3260	6850	23850	53970	120862	9668	24000	6043	160573
V_1F_2	38242	28650	66892	12010	10860	8000	3260	6850	23850	64830	131722	10537	24000	6586	172845
V_1F_3	38242	28650	66892	12010	3250	8000	3260	6850	23850	57220	124112	9928	24000	6205	164245
V_1F_4	38242	28650	66892	12010	7055	8000	3260	6850	23850	61025	127917	10233	24000	6395	168545
V_2F_1	42890	28650	71450	12010	0	8000	3260	6850	23850	53970	125420	10033	24000	6271	165724
V_2F_2	42890	28650	71450	12010	10860	8000	3260	6850	23850	64830	136280	10902	24000	6814	177996
V_2F_3	42890	28650	71450	12010	3250	8000	3260	6850	23850	57220	128670	10293	24000	6433	169396
V_2F_4	42890	28650	71450	12010	7055	8000	3260	6850	23850	61025	132475	10598	24000	6623	173696
V_3F_1	34593	28650	65243	12010	0	8000	3260	6850	23850	53970	119213	9537	24000	5960	158710
V_3F_2	34593	28650	65243	12010	10860	8000	3260	6850	23850	64830	130073	10405	24000	6503	170981
V_3F_3	34593	28650	65243	12010	3250	8000	3260	6850	23850	57220	122463	9797	24000	6123	162383
V_3F_4	34593	28650	65243	12010	7055	8000	3260	6850	23850	61025	126268	10101	24000	6313	166682

Here, V_1F_1 = BARI Amm-11 + No fertilizer, V_1F_2= BARI Amm-11 + Cow-dung, V_1F_3= BARI Amm-11+ Recommended chemical fertilizer, V_1F_4= BARI Amm-11+ Chemical fertilizer + Cow-dung, V_2F_1 = BARI Amm-4 + No fertilizer, V_2F_2= BARI Amm-4+ Cow-dung, V_2F_3= BARI Amm-4 + Recommended chemical fertilizer, V_2F_4= BARI Amm-4 + Chemical fertilizer + Cow-dung, V_3F_1 = Thai Baromasi + No fertilizer, V_3F_2= Thai Baromasi + Cow-dung, V_3F_3= Thai Baromasi + Recommended chemical fertilizer, V_3F_4= Thai Baromas + Chemical fertilizer + Cow-dun

Appendix VI: Some plates of research work.

Plate-1: Land preparation

Plate-2: Seedling stage and tagging

Plate-3: Harvesting period