SCREENING OF SUITABLE CHILI VARIETIES FOR ORGANIC CHILI PRODUCTION UNDER MANGO BASED AGROFORESTRY SYSTEM

A THESIS
BY

MST. NAZMUN NAHAR
Registration No: 1605448
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MASTER OF SCIENCE (M.S.)

IN

AGROFORESTRY AND ENVIORNMENT

DEPARTMENT OF AGROFORESTRY AND ENVIORNMENT
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

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DEPARTMENT OF AGROFORESTRY AND ENVIORNMENT
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

DECEMBER 2017

Dedicated to My Beloved Parents

SCREENING OF SUITABLE CHILI VARIETIES FOR ORGANIC CHILI PRODUCTION UNDER MANGO BASED AGROFORESTRY SYSTEM

ABSTRACT

A field experiment was carried out at the Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, during October, 2016 to March, 2017 to evaluate the varietal performance of chili and organic chili production under mango based agroforestry system. The experiment was conducted in the mango orchard where the tree saplings were planted at the spacing 6 m × 6 m in the year 2006. The experiment was laid out in two factorial RCBD with 3 (three) replications. Factor A (three chili varieties) viz. V_1 = Hybrid, V_2 = Kajli and V_3 = Shity. On the other hand, factor B was four types of fertilizer & manure applications viz. no fertilizer (F_1), cow-dung (F_2), poultry manure (F_3) and chemical fertilizer (F_4). There were twelve treatment combinations and there were: V_1F_1 (Hybrid + no fertilizer), V_1F_2 (Hybrid + cowdung), V_1F_3 (Hybrid + poultry), V_1F_4 (Hybrid + chemical fertilizer), V_2F_1 (Kajli + no fertilizer), V_2F_2 (Kajli + cowdung), V_2F_3 (Kajli + poultry), V_2F_4 (Kajli + chemical fertilizer), V_3F_1 (Shity + no fertilizer), V_3F_2 (Shity + cow dung), V_3F_3 (Shity + poultry) and V_3F_4 (Shity + chemical fertilizer). The result of the experiment revealed that plant height (30, 45, 60, 75 and 90 DAT), leaf length (30, 45, 60, 75 and 90 DAT), leaf breadth (30, 45, 60, 75 and 90 DAT), number of leaf/plant (30, 45, 60, 75 and 90 DAT), number of shoot/plant (45, 60, 75 and 90 DAT), number of fruit/plant, weight of fruit/plant (g), total number of fruit/plot, total weight of fruit/plot (kg), fruit length (cm), fruit breadth (cm), fruit number yield (t/ha), % dry weight of fruit and yield (ton/ha) of chili were significantly varied due to different chili variety and fertilizer and manure application. In case of main effects of variety, the highest fruit yield (12.99 ton/ha) was recorded from the variety Kajli (V_2). On the other hand, lowest fruit yield (5.49 ton/ha) was obtained from the variety Shity (V_3). In case of main effects of fertilizer and manure application, the highest fruit yield (12.16 ton/ha) was recorded from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest fruit yield (6.949 ton/ha) was obtained from the plot where no fertilizer (F_1) was used. In case of interaction effects of the chili variety and fertilizer and manure applications, the maximum yield (17.09 ton/ha) was obtained from the treatment combination V_2F_4 (Kajli + chemical fertilizer) and minimum yield (3.54 ton/ha) was obtained from the treatment combination V_3F_1 (Shity + no fertilizer). Again, from the economic analysis, the highest BCR (3.42) was recorded from the treatment

combination of Kajli (V_2) + chemical fertilizer (F_4). On the other hand, the lowest BCR (1.80) was recorded from the treatment combination of Shity(V_3) + no fertilizer (F_1) was applied. Moreover, the varietal performance of different chili varieties under mango based agroforestry system ranked as Kajli>Hybrid>Shity and out of the four fertilizer and manure applications chemical fertilizer would be the best fertilizer treatment. Though organic manure (Poultry manure) was given less production than chemical fertilizer, but it is ecofriendly and safe. In safety point of view, organic manure is the best for chili production.

ACKNOWLEDGEMENT

All praises are going to Almighty Allah for enabled me to complete this thesis for the degree of Master of Science (MS) in Agroforestry and Environment.

It is my pleasure to express my heartiest respect, sincere appreciation and immense indebtedness to my respectable teacher and research Supervisor Professor Dr. Md. Shafiqul Bari, Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur for his scholastic guidance during planning and execution of the research, valuable suggestions, continuous support and all kind of help throughout the period of research work and preparation of manuscript of the thesis.

Heartiest gratitude and deep sense of admiration to my respected Co-Supervisor Professor Dr. Md. Shoaibur Rahman, Chairman, Department of Agroforestry and Environment for his valuable suggestions, sincere help, scholarly instructions during research conduction and careful correction of the manuscript of the thesis.

I recognize a profound thanks to Md. Hafiz All Amin, Associate Professor, and Md. Abu Hanif, Assistant Professor, Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur for their important suggestions, and all round help and kindly support for successful completion of the manuscript of the thesis.

I am very thankful to all my friends and well-wishers for their eagerness and direct and indirect helps during the period of research work.

I get pleasure to express my boundless gratitude and heartiest respect to my beloved parents for their great sacrifice and efforts during the whole study period in my life and other relatives who wished success through my academic career.

December 2017

The Author

Mst. Nazmun Nahar

CHAPTER 1

INTRODUCTION

Chili (*Capsicum annum* L.), the most important spice crop is grown all over Bangladesh. It is a high value crop that is grown for cash by farmers all over the world (Aliyu *et al*., 2012). It (*Capsicum* spp.) belongs to the Solanaceae family, a year round crop used in variety of ways (Erinle, 1989; Akinyosoye, 1977). It is a spice, a fruit vegetable widely cultivated in the world and which importance in human food is capital (Dias *et al*., 2013; Wahyuni *et al*., 2013). Originated from South and Central America, chili, of the genus Capsicum, has more than 25 species of which only five (*C. annuum* L., *C. chinense* Jacq., *C. frutescens* L, *C. baccatum* L. and *C. pubescen*s Keep.) are domesticated and cultivated (Bosland and Botava, 2000; Costa *et al.,* 2009). It is one of the richest sources of vitamin C and A (Howard, 2000). It is an indispensable spice, which is liked for pungency and spicy taste and the appealing colour adds to the curry. Chili fruits are consumed as table purpose as well as spice and condiments. Throughout the world, chili is consumed fresh, dried or in powder (El-Ghoraba *et al*., 2013). It is rich in proteins, lipids, carbohydrates, fibres, mineral salts (Ca, P, Fe) and in vitamins A, D3, E, C, K, B2 and B12 (El-Ghoraba *et al*., 2013). The fruits are an excellent source of health-related phytochemical compounds, such as ascorbic acid (vitamin C), carotenoids (provitamin A), tocopherols (vitamin E), flavonoids, and capsaicinoids that are very important in preventing chronic diseases such as cancer, asthma, coughs, sore throats, toothache, diabetes and cardiovascular diseases (El-Ghoraba *et al.,* 2013; Wahyuni *et al*., 2013). Moreover, the consumption of fresh fruits facilitates starchy food digestion (Bhattacharya *et al.,* 2010). Chili has antioxidant, anti-mutagenesis, hypocholesterolemic and immunosuppressive properties (El-Ghoraba *et al*., 2013) and also inhibits bacterial growth and platelet agglomeration (Wahyuni *et al*., 2013). At global level, chili is one of the spices that generate huge revenues for producers and therefore contributes to poverty alleviation and improvement of women’s social status (Karungi *et al*., 2013).

Despite its economic, food and medicinal importance, chili remains in many countries a neglected crop that is rarely of national priority in terms of agricultural development (FAO, 2010). Therefore, its cultivation is still traditional and is facing many biotic (Pests, diseases), and abiotic (drought, high soil moisture, salinity, soil poverty, etc.) stresses that cause severe yield losses (Khan *et al.,* 2009; Segnou *et al.,* 2013; Zhani *et al.*, 2013).

At present chili is cultivated in an area of about 92307.69 ha with total production of 123000 MT chili during 2014-2015 in Bangladesh (BBS,2015). However, the average yield of dry chili is low (700-800 kg/ha) in Bangladesh compared to the neighboring countries (1000-1200 kg/ha). One of the reasons of lower yield might be imbalanced use of fertilizers and manure and scarcity of land for chili cultivation. The production of chili largely depends on the use of fertilizers, irrigation, pesticide etc. The Government of Bangladesh has not provided priority to the agriculture sector to increase the production of chili by giving subsidy to the farmers on different inputs such as seeds, fertilizer, irrigation etc. to achieve self-sufficiency in chili production.

On the other hand, Mango (*Mangifera indica*) belong to the genus *Mangifera* of the family Anacardiaceae. Mango has become naturalized and adapted throughout the tropics and subtropics. It is the most popular and tasty fruit in Bangladesh and it contains adequate quantity of carotene or vitamin A and minerals. It is called the king of fruits. Mango plays an important part in the diet and cuisine of many diverse cultures Mango is cultivated in almost all districts of Bangladesh. But a good quality and high value mango is grown well in the districts of north-western and south-western region because of soil and weather condition. But now-a-days, mango is cultivated commercially in all districts of Bangladesh. Mango trees are recognized as national tree of Bangladesh, and eaten throughout the world (Salvin, 2012).

The production of chili and mango is not sufficient to meet up the need of the people of Bangladesh. Due to steadily increasing population pressures in the Bangladesh coupled with expansion of urban and industrial areas, farmers have been forced to shorten the fallow period, thereby scarcity of land for cultivation is increasing day by day. This situation threatens the livelihoods of people dependent on agriculture. By leaving horizontal agriculture (Traditional) and practicing vertical agriculture (Agroforestry), this problem can be solved. Agroforestry provides potential for more sustainable land use. Deliberate maintenance or cultivation of trees or other woody plants with crops or pasture has multiple benefits, and can provide farmers, communities and society at large with a wide array of forest-related goods and services (Mac Dicken and Vergara, 1990). Trees in agroforestry systems also have important uses such as holding the soil against erosion and improving soil fertility (by fixing nitrogen or bringing minerals from deep in the soil and depositing them by leaf-fall). But, in our country agroforestry is not popular in our country. Most of the farmers does not know about agroforestry system, its beneficial sides, its technical parts. That’s why they are taking time in adopting agroforestry system.

The aims of organic production system are supporting and sustaining healthy ecosystems, soil, farmers, food production, the community, and the economy. Reduction and elimination of the adverse effects of synthetic fertilizers and pesticides on human health and the environment is a strong indicator that organic agriculture is gaining worldwide attention. Organic fertilizers are eco-friendly, since they are from organic sources. The current global scenario firmly gives emphasize on the need to adopt. The sustainability of traditional agriculture in Bangladesh is under threat because of the continuous degradation of land and water resources and declining yields due to the indiscriminate use of agro-chemicals. Sustainability in agroecosystems involves environmentally-friendly techniques based on biological and non- chemical methods (Bonato and Ridray, 2007). So, organic agroforestry production system is very need for Bangladesh.

Farmers those have mango orchard are cultivating different kinds of vegetables and spices at the floor of mango orchard. But usually they are using chemical fertilizers and not aware about which variety will give much yield and economic benefits. So, we need to identify the suitable chili variety for organic chili production in the floor of mango orchard. Considering the above circumstances, the present study was conducted with mango as upper-story and three chili varieties as ground-story components using different fertilizer and manure applications package with the following objectives:

- To identify suitable chili variety under mango based agroforestry system.
- To find out the appropriate fertilizer and manure for chili production under mango based agroforestry system.
- To evaluate the economic return of organic and inorganic chili production under mango based agroforestry system.

CHAPTER 2

REVIEW OF LITERATURE

Agroforestry is a new field of organized scientific pursuit although the practice encompasses some age-old land use activities. It 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 Concepts of agroforestry

2.2 Effects of organic manures and inorganic fertilizers on the growth and development of crop

2.3 Agroforestry system based on mango

2.4 Vegetable based agroforestry system

2.5 Spice based agroforestry system

2.6 Chili based agroforestry system

2.7 Economics of agroforestry system

2.1 Concepts of Agroforestry

According to the Food and Agriculture organization (FAO), "Sustainable agriculture is the successful management of agricultural resources to satisfy changing human needs while maintaining or enhancing the quality of environment and conserving natural resources". This concept emphasizes on present needs without sacrificing the needs of future (Brundtle and Commission, 1987).

"Agroforestry should be recognized as a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm and rangeland, diversifies and sustains production for increased social, economic and environmental benefits (Leakey, 1996).

Hasanuzzaman *et al.,* (2014) stated that cropland agroforestry is an important production system in the southwest region of Bangladesh. This study focused on the floristic composition and management of existing cropland agro-forests. A total of 313 cropland agro forests were surveyed and 83% respondents practiced pure agroforestry while the remaining 17% practiced agroforestry with fisheries. A total of 18 forest trees and 2 shrubs were recorded from 11 families and 59 fuel wood species and wider spacing for fruit trees. A wide range of rotation periods, from 5 to 25 years, was observed for both cases.

Michon *et al*., (1986) stated that the agroforestry garden system in Maninjau in West Sumatra is characterized by an intensive integration of forest species and commercial crops, forming a forest- like system. The intimate association of different species provides both subsistence and commercial products which supplement rice production. This complex agroforestry is managed by the combination between cultural practices and respect of natural processes of vegetation production and reproduction. It represents a profitable production system and constitutes an efficient buffer between villages and protected forest. It is a good model of association between integration of forest resources and cultivation of cash crops in the form of a sustainable and flexible system.

Long *et al.,* (2003) studied that the lacquer tree (*Toxicodendron vernicifiuum*) based agroforestry system is a very important farming system with development potential in western Yunnan, southwest China. It is, however, less understood in scientific fields. The Lemo people (a branch of the Bai minority nationality) traditionally grow lacquer trees interplanted with upland food crops in swidden fields. During a 10–15 year fallow period, farmers can harvest various products from lacquer trees, including resin for selling or trading, leafy shoots for vegetable, pericarps for making wax, roots and leaves for pesticide, dry resin for medicine, and seeds for vegetable oil extraction. The Lemo people believe the lacquer tree is the most important crop in their community. The lacquer agroforestry system provides the Lemo people with food, cash income and environmental benefits. Further studies on the lacquer agroforestry system will be indispensable to improve this system so as to disseminate it to other communities.

Agroforestry can contribute to household income/consumption directly through the production of goods (fruits, poles, fuel wood) and indirectly through goods and services such as fodder for livestock, reduction of land degradation, improved soil and water conservation. In addition, other benefits can be realized downstream through reduction of soil erosion and/or increased water flow control. These systems at a more aggregate level can also provide services for international consumers, through benefits for example of carbon sequestration and protection of international waters (FAO, 2001).

Alao and Shuaibu, (2013) stated that agroforestry has been defined as a dynamic ecologically based natural resources management system that through the integration of trees on farms and in the agricultural landscape diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. This paper highlighted agroforestry practices and concepts in sustainable land use systems. The benefit derivable from the interface between forest trees and agricultural crops are enormous. They include the optimal use of land for both agricultural and forestry production on a sustainable basis including the improvement of the quality of soil. This is in addition to the socio-economic benefits that are accruable from agroforestry. Indeed, the advantage of agroforestry is all encompassing and germane to a sustainable production system and livelihood.

Rahman *et al*., (2012) stated that in the Padma floodplain of Bangladesh, the traditional system of agriculture has become unsuitable due to high population growth. Mango based agroforestry which has been practiced by the farmer since the 1990s, is a promising alternative and is considered as one of the few options to lift farmers out of poverty and improve livelihood security. Farmers with the least were found to allocate a higher percentage of their land to agroforestry, and the increased income from agroforestry compared to other agricultural systems helps reduce relative poverty. This income maintains basic household needs, providing food security and fuel wood, and contributes to healthcare, housing and sanitation conditions, and meeting educational expenses.

Oladokun, (1990) showed that almost all the farmers intercropped other crops with cocoa. The intercrops included food crops such as plantain (92.3), cocoyam (85.7%), cassava (51.3%), yam (41.3%), maize (38.9%), melon (31.4%), cowpea (28.6%) and pineapple (26.0%) and tree crops such as oil palm (71.5%), kola (67.3%), coffee (41.0%), coconut (7.9%) and citrus (7.2%). Other crops are ewe-iran (*Sarcophrynium* *brachystachys*) and ewe-gbodogi (*Megaphrynium macrostachyum*) (45.2%), african walnut (*Tetracarpidium conophorum*) (42.2%), aligator pepper (*Aframomum melegueta*) (31.6%), and iyere (*Piper guinense*) (20.2%). Guava, mango, pawpaw and vegetables such as celosia, okra and solanum occur in cocoa plots at rather low frequencies. As many as six or more other crops can be intercropped with cocoa at the same time.

2.2 Effects of Organic Manures and Inorganic Fertilizers on the Growth and Development of crop

Deore *et al.,* (2010) determined the effects of foliar applications of a novel organic liquid fertilizer on growth and yield in chili (*Capsicum annum* L. var. Shama). The pot experiments were carried out in Botanical garden, Fergusson College, Pune. Plants were sprayed with five doses (1% - 5%) of novel organic liquid fertilizer along with untreated control plants. *Capsicum* which belongs to family Solanaceae is referred to as red pepper. Chili is an important commercial crop of India grown for its green fruits as vegetable and red form as spice. Many food industries have been using chilies in preparation of processed products and pharmaceutical preparations. The present investigation has revealed the consistent and significant results for growth parameters due to applications of novel organic liquid fertilizer. Out of five different treatments, the 3% treatment resulted in maximum, plant height; number of branches per plant; leaf number; leaf area; fresh and dry weight of the plant; number of fruits per plant and total yield.

Singh and Chauhan, (2009) stated that pH having 5.3 to 5.5 to study the effect of organic sources of nutrients viz., vermicompost, FYM and along with inorganic fertilizers in French bean under irrigated condition with an objective to study growth and yield without degrading soil quality by using various nutrient compositions. In this investigation, vermicompost treatment (T2) recorded the highest in all observations except biomass of whole plant (above and ground biomass) which was recorded highest in N:

P: K (T1) treatment this may be due to high composition of Nitrogen in inorganic fertilizers which supplement to the plant's vegetative phase. Thus it may be concluded that vermicompost was found useful than any other type of treatments under irrigated condition of Srinagar valley.

Ullah *et al.,* (2010) conducted a field experiment at the Horticultural Farm of Bangladesh Agricultural University (BAU), Mymensingh during the period from December 2004 to April 2005 to evaluate the effect of manures and fertilizers on the yield of brinjal. The maximum branching (20.1) with the highest number fruits/plant (15.2), fruit length (14.1 cm) and fruit diameter (4.3 cm) were found combined applications of manures and fertilizers. The highest yield (45.5 t ha-1) was also obtained from the combined applications of organic and inorganic sources of nutrients. Applications of mustard oil cake or poultry manure alone gave better performance compared to only chemical fertilizers. The organic matter content and availability of N, P, K and S in soil were increased by organic matter applications. On the other hand, soil pH was increased with chemical applications than organic.

Kumar *et al.,* (2014) conducted a study to investigate the influence of different organic manure doses on the herbage biomass and essential oil yield and oil quality of patchouli *Pogostemon cablin* (Blanco) Bench under Teak based agroforestry system. He concluded that, among seven treatment of different organic manure tested, the 100% vermicompost exhibited significantly high dry herbage yield, essential oil yield and oil content (%) in first second and third harvest per year from patchouli crop under teak based agroforestry system.

Huez López *et al*., (2011) worked on the effect of two sources of nitrogen on plant growth, and fruit yield of chili pepper (*Capsicum annuum* L.) cv. An organic source extracted from grass clippings in rates of 120 and 200 kg N ha^{-1}, and another inorganic (ammonium nitrate) in rate of 120 kg ha^{-1} were combined with low, moderate and high (1.5, 4.5, and 6.5 dS m^{-1}) salinity levels arranged in a randomized complete block design replicated four times. Salinity treatments reduced dry matter production, leaf area, relative growth rate and net assimilation rate but increased leaf area ratio. The organic fertilizer produced higher fruit yields than the inorganic fertilizer. The highest fruit yield was obtained with the increased rate of organic N. The fruit number was more affected by salinity than the individual fruit weight.

Vimala *et al*., (2007) studied that four rates (0, 20, 40, 60 t/ha) of organic fertilizer (processed poultry manure) and three rates of inorganic fertilizer (0, 2 and 3 t/ha) were evaluated on bird chili grown on an upland clay soil. Significant effects of processed poultry manure (PPM) and inorganic fertilizer (NPK) rates on yield were obtained. Interaction effects between PPM and NPK were not significant. Yield increased significantly from 6.46 t/ha at zero fertilizer to 15.49 t/ha at 20 t/ha PPM + 2 t/ha inorganic fertilizer (N: P_2O_5:K_2O: MgO = 12:12:17:2). The optimum rate of inorganic fertilizer was 1.91 t/ha. The optimum rate of organic fertilizer was 52 t/ha. Fertilizers had no significant effect on fruit weight, but had a significant effect on fruit length. Nutrient contents did not differ significantly, except for fruit Ca, Fe and Mn and leaf Mg and Mn. Most soil chemical properties improved with increasing rates of organic fertilizer.

Rahman *et al.,* (2012) carried out an experiment to investigate the effects of bio compost, cow dung compost and NPK fertilizers on growth, yield and yield components of chili. 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), T_{11}= 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 (3 kg/pot) + NPK (T_1) produced the highest germination (%), vigour index, growth and yield of chili and the lowest yield and yield contributing parameters were recorded in control (T_{15}). The results suggest that inorganic fertilizers (NPK) with bio compost (3 kg/pot) is suitable for better production of chili that may increase soil fertility and this integrated approach could be contributed to improve crop production.

Vitkar *et al*., (2007) conducted an experiment in Maharashtra, India, to determine the effect of organic and inorganic fertilizers on the growth and green fruit yield of chili (*Capsicum annuum*) during 2003-04. Treatments comprised: a control, 100 or 50% recommended NPK rate (RDF), 100, 50 or 25% N through vermicompost and/or 100, 50 or 25% N through neem cake. Treatment with 50% N through vermicompost + 50% N through neem cake produced the highest plant height, number of primary branches, number of fruits per plant, fruit weight, fruit length, fruit diameter and total yield per hectare compared to all the other treatments including the control variant.

Chanda *et al.,* (2011) conducted field trials by using different fertilizers having equal concentration of nutrients to determine their impact on different growth parameters of tomato plants. Six types of experimental plots were prepared where T_1 was kept as control and five others were treated by different category of fertilizers (T_2-Chemical fertilizers, T_3-Farm Yard Manure (FYM), T_4-Vermicompost, T_5 and T_6- FYM supplemented with chemical fertilizers and vermicompost supplemented with chemical fertilizer respectively). The treatment plots (T_6) showed 73% better yield of fruits than control, Besides, vermicompost supplemented with N.P.K treated plots (T_5) displayed better results with regard to fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches and number of fruits per plant from other fertilizers treated plants.

Umrao *et al.,* (2013) conducted experiment on effect of organic fertilizers on the growth and yield of garlic (*Allium sativum*) under *Tectona grandis* based agroforestry system with seven treatments each in open and shade conditions. The treatment combinations used were control, FYM, vermicompost, neem cake, 50% FYM + 50% vermicompost, 50% FYM + 50% neem cake, 50% vermicompost + 50% neem cake. The results showed that different treatment of organic fertilizers had a positive effect on the growth and yield of plants under both open and shaded conditions but plants grown under shade conditions performed better in comparison to the ones grown in the open. Among all the treatment combination the applications of FYM have better influence on growth and yield of garlic under open and shade conditions but more yield was obtained with the applications of FYM under light shade of trees.

2.3 Agroforestry System Based on Mango

Shinde *et al.,* (2010) found that the grain yield plant^{-1} indicated positive and highly significant correlation with straw yield plant^{-1}, harvest index and weight of grains on main ear head at phenotypic and genotypic level, while number of fingers on main ear head at genotypic level only. Under mango based agroforestry system, path analysis indicated that finger length, harvest index, number of fingers on main ear head and straw yield plant"^{1} had direct positive effect on grain yield at genotypic level. Selection programme based on number of fingers on main ear head and straw yield plant^{-1} will be effective for grain yield improvement in finger millet under mango based agroforestry system.

Abedin *et al.*, (1987) conducted a survey in the Ganges floodplain of Bangladesh to understand the distribution and uses of multipurpose trees, tree- crop interactions, and the crafts/cottage industries these trees support. A predesigned survey questionnaire was used. Results showed that *Acacia nilotica, A. catechu, Artocarpus heterophyllus, Phoenix sylvestris, Borassus flabellifer* and *Mangifera indica* are the major tree species grown on the croplands in the low-rainfall Ganges floodplain area for fruit, timber, fuel, and building material. The trees support different crafts/cottage industries. Fuel was a common, though not primary, use of all the tree species. Uses of particular trees varied from place to place and their order of importance changed over time. Species distribution differed among regions. Tree- crop combinations and their interactions depended more on land type, age of the trees, canopy structure, and plot location of trees rather than the type of species grown. Determination of optimum tree densities, optimum economic age for cutting, relative economic importance, and improved management practices are critical issues for future research.

Alam and Sarker, (2011) stated that The cultivation of different plants around homesteads for subsistence and cash income has been a long tradition in Bangladesh. This study explores stand structure, composition, and biodiversity within the homestead agroforests of the drought-prone, northwestern region of Bangladesh. In 96 randomly selected homesteads within 3 study villages, we identified 56 tree species. Among those, *Mangifera indica* (mango) was the most popular fruit bearing species. Four non-parametric diversity indices were derived to provide a characterization of biodiversity. The Sørenson similarity index was also used to compare the similarity of species among different landholding size classes. The overall Shannon-Wiener biodiversity index and Pielou's evenness index values were 1.82 and 0.45, respectively. This study confirms that the farmers had strong preference for fruit species over timber yielding ones, and because of better growth performance natives were preferred over exotics.

Rathore *et al.,* (2013) studied that first phase (1995–2005), five mango based agri-horticultural models (AHM) viz. Mango + cowpea–toria, mango + cluster bean/okra–toria, mango + sesame–toria, mango + black gram–toria and mango + pigeon pea in addition to sole mango plantation (no intercrop) and in second phase (2005–2010), two mango based AHM (mango + colocasia and mango + turmeric) in addition to sole mango (no intercrop) were studied. The mean maximum cowpea equivalent yield (t ha^{-1}) was harvested from cowpea (1.84) followed by okra (1.21), black gram (1.11), sesame (0.68) and mean minimum with pigeon pea (0.58). The crop yield reduction among the mango based AHM was observed from third year to tenth year. The positive correlation was found between light transmission and intercrops yields amongst all models during both phases. However, the correlation between mango canopy spread and intercrop yields shown negative trends. The yield reduction in intercrops varied from 37.0–52.6 % during first phase and 20.6–23.5 % during second phase of experimentation compared to sole crop. The results revealed that the fruit based AHM were effective in improving fruit yields of the mango. The mean maximum fruit yield of mango (7.02 t ha^{-1}) was harvested with cowpea–toria crop rotation followed by black gram–toria (6.59 t ha^{-1}) and minimum fruit yield (5.76 t ha^{-1}) realized with sole mango tree during first phase (1999–2005). Likewise, mean maximum fruit yield (13.71 t ha^{-1}) from mango tree was obtained in the turmeric block followed by (13.00 t ha^{-1}) in colocasia block and minimum fruit yield with sole mango tree (11.86 t ha^{-1}). All the treatments of AHM recorded higher soil moisture as compared to sole mango plantation during both phases. The moisture retention under different AHM was in the order of cowpea (13.32 cm) > black gram (13.29 cm) > pigeon pea (13.27 cm) > okra (12.42 cm) > sesame (12.17 cm) > sole mango (11.62 cm) during first phase, whereas moisture retention was observed in the order of turmeric (14.20 cm) > colocasia (14.01 cm) > sole mango (12.60 cm) during second phase. The cowpea–toria crop rotation with mango gave maximum benefit: cost ratio followed by okra–toria under rainfed conditions. Besides economic viability of cowpea–toria with mango, this system had improved tree growth as well as fruit yield of mango. In the second phase, mango + turmeric yielded more benefit than mango + colocasia system. In the first phase, the mango + cowpea–toria system improved organic carbon, total nitrogen, phosphorus, potash and reduced pH by 49.0, 56.3, 48.6, 58.5 and 11.6 %, respectively as compared to initial values whereas mango + turmeric system increased organic carbon, nitrogen, phosphorus, potash and reduction in pH by 51.0, 45.0, 29.7, 29.0 and 3.4 %, respectively over initial values within soil depths of 0–30 cm during second phased. Mango based AHM is recommended for adoption with selective intercrops up to 15 years of age of mango plantation for multiple outputs and good economic viability without impairing site fertility.

Rahman *et al.,* (2012) studied that the traditional system of agriculture has become unsustainable due to high population growth. Mango-based agroforestry which has been practiced by the farmers since the 1990s, is a promising alternative and is considered as one of the few options to lift farmers out of poverty and improve livelihood security. This paper examines the potential of mango-based agroforestry to improve livelihoods, using data collected by rapid rural appraisal, farmer participatory research, stakeholder analysis and a farm household survey in six representative villages in the floodplain. Farmers with the least land were found to allocate a higher percentage of their land to agroforestry, and the increased income from agroforestry compared to other agricultural systems helps reduce relative poverty. This income maintains basic household needs, providing food security and fuelwood, and contributes to healthcare, housing and sanitation conditions, and meeting educational expenses.

2.4 Vegetable Based Agroforestry System

Hanif *et al.*, (2010) conducted a field experiment and the treatments were three okra variety viz. hybrid okra variety, BARI-1 and local okra variety, which were used as ground layer crop. There was also control (sole cropping) treatment. The aim of the experiments was to study the growth performance and selection of potential okra variety under litchi based agroforestry system. The yield contributing parameters were maximum in sole cropping of hybrid okra. The yield was highest (10.24 t ha^{-1}) in mono-cropping of hybrid okra and the lowest yield (4.24 t ha^{-1}) was found in T6 (Litchi + Local okra variety). But the litchi based agroforestry system ensures higher return and more sustainable than sole cropping. The suitability of okra variety may be ranked as Okra hybrid variety > BARI-1 okra > Local okra variety.

Rathore *et al.,* (2013) conducted an experiment where a total of 15 years of experimentation period (1995–2010) was divided into two phases. In the first phase (1995–2005), five mango based agri-horticultural models (AHM) viz. Mango + cowpea–toria, mango + cluster bean/okra–toria, mango + sesame–toria, mango + black gram–toria and mango + pigeon pea in addition to sole mango plantation (no intercrop) and in second phase (2005–2010), two mango based AHM (mango + colocasia and mango + turmeric) in addition to sole mango (no intercrop) were studied.

The mean maximum cowpea equivalent yield (t ha^{-1}) was harvested from cowpea (1.84) followed by okra (1.21), black gram (1.11), sesame (0.68) and mean minimum with pigeon pea (0.58). The crop yield reduction among the mango based AHM was observed from third year to tenth year. The positive correlation was found between light transmission and intercrops yields amongst all models during both phases.

Kan *et al*., (2008) conducted a survey with 133 households during 2003–2005 showed that the surveyed farmers managed 17 different tree-crop simultaneous systems with 97% of all sites including fruit species. The annual components were commercially the more important and were given the highest priority—with cereals (47%), vegetables (27%), fodder (19%) and cash crops (7%). Irrespective of tree species and plantation age, the most frequently observed tree density was 200–500 trees ha^{-1}, although subject to large variations. The dominance of younger trees <10 years (41%) was evidence of the recent interest in TIS and was obviously linked to recent land reforms and change in land ownership. The knowledge of TIS management among those surveyed was rather superficial. The interaction between agroforestry, environmental research and farmers' practices must be improved given the growing interest and significance of TIS for the rural population, and the government must increase private landowners' participation in farm management and decision-making.

Pouliot *et al.,* (2012) stated that in Western Africa, interactions between trees and agricultural crops are a key element in determining parkland management in an agricultural environment that is rapidly changing. Eggplant (*Solanum melongena*), chili pepper (*Capsicum annuum*), taro (*Colocasia esculenta*) and pearl millet *(Pennisetum glaucum*) were tested for their shade tolerance under *Parkia biglobosa* trees in south-central Burkina Faso using a split-plot design. Soil characteristics, chlorophyll fluorescence and crop growth and yield were measured to quantify the effect of *P. biglobosa* on the crops and their environment. The experiment ran during 2 years. *P. biglobosa* suppressed the vegetative growth and yield of pearl millet in both years. Eggplant and chili pepper were severely injured by the rains and produced fruits only during the first year. Eggplant yields were suppressed by trees to between one third and one tenth of the yield in the control plots. However, chili pepper yields increased by up to 150% when grown under the tree canopy compared to the control. In both years, the vegetative growth and yield of taro was higher when grown in the shade than outside the tree canopy.

Miah *et al.,* (2008) conducted a field experiment to investigate the growth and yield performance of tomato under eight years old Sissoo and three years old Ghora neem trees. The treatments were two timber species i.e T_2: Ghoraneem (*Melia azedarach*) and T_3: Sissoo (*Dalbergia sissoo*) with one control plot (T_1: open field). Except plant height all the growth and yield contributing characters of tomato showed the highest values under open field followed by ghoraneem. Under sissoo significantly tallest plant (12.3 cm) was recorded but all other parameters were found significantly lowest. The study revealed that tomato can easily be grown under three years ghoraneem orchard without significant yield loss although open field produced the highest yield (71.11 t ha^{-1}) eight years sissoo orchard should not be allowed for tomato production as the yield under sissoo was severely poor.

Gold and Hanover, (1987) studied that historical development of a permanent agriculture system based on the use of agroforestry in the temperate zone is traced. In general, reasons for a renewed interest in agroforestry include the end of cheap, subsidized fossil fuels; increased concern about soil erosion and marginal land use; an international awakening as to the dangers of indiscriminate use of pesticides, herbicides and other chemicals; and a need to balance food production with other land uses. For the forestry profession in particular, reasons for interest in agroforestry stem from a need to revitalize rural economies, the desire to increase timber exports, and potential resolution to land use conflicts between agriculture and forestry. Through use of agroforestry management systems, an increase in both economic and silvicultural benefits are obtainable.

In Tamil Nadu, India, Madhu *et al., (*2005) conducted a field experiment to study the effect of lopping on biomass production of *Eucalyptus globulus* and yield of potato and oats in agroforestry system. Trees which were not lopped up to the 10th year produced the highest total biomass of 436.63 t/ha whereas those lopped in alternate years and every year from the 4th year produced 218.29 and 140.76 t/ha, respectively. The reduction in intercrop yield of potato was 12.4-15.6% in agroforestry system as compared to sole crop but potato was the most profitable option, and, therefore, recommended for higher production, profitability and protection of sloping lands in the Nilgiri hills, the results was collaborating in another fimdings.

2.5 Spice Based Agroforestry System

Pramila and Singh*,* (2016) conducted a field experiment to evaluate the effect of poplar based agroforestry system and open system (without poplar) on yield of different wheat varieties and soil physio-chemical properties. The experiment was laid out in randomized block design with 4 treatments and each replicated thrice under both the growing conditions. The crop treatments are wheat varieties viz. UP-2572, PBW-550, DBW-711 and PBW-373. The highest grain yield of all the wheat varieties was obtained under open farming system. Highest grain yield of wheat was recorded in UP-2572 under open farming system. Agroforestry is proven land use system for vertically enhancing soil health against unsuitable weather condition. The distribution of soil properties was detected from the depth 0-15 cm in poplar based agroforestry system and as well as in open system. During the experiment it was found that agroforestry adds more nutrients to the soil compared to open system.

Khan *et al.,* (2015) experimented that turmeric is grown as medicinal plant in Pakistan whereas mulberry is cultivated mainly for silkworm rearing. The study was conducted to assess the potential of turmeric varieties as intercrop with mulberry. Turmeric intercropping with mulberry plantation was grown to evaluate four varieties and planting distance of turmeric rhizomes on the basis turmeric yield performance. Three planting distances (20, 40 and 60 cm) for each variety were maintained with three replications in Randomized Complete Block Design. The results showed that turmeric yield was higher when grown with 40 cm planting distance. The comparative performance of varieties indicated that Kesari was the best variety with respect to yield tons/ha (50.33 ± 2.517) to be grown with mulberry as an intercrop with planting distance of 40 cm. Kasturi and CA69 having medium duration growth habit are suitable for cultivation as intercrop with mulberry. The study emphasizes that mulberry plantations may be intercropped with turmeric to harvest the maximum potential of resources.

Hossain *et al.,* (2009) studied that the effects of relative light intensity (RLI) on the growth, yield and curcumin content of turmeric (*Curcuma longa* L.) were examined in Okinawa, Japan. The plants were shaded with white nets with different mesh sizes for maintaining respective RLI. Five RLI, 100 (without shading), 82, 79, 73 and 59% in 2004–2005 and four RLI, 100, 68, 52 and 48% in 2005–2006 were evaluated. In the first experiment, plant height increased markedly, but the number of leaves and tillers, and SPAD value increased slightly in the plants grown at 59–82% RLI compared with control (without shading). Turmeric shoot biomass and yield increased significantly at 59–82% RLI and they were highest at 73% RLI in the first experiment. Curcumin content of turmeric increased markedly at 59–73% RLI as compared with the control in the first experiment. Similar results in plant growth, shoot biomass, yield and curcumin content were obtained in the second experiment, but the effects of RLIs were smaller than in the first experiment because of late planting. This study indicates that turmeric is a partial shade-tolerant plant that could be cultivated at around 59–73% RLI for higher yield and curcumin content in Okinawa. However, the degree of RLI required for better turmeric cultivation may vary with the place, year and irradiance level.

Bahadur *et al*., (2000) conducted a field experiment to study the effect of different spacing (50 cm x 20 cm, 50 x 30 cm and 50 x 40 cm) and K_2O

rate (0, 40, 75, 120 and 150 Kg ha G1) on the growth, dry matter, production and yield of turmeric (*Curcuma longa* L.). Close spacing produced the tallest plants (87.89 cm), medium spacing produced the plants (87.89 cm), medium spacing produced the plants with the highest finger breadth (6.95 cm) and primary finger per plant (2.71) while wide spacing produced with the highest number of tillers per hill (3.42), leaves per plant (8.56), total dry weight per plant (53.79 g) and highest yield per plant (189.35 g). But total yield (t ha G_1) was highest with close spacing. Almost all of the characters studied showed increasing trend with increasing rate of potassium and the highest yield (15.4 t ha G_1) was obtained with 120 Kg ha G_1K_2O. The interaction effect of spacing and potassium exhibited insignificant variation in most of the characters.

Narain *et al.,* (1997) conducted a field experiment. The plots were planted with *Leucaena leucocephala* and Eucalyptus hybrid, either as block plantation or in alley farming with maize *(Zea mays*), *Chrysopogon fulvus* grass or turmeric (*Curcuma longa*). The runoff and soil loss were reduced by 27% and 45% by contour cultivation of maize. Contour tree-rows or *leucaena* hedges reduced the runoff and soil loss by 40% and 48%, respectively, over the maize plot, reducing soil loss to about 12.5 Mg ha^{-1}. Such vegetative measures, that are productive while being protective, offer viable alternative for erosion control in areas with gentile slopes of the valley region. High density block plantations of eucalyptus and *leucaena* almost completely controlled erosional losses and can be recommended for steeper slopes that are vulnerable to heavy erosion.

Das *et al.,* (2011) conducted an intercropping trial during 2007–2010 on 6-year-old aonla (*Emblica officinalis Gaertn.*; cv. NA-7) orchard planted at 6 m × 6 m spacing and growing under rainfed calciorthent soil, to identify the suitable and profitable intercrops. The intercrops grown were turmeric, ginger and arbi. The results indicated that the production of fruits significantly increased due to intercrops and it was maximum in aonla in association with turmeric (13.30 tonnes/ha) followed by arbi (11.71 tonnes/ha). On the other hand, reduction in yield of intercrops was

7.5–12.0% for turmeric, 12.2–19.3% for ginger and 15.7–25.3% for arbi compared to the yield in open area without trees.

2.6 Chili Based Agroforestry System

Islam *et al*., (2008) conducted a field experiment to evaluate the performance of seven winter vegetables under coconut-lemon based multistrata system Tomato, chili, carrot, onion, garlic, turnip and french bean were the tested vegetables under two treatments namely multistrata system T1 (Lemon + Coconut based, 35-50% reduced Photosynthetic Active Radiation (PAR)) and full sunlight condition T0 (100% PAR). There were significant variations in respect of plant height of winter vegetables (except chili and turnip) under shade condition. On the other hand, significantly highest yield per plot and yield per hectare were observed when plant grown under full sunlight condition. Moreover, the economic analysis showed that among the seven vegetables carrot gave the highest economic return (108,937 Tk./ha) followed by chili (95295 Tk./ha) under multristrata (Lemon + Coconut) agroforestry system. Therefore, production of winter vegetables especially carrot and chili under multistrata agroforestry systems are economically profitable than sole production systems.

Chakraborti, (2000) stated that the effectiveness of some neem (*Azadirachta indica*)-based treatments on the management of three species, viz., *Aphis gossypii, Scirtothrips dorsalis* and yellow mite, *Hemitarsonemus latus* [*Polyphagotarsonemus latus*], which acted as vectors of chili leaf curl virus in red chili (*Capsicum annuum*). All the integrated treatments effectively checked the populations of the vector species, kept their populations at low levels, sponsored good yield and were superior to chemical check (sprays of phosphamidon at 15-day intervals) which afforded poor control of thrips and mites at 40 days after treatment (DAT). All the integrated treatments, without or with the inclusion of one spray of phosphamidon at 45 DAT, also appeared to be safe to natural enemies; coccinellid and syrphid predators, whereas chemical check caused drastic reduction in their populations.

Mutanal *et al*., (2009) conducted a long term experiment on agroforestry involving arable crops (sorghum, groundnut, chili and ragi), silvicultural crop (teak), horticultural crop (papaya) and pasture crops (subabul and guinea grass) was initiated during 1984 on red gravelly soils at Dharwad (Karnataka). Teak was planted at 10 m and 20 m apart with 2 m between plants. In between two teak plants a papaya seedling was planted. On either side of teak+papaya row, grass slips and subabul seedlings were planted. Of the 4 arable crops, one crop was grown each year in fixed rotation in the interspaces of teak rows from 1994-2005. Grain yield of arable crops was higher in 20 m alley of teak + papaya rows as compared to 10 m alley of teak + papaya. Among the four crops, average grain yields were obtained in the order of sorghum > groundnut > ragi > chili with teak. Net returns were in the order of groundnut > sorghum > ragi > chili. During 1984-93 and sorghum > groundnut > ragi > chili during 1994-2001. Groundnut and sorghum crops realized stable yields and returns as compared to chili or ragi. Grain yields were significantly higher in teak + papaya as compared to teak + papaya + grass or subabul.

2.7 Economics of Agroforestry System

Kassa, (2015) studied that Fruit-tree based agroforestry represents a more environmentally friendly system, the economic returns and adoption determinants of which have only been modestly studied to date. This study investigated the determinants of practicing fruit-tree based agroforestry and the associated costs incurred and returns earned by practitioners. It contrasted the economic performance of agroforestry based systems versus monocropping systems using economic performance indicators at the household level in Wondo District. Data were collected from 149 selected households through structured interviews, focus group discussions, key informant interviews, market assessments as well as field observation. Variables including nearness to the main road, farming experience, labor, landsize and income significantly affected the practice of fruit tree based agroforestry system. Attention is needed in the design of policies and strategies for promoting the fruit-tree based agroforestry system which is more attractive financially, in addition to being labor saving and less risky investment than the monocropping systems.

CHAPTER 3

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

3.1.2 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 5.1. The details soil properties are presented in Appendix-I.

3.1.3 Climate

The experimental site was situated under the tropical climate characterized by heavy rainfall from July to August and scanty rainfall the rest period of the year. Monthly maximum and minimum temperatures, rainfall and relative humidity recorded during the experimental period (October, 2016 to March, 2017) are included in the Appendix-II.

3.2 Experimental Period

Duration of the experiential period was from October, 2016 to March, 2017.

3.3 Seed Collections

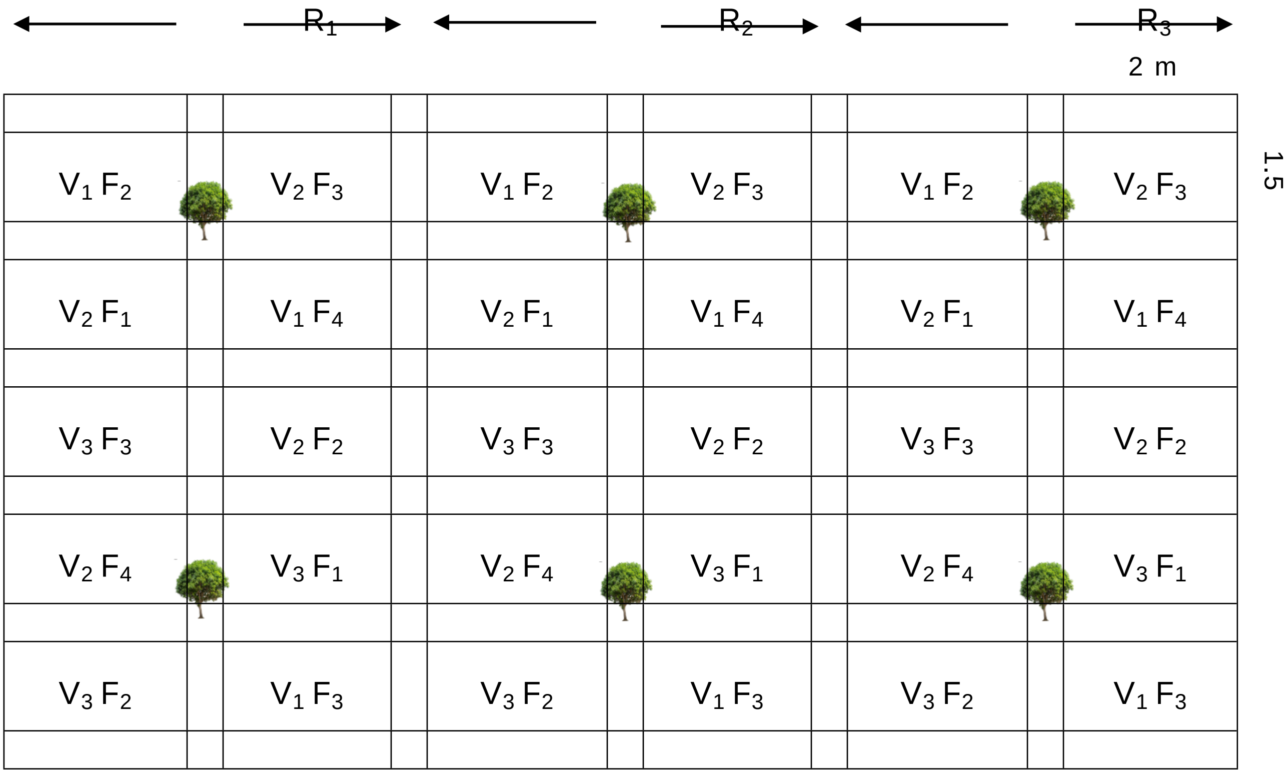
Chili seeds were collected from Bangladesh Agricultural Development Corporation (BADC), Dinajpur, Bangladesh.

3.4 Raising of Seedlings

Seedling was raised in seedbed of Departmental Research Field of Agroforestry and Environment. 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 each three varieties of chili (Hybrid, Kajli and Shity) were sown in the seed bed on 15 September, 2016. Seedlings germinated on 20 September, 2016.

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 2m x 1.5m. So the total area of each plot was 3m^2.



$V_1 F_1$		$V_3 F_4$		$V_1 F_1$		$V_3 F_4$		$V_1 F_1$		$V_3 F_4$

Fig 1: Field Layout

3.6 Experimental Treatments

The experiment consisted of two factors;

Factor –A: (Varieties)

V_1= Hybrid

V_2= Kajli

V_3=Shity

Factor- B (Fertilizer & Manure Applications)

F_1= No fertilizer, no manure & no pesticide

F_2= Cow-dung manure and neem oil sprayed as bio-pesticide

F_3= Poultry manure and neem oil sprayed as bio-pesticide

F_4= Recommended chemical fertilizer & chemical pesticide

Treatments combinations:

V_1F_1 = Hybrid + No fertilizer, no manure & no pesticide

V_2F_1= Kajli + No fertilizer, no manure & no pesticide

V_3F_1= Shity + No fertilizer, no manure & no pesticide

V_1F_2= Hybrid + Cow-dung manure and neem oil sprayed as bio-pesticide

V_2F_2= Kajli + Cow-dung manure and neem oil sprayed as bio-pesticide

V_3F_2= Shity + Cow-dung manure and neem oil sprayed as bio-pesticide

V_1F_3= Hybrid + Poultry manure and neem oil sprayed as bio-pesticide

V_2F_3= Kajli + Poultry manure and neem oil sprayed as bio-pesticide

V_3F_3= Shity + Poultry manure and neem oil sprayed as bio-pesticide

V_1F_4= Hybrid + Recommended chemical fertilizer & chemical pesticide

V_2F_4= Kajli + Recommended chemical fertilizer & chemical pesticide

V_3F_4= Shity + Recommended chemical fertilizer & chemical pesticide

3.7 Characteristics of Mango

Scientific name: *Mangifera indica L.*

Family: Anacardiaceae (cashew family)
Distribution: All tropical and subtropical regions. It has been grown throughout tropical and subtropical world for thousands of years and has become integral part of many cultures. There are many different names for mangoes around the world today it reflects the cultures and languages spoken by people who grow them. Many of the names for have common derivations, reflecting the origins and spread of the mango tree along with the spread of human communities.

Botanic Description
Mango is long-lived evergreen trees that can reach heights of 15-30 m (50100ft). Most cultivated mango trees are between 3 and 10 m (10-33) tall when fully mature depending on the variety and the amount of pruning. Wild non-cultivated seedling trees often reach 15 m (50) when found in favorable climates, and they can live for over 100years and develop trunk girths of over 4m (13ft). Grows from sea level to1200m (3950ft) tropical latitudes; however, most commercial varieties are grown below 600m (1950ft); rainfall 400-3600mm (16-140in), fruits best with a well-defined winter dry period.

Mango trees typically branch 0.6-2 m (2-6.5 ft) above the ground and develop evergreen, dome-shaped Mango grown in heavily forested areas branch much higher than solitary trees and have an umbrella-like form. The Mango has a long taproot that often branches just below ground level, forming between two and four major anchoring taproots that can reach 6 m (20 ft) down to the water table. Fast, >1.5 m/yr (5 ft/yr) in ideal conditions. The details of mango tree were:

Planting orientation : North-South

Mango variety : Amropali

Age of mango tree : 7 years

Spacing : 6m x 6m

Average plant : 6.11m

Average canopy diameter : 255.6cm

Main agroforestry uses: Home gardens, silvopasture.

Main uses: Fruit, flavoring, medicinal, timber.

3.8 Land Preparation

The land of experimental plot was opened in the first week of September 2016 with a power tiller and it was made ready for planting on 4 October 2016. 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 4 October 2016 fertilizers and manures were applied. The fertilizers and manures were applied as per the treatments. Poultry manure and cow-dung applications rate was 5t/ha and 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 and poultry 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 15 October, 2016. In each plot there were 15 plants. The spacing was 50cm x 40cm. 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 chili 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 chili 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 chili 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 chili 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, poultry were applied. In the plots of cowdung and poultry, neem oil (2%) was sprayed against pathogen infestation.

3.13 Harvesting Chili Fruits

Fruits were harvested before ripening stage when they were fully matured. Harvesting was started on 6th February, 2017 and completed by 28 March 2017. 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. Ten plants were selected at random from each unit plot to collect experimental data. The plants in the outer rows and at the extreme end of the two middle rows were excluded to avoid the border effects. 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 30, 45, 60, 75 and 90 DAT. Height was measured by using centimeter scale from the soil surface to the tip of the plant.

3.14.2 Leaf length (cm)

The length of the leaf was obtained with the help of centimeter scale at 30, 45, 60, 75 and 90 DAT.

3.14.3 Leaf breadth (cm)

The breadth of the leaf was obtained with the help of centimeter scale at 30, 45, 60, 75 and 90 DAT.

3.14.4 Number of leaves per plant

It was recorded with at an interval of 15 days starting from 30, 45, 60, 75 and 90 DAT.

3.14.5 Number of shoots per plant

It was recorded at 30, 45, 60, 75 and 90 DAT.

3.14.6 Number of fruits per plant

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

3.14.7 Weight of fruits per plant (g)

It was recorded at the time of final harvest.

3.14.8 Total number of fruits per plot

It was recorded at the time of final harvest.

3.14.9 Total weight of fruits per plot (kg)

It was recorded at the time of final harvest.

3.14.10 Yield of fruits (ton/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.

3.14.11 Fruit number yield (t/ha)

This fruit number yield 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.

3.14.12 Fruit length (cm)

It was recorded 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.

3.14.13 Fruit breadth (cm)

It was recorded 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.

3.14.14 Dry matter contents (%) of fruits

A sample weight (100g) of freshly harvested chili fruits was taken and air-dried in the laboratory. Air-dried sample was then oven dried for 48 hours at $70^0C \pm 2\ ^0C$ in an oven. After drying it was weighted in an electric balance having a sensitivity of 0.1mg.

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 litchi sapling was included in this study. The management cost of litchi 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 potato tuber 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 (ANOVA) “Analysis of Variance” technique with the help of the computer package MSTAT-C. The mean differences were adjudged by the DMRT test (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter represents the result of the screening of three chili varieties with fertilizer and manure applications under mango based agroforestry system are presented in Table 1 to 22 and Figure 1 to 7. The findings of the study and interpretation of the result 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 Variety on Growth, Yield Contributing Characters and Yield of Chili

4.1.1 Plant height (cm)

By measuring plant height growth performance of a plant can be considered. Plant height of chili was recorded from the ground surface to the tip of the leaf in 10 plants of all the treatments. At different days after transplanting (DAT), plant height of chili was found significantly varied with different treatments (Table 1). At 30 DAT, the highest plant height (11.16cm) was obtained from the variety Shity (V_3) which was significantly followed by the variety Kajli (V_2). On the other hand, lowest plant height (10.49cm) was obtained from the variety Hybrid (V_1). At 45 DAT, the highest plant height (13.70 cm) was obtained from the variety Kajli (V_2) which was significantly followed by the variety Shity (V_3) whereas the lowest plant height (12.43) was observed from the variety Hybrid (V_1). At 60 DAT, highest plant height (22.95 cm) was recorded from the variety Kajli (V_2) and the lowest plant height (17.96cm) was observed from the variety Hybrid (V_1). At 75 DAT, the highest plant height (36.65 cm) was obtained from the variety Kajli (V_2), whereas the lowest plant height (28.06cm) was observed from the variety Hybrid (V_1). At 90 DAT, the highest plant height (54.77cm) was obtained from the variety Kajli (V_2), whereas the lowest plant height (40.17cm) was observed from the variety

Hybrid (V_1). The result is partially similar with the findings of Islam *et al.* (2008).

Table 1. Main effect of variety on plant height of chili plant at different DAT.

Treatments (variety)	Plant height (cm)				
	30DAT	45DAT	60DAT	75DAT	90DAT
Hybrid (V_1)	10.49 b	12.43 b	17.96 c	28.06 c	40.17 c
Kajli (V_2)	10.85 ab	13.70 a	22.95 a	36.65 a	54.77 a
Shity (V_3)	11.16 a	13.60 a	20.53 b	32.38 b	45.42 b
CV(%)	5.28	5.77	7.73	7.19	5.53

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 DMRT) at 5% level of probability.

4.1.2 Leaf length (cm)

At different days after transplanting (DAT), leaf length of chili was found significantly varied with different treatments (Table 2). At 30 DAT, the highest leaf length (4.56 cm) was obtained from the variety Kajli (V_2). On the other hand, lowest leaf length (3.66 cm) was obtained from the variety Shity (V_3). At 45 DAT, the highest leaf length (5.30 cm) was obtained from the variety Kajli (V_2), whereas the lowest leaf length (4.52 cm) was observed from the variety Hybrid (V_1). At 60 DAT, highest leaf length (6.77 cm) was recorded from the variety Kajli (V_2) and the lowest leaf length (5.46 cm) was observed from the variety Shity (V_3). At 75 DAT, the highest leaf length (6.97 cm) was obtained from the variety Kajli (V_2), whereas the lowest leaf length (6.34 cm) was observed from the variety Shity (V_3). At 90 DAT, the highest leaf length (7.98 cm) was obtained from the variety Kajli (V_2), whereas the lowest leaf length (6.71 cm) was observed from the variety Shity (V_3). The result is partially similar with the findings of Islam *et al*. (2008). This might be due to the genetic variation among the varieties.

Fig 2: Sizes of leaves in different chili varieties.

Table 2. Main effect of variety on leaf length of chili plant at different DAT.

Treatments (variety)	Leaf length (cm)				
	30DAT	45DAT	60DAT	75DAT	90DAT

Hybrid (V_1)	3.96 b	4.52 b	6.08 b	6.48 b	7.74 b
Kajli (V_2)	4.56 a	5.30 a	6.77 a	6.97 a	7.98 a
Shity (V_3)	3.66 c	4.67 b	5.46 c	6.34 c	6.71 c
CV(%)	6.15	3.77	1.34	0.96	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 DMRT) at 5% level of probability.

4.1.3 Leaf breadth (cm)

Leaf breadth of chili plant was found significantly varied with different treatments (Table 3) under mango based agroforestry system. At 30 DAT, the highest leaf breadth (1.93cm) was obtained from the variety Kajli (V_2). On the other hand, lowest leaf breadth (1.48cm) was obtained from the variety Shity (V_3). At 45 DAT, the highest leaf breadth (2.10cm) was obtained from the variety Kajli (V_2), whereas the lowest leaf breadth (1.87 cm) was observed from the variety Shity (V_3). At 60 DAT, the highest leaf breadth (2.36cm) was recorded from the variety Kajli (V_2) and the lowest leaf breadth (1.94 cm) was observed from the variety Hybrid (V_1). At 75 DAT, the highest leaf breadth (2.47 cm) was obtained from the variety Kajli (V_2), whereas the lowest leaf breadth (2.10cm) was observed from the variety Hybrid (V_1). At 90 DAT, the highest leaf breadth (2.80cm) was obtained from the variety Kajli (V_2), whereas the lowest leaf breadth (2.359 cm) was observed from the variety Hybrid (V_1). This happened due to varietal characteristics.

Table 3. Main effect of variety on leaf breadth of chili plant at different DAT.

Treatments	Leaf breadth (cm)

(variety)	30DAT	45DAT	60DAT	75DAT	90DAT
Hybrid (V_1)	1.73 b	1.88 b	1.94 c	2.10 c	2.36 c
Kajli (V_2)	1.93 a	2.10 a	2.36 a	2.47 a	2.80 a
Shity (V_3)	1.48 c	1.87 b	2.10 b	2.24 b	2.56 b
CV(%)	6.85	2.30	2.67	2.22	2.42

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 DMRT) at 5% level of probability.

4.1.4 Number of leaf/plant

Number of leaf/plant of chili was found significantly varied with different treatments (Table 4), at 45 DAT, 75 DAT and 90 DAT. But at 30 DAT and 60 DAT there was no significant variation among the variety. At 30 DAT, the highest number of leaf/plant (10.68) was obtained from the variety Hybrid (V_1). On the other hand, lowest number of leaf/plant (10.13) was recorded from the variety Kajli (V_2). At 45 DAT, the highest number of leaf/plant (16.64) was obtained from the variety Hybrid (V_1), whereas the lowest number of leaf/plant (16.25) was observed from the variety Shity (V_3). At 60 DAT, the highest number of leaf/plant (28.40) was recorded from the variety Hybrid (V_1) and the lowest number of leaf/plant (27.23) was observed from the variety Kajli (V_2). At 75 DAT, the highest number of leaf/plant (56.59) was found from the variety Kajli (V_2), whereas the lowest number of leaf/plant (41.06) was observed from the variety Shity (V_3). At 90 DAT, the highest number of leaf/plant (90.13) was obtained from the variety Kajli (V_2), whereas the lowest number of leaf/plant (64.93) was observed from the variety Shity (V_3). This might be attribute due to the situation of cellular expansion and cell division of leaves under shaded condition (Schoch, 1972).

Table 4. Main effect of variety on number of leaf/plant of chili plant at different DAT.

Treatments (variety)	Number of leaf/plant				
	30DAT	45DAT	60DAT	75DAT	90DAT
Hybrid (V_1)	10.68	16.64 a	28.40	48.49 b	77.94 b
Kajli (V_2)	10.13	13.47 b	27.23	56.59 a	90.13 a
Shity (V_3)	10.25	16.25 a	27.26	41.06 c	64.93 c
CV(%)	8.64	12.57	9.82	9.77	13.91

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 DMRT) at 5% level of probability.

4.1.5 Number of shoot/plant

At different days after transplanting (DAT), number of shoot/plant of chili was found significantly varied with different treatments (Table 5). At 45 DAT, the highest number of shoot/plant (3.74) was obtained from the variety Kajli (V_2) which was significantly followed by the variety Hybrid (V_1). On the other hand, lowest number of shoot/plant (0.94) was obtained from the variety Shity (V_3). At 60 DAT, the highest number of shoot/plant (4.47) was recorded from the variety Kajli (V_2) which was significantly followed by the variety Hybrid (V_1). On the other hand, lowest number of shoot/plant (1.21) was obtained from the variety Shity (V_3). At 75 DAT, the highest number of shoot/plant (4.88) was observed from the variety Kajli (V_2) which was significantly followed by the variety Hybrid (V_1). On the other hand, lowest number of shoot/plant (1.80) was obtained from the variety Shity (V_3). At 90 DAT, the highest number of shoot/plant (4.95) was obtained from the variety Kajli (V_2) which was significantly followed by the variety Hybrid (V_1). On the other hand, lowest number of shoot/plant

(1.88) was obtained from the variety Shity (V_3). The result is partially similar with the findings of Islam *et al*. (2008).

Table 5. Main effect of variety on number of shoot/plant of chili.

Treatments (variety)	Number of shoot/plant			
	45DAT	60DAT	75DAT	90DAT
Hybrid (V_1)	3.68 a	4.24 a	4.84 a	4.94 a
Kajli (V_2)	3.74 a	4.47 a	4.88 a	4.95 a
Shity (V_3)	0.94 b	1.21 b	1.79 b	1.88 b
CV(%)	10.04	8.78	6.34	6.07

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 DMRT) at 5% level of probability.

4.1.6 Number of fruit/plant

The number of fruit/plant of chili was found significantly varied with different treatments (Table 6). The maximum number of fruit/plant (114.4) was obtained from the variety Kajli (V_2). On the other hand, minimum number of fruit/plant (40.58) was obtained from the variety Shity (V_3).

4.1.7 Weight of fruit/plant (g)

The Weight of fruit/plant of chili was found significantly varied with different treatments (Table 6). The highest weight of fruit/plant (254.4 g) was observed from the variety Kajli (V_2). On the other hand, lowest weight of fruit/plant (117.3 g) was obtained from the variety Shity (V_3).

4.1.8 Total Number of fruit/plot

The total number of fruit/plot of chili was found significantly varied with different treatments (Table 6). The maximum total number of fruit/plot

(1740) was obtained from the variety Kajli (V_2). On the other hand, minimum total number of fruit/plot (642.4) was obtained from the variety Shity (V_3).

4.1.9 Total weight of fruit/plot (kg)

The total weight of fruit/plot of chili was found significantly varied with different treatments (Table 6). The highest total weight of fruit/plot (3.87 kg) was observed from the variety Kajli (V_2). On the other hand, lowest total weight of fruit/plot (1.65 kg) was obtained from the variety Shity (V_3).

Table 6. Main effect of variety on the yield contributing characters of chili.

Treatments (variety)	Number of fruit/plant	Weight of fruit/plant (g)	Total number of fruit/plot	Total weight of fruit/plot (kg)	Fruit length (cm)	Fruit breadth (cm)
Hybrid (V_1)	46.58 b	208.4 b	746.8 b	2.99 b	8.39 b	0.97 a
Kajli (V_2)	114.4 a	254.4 a	1740 a	3.87 a	7.42 c	0.87 b
Shity (V_3)	40.58 c	117.3 c	642.4 c	1.65 c	9.73 a	0.69 c
CV(%)	9.66	6.87	2.42	4.80	8.25	10.92

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 DMRT) at 5% level of probability.

4.1.10 Fruit length (cm)

Fruit length of chili was found significantly varied with different treatments (Table 6). The highest fruit length (9.73 cm) was obtained from the variety Shity (V_3). On the other hand, lowest fruit length (7.42 cm) was recorded from the variety Kajli (V_2). This happened due to the varietal characteristics.

4.1.11 Fruit breadth (cm)

Fruit breadth of chili plant was found significantly varied with different treatments (Table 6) under mango based agroforestry system. The highest fruit breadth (0.97 cm) was found from the variety Hybrid (V_1). On the other hand, lowest fruit breadth (0.69 cm) was obtained from the variety Shity (V_3). This may be happened due to the varietal characteristics.

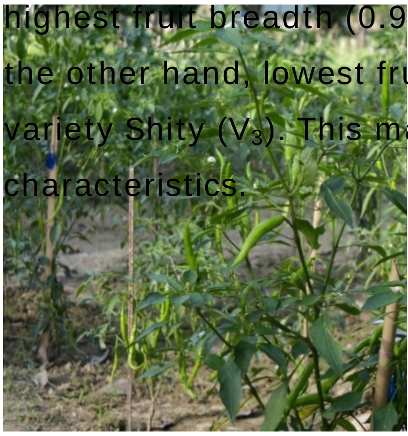


Fig 3: Fruit sizes of chili varieties like Hybrid, Kajli and Shity.

4.1.12 Fruit number yield (t/ha)

The fruit number yield of chili was found significantly varied with different treatments (Table 7). The maximum fruit number yield (5801 t/ha) was obtained from the variety Kajli (V_2). On the other hand, minimum fruit number yield (2141 t/ha) was recorded from the variety Shity (V_3).

Table 7. Main effect of variety on the yield contributing characters of chili.

Treatments (variety)	Fruit number yield (t/ha)	% dry weight of fruit
Hybrid (V_1)	2406 b	10.15 c
Kajli (V_2)	5801 a	10.69 b
Shity (V_3)	2141 c	12.57 a
CV(%)	5.53	3.71

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 DMRT) at 5% level of probability.

4.1.13 Percent dry weight of fruit

Percent dry weight of fruit of chili was found significantly varied with different treatments (Table 7). The highest % dry weight of fruit (12.57) was found from the variety Shity (V_3). On the other hand, lowest % dry weight of fruit (10.15) was obtained from the variety Hybrid (V_1).

4.1.14 Yield (ton/ha)

The yield of chili (ton/ha) was significantly affected by the different varieties (fig. 4). The highest fruit yield (12.99 ton/ha) was recorded from the variety Kajli (V_2). On the other hand, lowest fruit yield (5.49 ton/ha) was obtained from the variety Shity (V_3). The result is partially similar with the findings of Islam *et al*. (2008). This might be due to the varietal characteristics among the varieties.

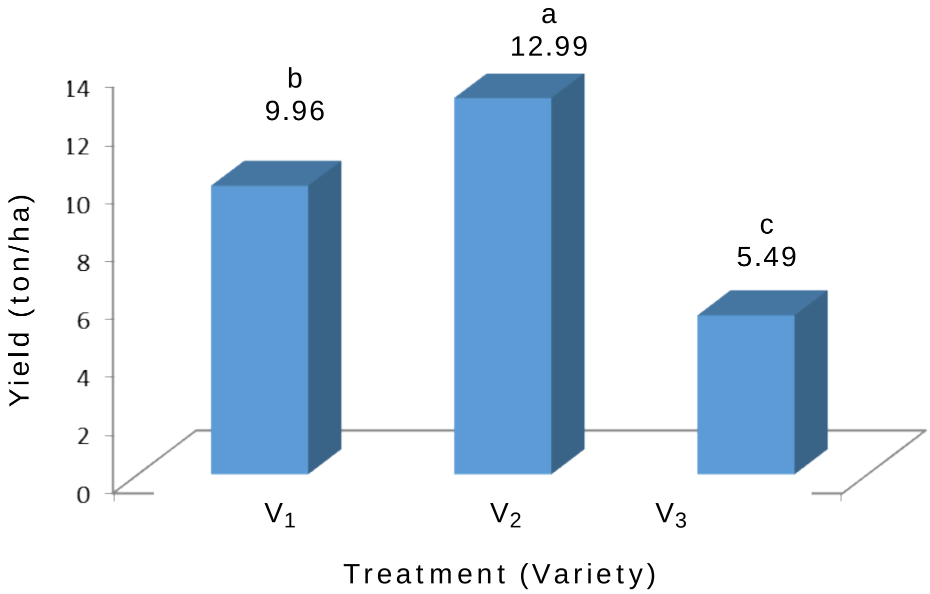


Figure 4: Main effect of variety on yield of chili

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

4.2.1 Plant height (cm)

By measuring plant height growth performance of a plant can be considered. Plant height of chili was recorded from the ground surface to the tip of the leaf in 10 plants of all the treatments. At different days after transplanting (DAT), plant height of chili was found significantly affected due to the applications of different fertilizer and manure (Table 8). At 30 DAT, the highest plant height (12.02 cm) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest plant height (9.63 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 45 DAT, the highest plant height (15.01 cm) was recorded from the plot where chemical fertilizer (F_4) was applied. Whereas, lowest plant height (11.22 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 60 DAT, the highest plant height (24.56 cm) was obtained from the plot where chemical fertilizer (F_4) was applied and lowest plant height (16.29 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 75 DAT, the highest plant height (40.69 cm) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest plant height (24.47 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 90 DAT, the highest plant height (55.68 cm) was obtained from the plot where chemical fertilizer (F_4) was applied and lowest plant height (37.99 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. This result is also agreed by Islam *et al*. (2017) and Heeb *et al*. (2006).

Table 8. Main effect of fertilizer and manure applications on plant height of chili plant at different DAT.

Treatments (fertilizer and manure applications)	Plant height (cm)				
	30DAT	45DAT	60DAT	75DAT	90DAT
No fertilizer (F_1)	9.63 d	11.22 d	16.29 c	24.47 d	37.99 d
Cow-dung (F_2)	10.35 c	12.93 c	19.88 b	29.81 c	43.85 c
Poultry manure (F_3)	11.33 b	13.82 b	21.20 b	34.49 b	49.62 b
Chemical fertilizer (F_4)	12.02 a	15.01 a	24.56 a	40.69 a	55.68 a
CV(%)	5.28	5.77	7.73	7.19	5.53

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 DMRT) at 5% level of probability.

4.2.2 Leaf length (cm)

At different days after transplanting (DAT), leaf length of chili was found significantly affected due to the applications of different fertilizer and manure (Table 9). At 30 DAT, the highest leaf length (4.66 cm) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest leaf length (3.44 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 45 DAT, the highest leaf length (5.35 cm) was recorded from the plot where chemical fertilizer (F_4) was applied. Whereas, lowest leaf length (4.11 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 60 DAT, the highest leaf length (6.60 cm) was obtained from the plot where chemical fertilizer (F_4) was applied and lowest leaf length (5.60 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 75 DAT, the highest leaf length (7.18 cm) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest leaf length (5.88 cm) was obtained from the plot where no fertilizer (F_1) was applied.

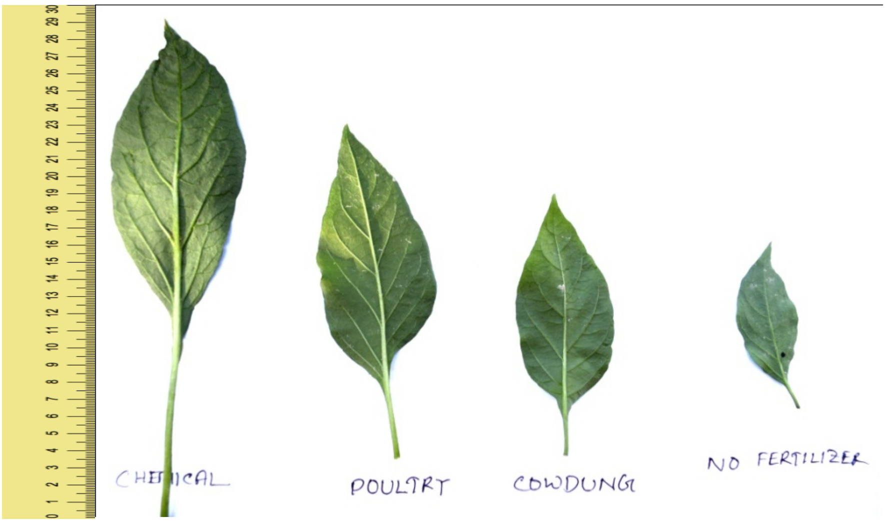


Fig 5: Sizes of leaves in different fertilizer and manure applications.

Table 9. Main effect of fertilizer and manure applications on leaf length of chili plant at different DAT.

Treatments (fertilizer and manure applications)	Leaf length (cm)				
	30DAT	45DAT	60DAT	75DAT	90DAT
No fertilizer (F_1)	3.44 d	4.11 d	5.60 d	5.88 d	6.75 d
Cow-dung (F_2)	3.92 c	4.76 c	5.98 c	6.47 c	7.46 c
Poultry manure (F_3)	4.23 b	5.11 b	6.22 b	6.86 b	7.66 b
Chemical fertilizer (F_4)	4.66 a	5.35 a	6.60 a	7.18 a	8.04 a
CV(%)	6.15	3.77	1.34	0.96	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 DMRT) at 5% level of probability.

At 90 DAT, the highest leaf length (8.04 cm) was obtained from the plot where chemical fertilizer (F_4) was applied and lowest leaf length (6.75 cm) was obtained from the plot where no fertilizer (F_1) was applied. The maximum leaf length was obtained from the plot where chemical fertilizer was applied because chemical fertilizer has instant capability to release nutrient than organic manure. This result is also agreed by Islam *et al*. (2017) and Heeb *et al*. (2006).

4.2.3 Leaf breadth (cm)

At different days after transplanting (DAT), leaf breadth of chili was found significantly affected due to the applications of different fertilizer and manure (Table 10). At 30 DAT, the highest leaf breadth (1.99 cm) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest leaf breadth (1.46 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 45 DAT, the highest leaf breadth (2.23 cm) was recorded from the plot where chemical fertilizer (F_4) was applied. Whereas, lowest leaf breadth (1.60 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 60 DAT, the highest leaf breadth (2.42 cm) was obtained from the plot where chemical fertilizer (F_4) was applied and lowest leaf breadth (1.81 cm) was obtained from the plot where no fertilizer (F_1) was applied.

Table 10. Main effect of fertilizer and manure applications on leaf breadth of chili plant at different DAT.

Treatments (fertilizer and manure applications)	Leaf breadth (cm)				
	30DAT	45DAT	60DAT	75DAT	90DAT
No fertilizer (F_1)	1.46 d	1.60 d	1.81 d	1.96 d	2.25 d
Cow-dung (F_2)	1.64 c	1.91 c	2.07 c	2.21 c	2.49 c

Poultry manure (F_3)	1.76 b	2.05 b	2.23 b	2.35 b	2.70 b
Chemical fertilizer (F_4)	1.99 a	2.23 a	2.42 a	2.56 a	2.85 a
CV(%)	6.85	2.30	2.67	2.22	2.42

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 DMRT) at 5% level of probability.

At 75 DAT, the highest leaf breadth (2.56 cm) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest leaf breadth (1.96 cm) was obtained from the plot where no fertilizer (F_1) was applied. At 90 DAT, the highest leaf breadth (2.85 cm) was obtained from the plot where chemical fertilizer (F_4) was applied and lowest leaf breadth (2.25 cm) was obtained from the plot where no fertilizer (F_1) was applied. The maximum leaf breadth was obtained from the plot where chemical fertilizer was applied because chemical fertilizer has instant capability to release nutrient than organic manure. This result is also agreed by Islam *et al*. (2017) and Heeb *et al*. (2006).

4.2.4 Number of leaf/plant

Number of leaf/plant of chili was found significantly affected due to the applications of different fertilizer and manure (Table 11). At 30 DAT, the highest number of leaf/plant (12.34) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest number of leaf/plant (8.57) was obtained from the plot where no fertilizer (F_1) was applied. At 45 DAT, the highest number of leaf/plant (18.79) was recorded from the plot where chemical fertilizer (F_4) was applied. Whereas, lowest number of leaf/plant (11.80) was obtained from the plot where no fertilizer (F_1) was applied. At 60 DAT, the highest number of leaf/plant (37.93) was obtained from the plot where chemical fertilizer (F_4) was applied and lowest number of leaf/plant (19.38) was obtained from the plot where no fertilizer (F_1) was applied.

Table 11. Main effect of fertilizer and manure applications on number of leaf/plant of chili plant at different DAT.

Treatments (fertilizer and manure applications)	Number of leaf/plant				
	30DAT	45DAT	60DAT	75DAT	90DAT
No fertilizer (F_1)	8.57 d	11.80 c	19.38 d	34.24 d	54.27 d
Cow-dung (F_2)	9.78 c	14.28 b	24.79 c	40.94 c	64.88 c
Poultry manure (F_3)	10.73 b	16.94 a	28.42 b	48.26 b	75.64 b
Chemical fertilizer (F_4)	12.34 a	18.79 a	37.93 a	71.41 a	115.9 a
CV(%)	8.64	12.57	9.82	9.77	13.91

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 DMRT) at 5% level of probability.

At 75 DAT, the highest number of leaf/plant (71.41) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest number of leaf/plant (34.24) was obtained from the plot where no fertilizer (F_1) was applied. At 90 DAT, the highest number of leaf/plant (115.9) was obtained from the plot where chemical fertilizer (F_4) was applied and lowest number of leaf/plant (54.27) was obtained from the plot where no fertilizer (F_1) was applied. The maximum number of leaf/plant was obtained from the plot where chemical fertilizer was applied. Because chemical fertilizer has instant capability to release nutrient than organic manure. This result is also agreed by Islam *et al*. (2017) and Heeb *et al*. (2006).

4.2.5 Number of shoot/plant

At different days after transplanting (DAT), number of shoot/plant of chili was found significantly affected due to the applications of different fertilizer and manure (Table 12). At 45 DAT, the highest number of shoot/plant (3.98) was recorded from the plot where chemical fertilizer

(F_4) was applied. Whereas, lowest number of shoot/plant (1.64) was obtained from the plot where no fertilizer (F_1) was applied. At 60 DAT, the highest number of shoot/plant (4.63) was obtained from the plot where chemical fertilizer (F_4) was applied and lowest number of shoot/plant (2.08) was obtained from the plot where no fertilizer (F_1) was applied.

Table 12. Main effect of fertilizer and manure applications on number of shoot/plant of chili.

Treatments (fertilizer and manure applications)	Number of shoot/plant			
	45DAT	60DAT	75DAT	90DAT
No fertilizer (F_1)	1.64 d	2.08 d	2.49 d	2.55 d
Cow-dung (F_2)	1.99 c	2.47 c	2.97 c	3.03 c
Poultry manure (F_3)	3.52 b	4.04 b	4.59 b	4.70 b
Chemical fertilizer (F_4)	3.98 a	4.63 a	5.30 a	5.42 a
CV(%)	10.04	8.78	6.34	6.07

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 DMRT) at 5% level of probability.

At 75 DAT, the highest number of shoot/plant (5.30) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest number of shoot/plant (2.49) was obtained from the plot where no fertilizer (F_1) was applied. At 90 DAT, the highest number of shoot/plant (5.42) was obtained from the plot where chemical fertilizer (F_4) was applied and lowest number of shoot/plant (2.55) was obtained from the plot where no fertilizer (F_1) was applied. The maximum number of shoot/plant was obtained from the plot where chemical fertilizer was applied. Because chemical fertilizer has instant capability to release nutrient than organic manure. This result is also agreed by Islam *et al*. (2017) and Heeb *et al*. (2006).

4.2.6 Number of fruit/plant

The number of fruit/plant of chili was found significantly affected due to the applications of different fertilizer and manure (Table 13). The maximum number of fruit/plant (96.02) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum number of fruit/plant (39.80) was obtained from the plot where no fertilizer (F_1) was applied.

4.2.7 Weight of fruit/plant (g)

The weight of fruit/plant of chili was found significantly affected due to the applications of different fertilizer and manure (Table 13). The maximum weight of fruit/plant (262.1g) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum weight of fruit/plant (116.8g) was obtained from the plot where no fertilizer (F_1) was applied.

4.2.8 Total Number of fruit/plot

The total no. of fruit/plot of chili was found significantly affected due to the applications of different fertilizer and manure (Table 13). The maximum total no. of fruit/plot (1329) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum total no. of fruit/plot (767.8) was obtained from the plot where no fertilizer (F_1) was applied.

4.2.9 Total weight of fruit/plot (kg)

The total weight of fruit/plot of chili was found significantly affected due to the applications of different fertilizer and manure (Table 13). The maximum total weight of fruit/plot (3.65 kg) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum total weight of fruit/plot (2.05 kg) was obtained from the plot where no fertilizer (F_1) was applied.

Table 13. Main effect of fertilizer and manure applications on the yield contributing characters of chili.

Treatments	Number	Weight	Total	Total	Fruit	Fruit

(fertilizer and manure applications)	of fruit/plant	of fruit/plant (g)	number of fruit/plot	weight of fruit/plot(kg)	length (cm)	breadth(cm)
No fertilizer (F_1)	39.80 d	116.8 d	767.8 d	2.05 d	7.61 c	0.69 c
Cow-dung (F_2)	62.06 c	177.9 c	859.9 c	2.32 c	8.23 bc	0.84 b
Poultry manure (F_3)	70.91 b	216.7 b	1215 b	3.32 b	8.86 ab	0.88 b
Chemical fertilizer (F_4)	96.02 a	262.1 a	1329. a	3.65 a	9.34 a	0.98 a
CV(%)	9.66	6.87	2.42	4.80	8.25	10.92

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 DMRT) at 5% level of probability.

4.2.10 Fruit length (cm)

The fruit length of chili was found significantly affected due to the applications of different fertilizer and manure (Table 13). The maximum fruit length (9.34 cm) was obtained from the plot where chemical fertilizer (F_4) was applied, which was significantly followed by plot where poultry manure (F_3) was applied. On the other hand, minimum fruit length (7.61 cm) was obtained from the plot where no fertilizer (F_1) was applied.

4.2.11 Fruit breadth (cm)

The fruit breadth of chili was found significantly affected due to the applications of different fertilizer and manure (Table 13). The maximum fruit breadth (0.98 cm) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum fruit breadth (0.69 cm) was obtained from the plot where no fertilizer (F_1) was applied.

4.2.12 Fruit number yield (t/ha)

The fruit no. yield of chili was found significantly affected due to the applications of different fertilizer and manure (Table 14). The maximum fruit number yield (4320 t/ha) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum fruit number yield (2559 t/ha) was obtained from the plot where no fertilizer (F_1) was applied.

Table 14. Main effect of fertilizer and manure applications on the yield contributing characters of chili.

Treatments (fertilizer and manure applications)	Fruit number yield (t/ha)	% dry weight of fruit
No fertilizer (F_1)	2559 d	9.86 d
Cow-dung (F_2)	2866 c	10.83 c
Poultry manure (F_3)	4051 b	11.47 b
Chemical fertilizer (F_4)	4320 a	12.40 a
CV(%)	5.53	3.71

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 DMRT) at 5% level of probability.

4.2.13 Percent dry weight of fruit

Percent dry weight of fruit of chili was found significantly affected due to the applications of different fertilizer and manure (Table 14). The maximum % dry weight of fruit (12.40) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum % dry weight of fruit (9.86) was obtained from the plot where no fertilizer (F_1) was applied.

4.2.14 Yield (ton/ha)

The yield of chili (ton/ha) was significantly affected due to the applications of different fertilizer and manure (fig.6). The highest fruit yield (12.16 ton/ha) was recorded from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest fruit yield (6.949 ton/ha) was obtained from the plot where no fertilizer (F_1) was applied. The maximum number yield was obtained from the plot where chemical fertilizer was applied because chemical fertilizer has instant capability to release nutrient than organic manure. This result is also agreed by Islam *et al*. (2017) and Heeb *et al*. (2006).

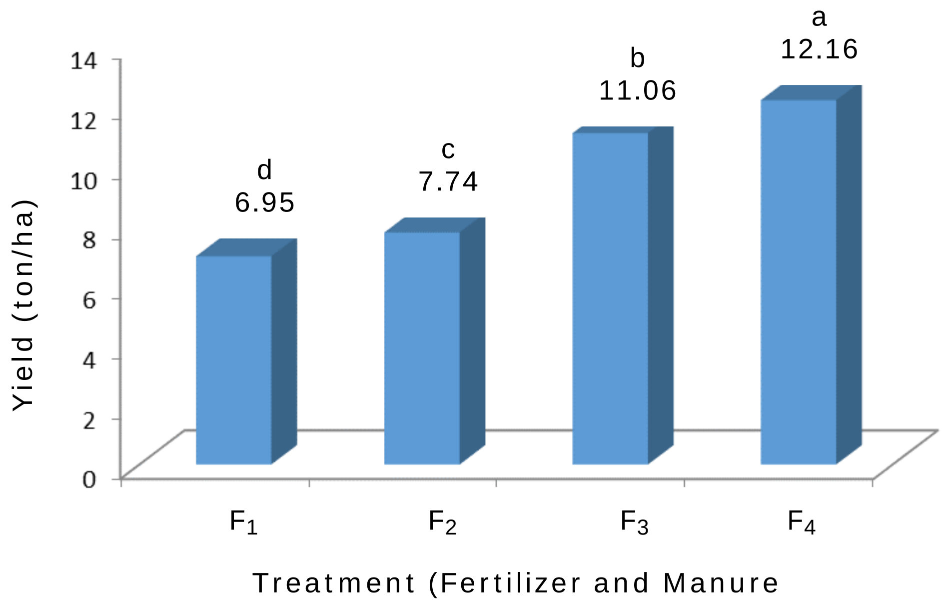


Figure 6: Main effect of fertilizer and manure applications on yield of chili

4.3 Interaction Effect of Variety and Fertilizer and Manure Applications on Growth, Yield Contributing Characters and Yield of Chili

4.3.1 Plant height (cm)

The interaction effect of variety and fertilizer & manure applications on the plant height of chili was found significantly different at different days after planting (Table 15). At 30 DAT, the highest plant height (12.75 cm) was obtained from the treatment V_3F_4 (Shity + chemical fertilizer) which is significantly followed by V_2F_4 (Kajli + chemical fertilizer). On the other hand, lowest plant height (9.32 cm) was obtained from the treatment V_2F_1 (Kajli + no fertilizer). At 45 DAT, the highest plant height (15.43 cm) was recorded from the treatment V_2F_4 (Kajli + chemical fertilizer) which is significantly followed by V_1F_4 (Hybrid + chemical fertilizer), V_2F_3 (Kajli + poultry) and V_3F_3 (Shity + poultry). Whereas, lowest plant height (10.98 cm) was obtained from the treatment V_2F_1 (Kajli + no fertilizer). At 60 DAT, the highest plant height (27.57 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) which is significantly followed by V_3F_4 (Shity + chemical fertilizer) and lowest plant height (14.77 cm) was obtained from the treatment V_1F_1 (Hybrid + no fertilizer). At 75 DAT, the highest plant height (52.23 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, lowest plant height (21.75 cm) was obtained from the treatment V_1F_1 (Hybrid + no fertilizer). At 90 DAT, the highest plant height (68.75 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) and lowest plant height (32.47 cm) was obtained from the treatment V_1F_1 (Hybrid + no fertilizer).

Table 15. Interaction effect of variety in association with fertilizer and manure applications on plant height of chili plant at different DAT.

Treatments (Variety and fertilizer applications)	Plant height (cm)				
	30DAT	45DAT	60DAT	75DAT	90DAT
V_1F_1	9.53 ef	11.00 f	14.77 f	21.75 g	32.47 h
V_1F_2	10.00 def	11.62 ef	17.49 ef	27.30 ef	37.97 g
V_1F_3	10.97 bcd	12.60 de	18.73 de	30.02 de	42.83 ef
V_1F_4	11.47 bc	14.52 abc	20.85 cd	33.16 cd	47.39 cde
V_2F_1	9.32 f	10.98 f	16.70 ef	23.51 fg	40.26 fg
V_2F_2	10.67 cd	13.85 bcd	23.43 bc	32.83 cd	50.13 cd
V_2F_3	11.57 bc	14.52 abc	24.12 b	38.04 b	59.93 b
V_2F_4	11.85 ab	15.43 a	27.57 a	52.23 a	68.75 a
V_3F_1	10.03 def	11.67 ef	17.41 ef	28.15 e	41.22 fg
V_3F_2	10.39 de	13.33 cd	18.70 de	29.29 de	43.46 ef
V_3F_3	11.47 bc	14.33 abc	20.75 cd	35.41 bc	46.08 de

V_3F_4	12.75 a	15.08 ab	25.25 ab	36.67 bc	50.91 c
CV(%)	5.28	5.77	7.73	7.19	5.53

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 DMRT) at 5% level of probability.

V_1F_1 = Hybrid + No fertilizer, no manure & no pesticide, V_1F_2 = Hybrid + Cow-dung manure and neem oil sprayed as bio-pesticide, V_1F_3 = Hybrid + Poultry manure and neem oil sprayed as bio-pesticide, V_1F_4 = Hybrid + Recommended chemical fertilizer & chemical pesticide, V_2F_1 = Kajli + No fertilizer, no manure & no pesticide, V_2F_2 = Kajli + Cow-dung manure and neem oil sprayed as bio-pesticide, V_2F_3 = Kajli + Poultry manure and neem oil sprayed as bio-pesticide, V_2F_4 = Kajli + Recommended chemical fertilizer & chemical pesticide, V_3F_1 = Shity + No fertilizer, no manure & no pesticide, V_3F_2 = Shity + Cow-dung manure and neem oil sprayed as bio-pesticide, V_3F_3 = Shity + Poultry manure and neem oil sprayed as bio-pesticide, V_3F_4 = Shity + Recommended chemical fertilizer & chemical pesticide.

Table 16. Interaction effect of variety in association with fertilizer and manure applications on leaf length of chili plant at different DAT.

Treatments (Variety and fertilizer applications)	Leaf length (cm)				
	30DAT	45DAT	60DAT	75DAT	90DAT
V_1F_1	3.51 f	3.73 f	5.64 f	5.95 h	7.10 e
V_1F_2	3.86 def	4.29 e	6.00 e	6.30 fg	7.75 d
V_1F_3	4.06 cde	4.83 d	6.14 e	6.73 e	7.92 c
V_1F_4	4.42 c	5.24 b	6.55 d	6.96 c	8.21 b
V_2F_1	3.73 ef	4.67 d	6.13 e	6.24 g	7.06 e
V_2F_2	4.33 c	5.33 ab	6.76 c	6.73 e	7.85 cd
V_2F_3	4.88 b	5.60 a	7.02 b	7.16 b	8.20 b
V_2F_4	5.30 a	5.61 a	7.16a	7.74 a	8.80 a

V_3F_1	3.09 g	3.92 f	5.03 h	5.45 i	6.09 g
V_3F_2	3.57 f	4.64 d	5.19 g	6.40 f	6.77 f
V_3F_3	3.76 ef	4.90 cd	5.51 f	6.68 e	6.86 f
V_3F_4	4.24 cd	5.20 bc	6.10 e	6.84 d	7.12 e
CV(%)	6.15	3.77	1.34	0.96	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 DMRT) at 5% level of probability.

V_1F_1 = Hybrid + No fertilizer, no manure & no pesticide, V_1F_2 = Hybrid + Cow-dung manure and neem oil sprayed as bio-pesticide, V_1F_3 = Hybrid + Poultry manure and neem oil sprayed as bio-pesticide, V_1F_4 = Hybrid + Recommended chemical fertilizer & chemical pesticide, V_2F_1 = Kajli + No fertilizer, no manure & no pesticide, V_2F_2 = Kajli + Cow-dung manure and neem oil sprayed as bio-pesticide, V_2F_3 = Kajli + Poultry manure and neem oil sprayed as bio-pesticide, V_2F_4 = Kajli + Recommended chemical fertilizer & chemical pesticide, V_3F_1 = Shity + No fertilizer, no manure & no pesticide, V_3F_2 = Shity + Cow-dung manure and neem oil sprayed as bio-pesticide, V_3F_3 = Shity + Poultry manure and neem oil sprayed as bio-pesticide, V_3F_4 = Shity + Recommended chemical fertilizer & chemical pesticide.

4.3.2 Leaf length (cm)

The interaction effect of variety and fertilizer & manure applications on the leaf length of chili was found significantly different at different days after planting (Table 16). At 30 DAT, the highest leaf length (5.30 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, lowest leaf length (3.09 cm) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 45 DAT, the highest leaf length (5.61 cm) was recorded from the treatment V_2F_4 (Kajli + chemical fertilizer) which is significantly followed by V_2F_3 (Kajli + poultry) and V_2F_2 (Kajli + cow dung). Whereas, lowest leaf length (3.73 cm) was obtained from the treatment V_1F_1 (Hybrid + no fertilizer). At 60 DAT, the highest leaf length (7.16 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) and lowest leaf length (5.03 cm) was obtained from the treatment V_3F_1 (Shity

+ no fertilizer). At 75 DAT, the highest leaf length (7.74 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, lowest leaf length (5.45 cm) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 90 DAT, the highest leaf length (8.80 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) and lowest leaf length (6.09 cm) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

4.3.3 Leaf breadth (cm)

The interaction effect of variety and fertilizer & manure applications on the leaf breadth of chili was found significantly different at different days after planting (Table 17). At 30 DAT, the highest leaf breadth (2.36 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, lowest leaf breadth (1.33 cm) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 45 DAT, the highest leaf breadth (2.41 cm) was recorded from the treatment V_2F_4 (Kajli + chemical fertilizer). Whereas, lowest leaf breadth (1.32 cm) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 60 DAT, the highest leaf breadth (2.70 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) and lowest leaf breadth (1.69 cm) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 75 DAT, the highest leaf breadth (2.89 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, lowest leaf breadth (1.82 cm) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 90 DAT, the highest leaf breadth (3.12 cm) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) and lowest leaf breadth (2.15 cm) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

Table 17. Interaction effect of variety in association with fertilizer and manure applications on leaf breadth of chili plant at different DAT.

Treatments (Variety and fertilizer applications)	Leaf breadth (cm)				
	30DAT	45DAT	60DAT	75DAT	90DAT

V_1F_1	1.50 def	1.62 g	1.72 f	1.92 h	2.20hi
V_1F_2	1.70 cd	1.87 f	1.91 e	2.05 g	2.28 h
V_1F_3	1.83 bc	1.93 ef	1.99 de	2.16 ef	2.41 g
V_1F_4	1.90 bc	2.09 cd	2.16 c	2.26 d	2.55 ef
V_2F_1	1.55 de	1.86 f	2.01 d	2.14 f	2.41 g
V_2F_2	1.81 bc	1.96 e	2.25 c	2.34 cd	2.65 de
V_2F_3	1.99 b	2.16 bc	2.47 b	2.53 b	3.01 b
V_2F_4	2.36 a	2.41 a	2.70 a	2.89 a	3.12 a
V_3F_1	1.33 f	1.32 h	1.69 f	1.82 i	2.15 i
V_3F_2	1.40 ef	1.91 ef	2.06 d	2.25 de	2.53 f
V_3F_3	1.48ef	2.07 d	2.25 c	2.36 c	2.70 d
V_3F_4	1.71 cd	2.20 b	2.40 b	2.53 b	2.88 c
CV(%)	6.85	2.30	2.67	2.22	2.42

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 DMRT) at 5% level of probability.

V_1F_1 = Hybrid + No fertilizer, no manure & no pesticide, V_1F_2 = Hybrid + Cow-dung manure and neem oil sprayed as bio-pesticide, V_1F_3 = Hybrid + Poultry manure and neem oil sprayed as bio-pesticide, V_1F_4 = Hybrid + Recommended chemical fertilizer & chemical pesticide, V_2F_1 = Kajli + No fertilizer, no manure & no pesticide, V_2F_2 = Kajli + Cow-dung manure and neem oil sprayed as bio-pesticide, V_2F_3 = Kajli + Poultry manure and neem oil sprayed as bio-pesticide, V_2F_4 = Kajli + Recommended chemical fertilizer & chemical pesticide, V_3F_1 = Shity + No fertilizer, no manure & no pesticide, V_3F_2 = Shity + Cow-dung manure and neem oil sprayed as bio-pesticide, V_3F_3 = Shity + Poultry manure and neem oil sprayed as bio-pesticide, V_3F_4 = Shity + Recommended chemical fertilizer & chemical pesticide.

Table 18. Interaction effect of variety in association with fertilizer and manure applications on number of leaf/plant of chili plant at different DAT.

Treatments (Variety and fertilizer applications)	Number of leaf/plant				
	30DAT	45DAT	60DAT	75DAT	90DAT
V_1F_1	8.77 ef	12.53 ef	21.70 efg	40.27 def	61.00 def
V_1F_2	9.67 cdef	14.20 de	25.50 de	45.44 cd	71.57 cde
V_1F_3	10.97 bcd	18.73 abc	31.17 bc	47.67 cd	81.07 bcd
V_1F_4	13.33 a	21.10 a	35.23 b	60.57 b	98.13 b
V_2F_1	8.63 ef	9.93 f	17.30 g	32.33 fg	56.20 ef
V_2F_2	10.13 cde	13.27 ef	22.97 ef	41.13 de	63.60 cdef
V_2F_3	10.50 cd	14.87 de	25.07 de	50.63 c	74.77 cde
V_2F_4	11.27 bc	15.80 cde	43.57 a	102.3 a	166.0 a
V_3F_1	8.30 f	12.93 ef	19.13 fg	30.13 g	45.61 f
V_3F_2	9.53 def	15.37 cde	25.89 de	36.23efg	59.47 ef
V_3F_3	10.73 cd	17.23 bcd	29.03 cd	46.47 cd	71.10 cde
V_3F_4	12.43 ab	19.47 ab	35.00 b	51.40 c	83.53 bc
CV(%)	8.64	12.57	9.82	9.77	13.91

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 DMRT) at 5% level of probability.

V_1F_1 = Hybrid + No fertilizer, no manure & no pesticide, V_1F_2 = Hybrid + Cow-dung manure and neem oil sprayed as bio-pesticide, V_1F_3 = Hybrid + Poultry manure and neem oil sprayed as bio-pesticide, V_1F_4 = Hybrid + Recommended chemical fertilizer & chemical pesticide, V_2F_1 = Kajli + No fertilizer, no manure & no pesticide, V_2F_2 = Kajli + Cow-dung manure and neem oil sprayed as bio-pesticide, V_2F_3 = Kajli +

Poultry manure and neem oil sprayed as bio-pesticide, V_2F_4 = Kajli + Recommended chemical fertilizer & chemical pesticide, V_3F_1 = Shity + No fertilizer, no manure & no pesticide, V_3F_2 = Shity + Cow-dung manure and neem oil sprayed as bio-pesticide, V_3F_3 = Shity + Poultry manure and neem oil sprayed as bio-pesticide, V_3F_4 = Shity + Recommended chemical fertilizer & chemical pesticide.

4.3.4 Number of leaf/plant

The interaction effect of variety and fertilizer & manure applications on the number of leaf/plant of chili was found significantly different at different days after planting (Table 18). At 30 DAT, the highest number of leaf/plant (13.33) was obtained from the treatment V_1F_4 (Hybrid + chemical fertilizer) which is significantly followed by V_3F_4 (Shity + chemical fertilizer). On the other hand, lowest number of leaf/plant (8.30) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 45 DAT, the highest number of leaf/plant (21.10) was recorded from the treatment V_1F_4 (Hybrid + chemical fertilizer) which is significantly followed by V_1F_3 (Hybrid +poultry),V_3F_4 (Shity + chemical fertilizer). Whereas, lowest number of leaf/plant (9.93) was obtained from the treatment V_2F_1 (Kajli + no fertilizer). At 60 DAT, the highest number of leaf/plant (43.57) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) and lowest number of leaf/plant (17.30) was obtained from the treatment V_2F_1 (Kajli + no fertilizer). At 75 DAT, the highest number of leaf/plant (102.3) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, lowest number of leaf/plant (30.13) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 90 DAT, the highest number of leaf/plant (166.0) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) and lowest number of leaf/plant (45.61) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

4.3.5 Number of shoot/plant

The interaction effect of variety and fertilizer & manure applications on the number of shoot/plant of chili was found significantly different at different days after planting (Table 19). At 45 DAT, the highest number of shoot/plant (5.57) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) which is significantly followed by V_2F_3 (Kajli + poultry). On the other hand, lowest number of shoot/plant (0.70) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 60 DAT, the highest number of shoot/plant (6.567) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) and lowest number of shoot/plant (0.80) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 75 DAT, the highest number of shoot/plant (7.27) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, lowest number of shoot/plant (1.20) was obtained from the treatment V_3F_1 (Shity + no fertilizer). At 90 DAT, the highest number of shoot/plant (7.37) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) and lowest number of shoot/plant (1.27) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

Table 19. Interaction effect of variety in association with fertilizer and manure applications on number of shoot/plant of chili.

Treatments (Variety and fertilizer applications)	Number of shoot/plant			
	45DAT	60DAT	75DAT	90DAT
V_1F_1	2.30 e	2.73 d	3.23 d	3.33 e
V_1F_2	2.87 d	3.37 c	4.10 c	4.21 d
V_1F_3	4.47 c	5.20 b	5.83 b	5.90 c
V_1F_4	5.07 b	5.67 b	6.20 b	6.33 b
V_2F_1	1.93 e	2.70 d	3.03 d	3.06 e
V_2F_2	2.29 e	2.98 cd	3.21 d	3.25 e
V_2F_3	5.17 ab	5.63 b	6.00 b	6.13 bc
V_2F_4	5.57 a	6.57 a	7.27 a	7.37 a
V_3F_1	0.70 g	0.80 f	1.20 g	1.27 h
V_3F_2	0.84 fg	1.07 f	1.60 fg	1.63 h
V_3F_3	0.93 fg	1.30 ef	1.93 f	2.07 g

V_3F_4	1.30 f	1.67 e	2.43 e	2.57 f
CV(%)	10.04	8.78	6.34	6.07

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 DMRT) at 5% level of probability.

V_1F_1 = Hybrid + No fertilizer, no manure & no pesticide, V_1F_2 = Hybrid + Cow-dung manure and neem oil sprayed as bio-pesticide, V_1F_3 = Hybrid + Poultry manure and neem oil sprayed as bio-pesticide, V_1F_4 = Hybrid + Recommended chemical fertilizer & chemical pesticide, V_2F_1 = Kajli + No fertilizer, no manure & no pesticide, V_2F_2 = Kajli + Cow-dung manure and neem oil sprayed as bio-pesticide, V_2F_3 = Kajli + Poultry manure and neem oil sprayed as bio-pesticide, V_2F_4 = Kajli + Recommended chemical fertilizer & chemical pesticide, V_3F_1 = Shity + No fertilizer, no manure & no pesticide, V_3F_2 = Shity + Cow-dung manure and neem oil sprayed as bio-pesticide, V_3F_3 = Shity + Poultry manure and neem oil sprayed as bio-pesticide, V_3F_4 = Shity + Recommended chemical fertilizer & chemical pesticide.

4.3.6 Number of fruit/plant

The interaction effect of variety and fertilizer & manure applications on the number of fruit/plant of chili was found significantly different (Table 20). The maximum number of fruit/plant (167.4) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum number of fruit/plant (21.67) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

4.3.7 Weight of fruit/plant (g)

The interaction effect of variety and fertilizer & manure applications on the weight of fruit/plant of chili was found significantly different (Table 20). The maximum weight of fruit/plant (337.7 g) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum weight of fruit/plant (67.87 g) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

4.3.8 Total Number of fruit/plot

The interaction effect of variety and fertilizer & manure applications on the total number of fruit/plot of chili was found significantly different (Table 20). The maximum total number of fruit/plot (2363) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum total number of fruit/plot (469.7) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

4.3.9 Total weight of fruit/plot (kg)

The interaction effect of variety and fertilizer & manure applications on the total weight of fruit/plot of chili was found significantly different (Table 20). The maximum total weight of fruit/plot (5.13 kg) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum total weight of fruit/plot (1.06 kg) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

4.3.10 Fruit length (cm)

The interaction effect of variety and fertilizer & manure applications on the fruit length of chili was found significantly different (Table 20). The maximum fruit length (10.30 cm) was obtained from the treatment V_3F_4 (Shity + chemical fertilizer) which is significantly followed by V_3F_3 (Shity + poultry), V_3F_1 (Shity + no fertilizer), V_3F_2 (Shity + cow dung) and V_1F_4 (Hybrid + chemical fertilizer). On the other hand, minimum fruit length (5.86 cm) was obtained from the treatment V_2F_1 (Kajli + no fertilizer).

Table 20. Interaction effect of variety in association with fertilizer and manure applications on the yield contributing characters of chili.

Treatments (Variety and fertilizer applications)	Number of fruit/plant	Weight of fruit/plant (g)	Total number of fruit/plot	Total weight of fruit/plot (kg)	Fruit length (cm)	Fruit breadth (cm)
V_1F_1	40.07 gh	170.5 e	693.0 h	2.530 ef	7.85 cd	0.75 de

V_1F_2	44.50 fg	188.6 e	717.7 gh	2.76 de	8.10 cd	1.00 abc
V_1F_3	48.40 efg	212.5 d	762.7 f	3.30 c	8.53 bc	1.03 ab
V_1F_4	53.33 ef	262.2 c	813.7 e	3.36 c	9.07 abc	1.11 a
V_2F_1	57.67 de	111.9 fg	1141 d	2.56 ef	5.86 e	0.74 de
V_2F_2	109.3 c	253.7 c	1333 c	2.90 d	7.10 d	0.84 cde
V_2F_3	123.3 b	314.2 b	2124 b	4.89 b	8.07 cd	0.88 bcd
V_2F_4	167.4 a	337.7 a	2363. a	5.13 a	8.67 bc	1.03 ab
V_3F_1	21.67 i	67.87 h	469.7 j	1.06 i	9.13 abc	0.57 f
V_3F_2	32.33 hi	91.60 g	529.0 i	1.31 h	9.50 ab	0.67 ef
V_3F_3	41.00 gh	123.5 f	759.7 fg	1.76 g	9.98 a	0.73 def
V_3F_4	67.33 d	186.4 e	811.3 e	2.46 f	10.30 a	0.80 de
CV(%)	9.66	6.87	2.42	4.80	8.25	10.92

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 DMRT) at 5% level of probability.

V_1F_1 = Hybrid + No fertilizer, no manure & no pesticide, V_1F_2 = Hybrid + Cow-dung manure and neem oil sprayed as bio-pesticide, V_1F_3 = Hybrid + Poultry manure and neem oil sprayed as bio-pesticide, V_1F_4 = Hybrid + Recommended chemical fertilizer & chemical pesticide, V_2F_1 = Kajli + No fertilizer, no manure & no pesticide, V_2F_2 = Kajli + Cow-dung manure and neem oil sprayed as bio-pesticide, V_2F_3 = Kajli + Poultry manure and neem oil sprayed as bio-pesticide, V_2F_4 = Kajli + Recommended chemical fertilizer & chemical pesticide, V_3F_1 = Shity + No fertilizer, no manure & no pesticide, V_3F_2 = Shity + Cow-dung manure and neem oil sprayed as bio-pesticide, V_3F_3 = Shity + Poultry manure and neem oil sprayed as bio-pesticide, V_3F_4 = Shity + Recommended chemical fertilizer & chemical pesticide.

4.3.11 Fruit breadth (cm)

The interaction effect of variety and fertilizer & manure applications on the fruit breadth of chili was found significantly different (Table 20). The maximum fruit breadth (1.11 cm) was obtained from the treatment V_1F_4

(Hybrid + chemical fertilizer) which is significantly followed by V_1F_2 (Hybrid + cow dung), V_1F_3 (Hybrid +poultry), V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum fruit breadth (0.57 cm) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

4.3.12 Fruit number yield (t/ha)

The interaction effect of variety and fertilizer & manure applications on the fruit no. yield of chili was found significantly different (Table 21). The maximum fruit number yield (7878 t/ha) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum fruit number yield (1566 t/ha) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

4.3.13 Percent dry weight of fruit

The interaction effect of variety and fertilizer & manure applications on the % dry weight of fruit of chili was found significantly different (Table 21). The maximum % dry weight of fruit (14.10) was obtained from the treatment V_3F_4 (Shity + chemical fertilizer). On the other hand, minimum % dry weight of fruit (8.93) was obtained from the treatment V_1F_1 (Hybrid + no fertilizer).

Table 21. Interaction effect of variety in association with fertilizer and manure applications on the yield contributing characters of chili.

Treatments (variety and fertilizer applications)	Fruit number yield (t/ha)	% dry weight of fruit
V_1F_1	2310 f	8.93 f
V_1F_2	2392 ef	10.13 e
V_1F_3	2542 ef	10.13 e
V_1F_4	2379 ef	11.40 cd
V_2F_1	3802 d	9.57 ef
V_2F_2	4444 c	10.27 e
V_2F_3	7079 b	11.23 d
V_2F_4	7878 a	11.70 cd
V_3F_1	1566 g	11.07 d
V_3F_2	1763 g	12.10 c
V_3F_3	2532 ef	13.03 b
V_3F_4	2705 e	14.10 a
CV(%)	5.53	3.71

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 DMRT) at 5% level of probability.

V_1F_1 = Hybrid + No fertilizer, no manure & no pesticide, V_1F_2 = Hybrid + Cow-dung manure and neem oil sprayed as bio-pesticide, V_1F_3 = Hybrid + Poultry manure and neem oil sprayed as bio-pesticide, V_1F_4 = Hybrid + Recommended chemical fertilizer & chemical pesticide, V_2F_1 = Kajli + No fertilizer, no manure & no pesticide, V_2F_2 = Kajli + Cow-dung manure and neem oil sprayed as bio-pesticide, V_2F_3 = Kajli + Poultry manure and neem oil sprayed as bio-pesticide, V_2F_4 = Kajli + Recommended chemical fertilizer & chemical pesticide, V_3F_1 = Shity + No fertilizer, no manure & no pesticide, V_3F_2 = Shity + Cow-dung manure and neem oil sprayed as bio-pesticide, V_3F_3 = Shity + Poultry manure and neem oil sprayed as bio-pesticide, V_3F_4 = Shity + Recommended chemical fertilizer & chemical pesticide.

4.3.14 Yield (ton/ha)

The interaction effect of variety and Fertilizer & manure applications on the yield of chili was found significantly different (Fig. 7). The maximum yield (17.09 ton/ha) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer) which is significantly followed by V_2F_3 (Kajli + poultry). On the other hand, minimum yield (3.54 ton/ha) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

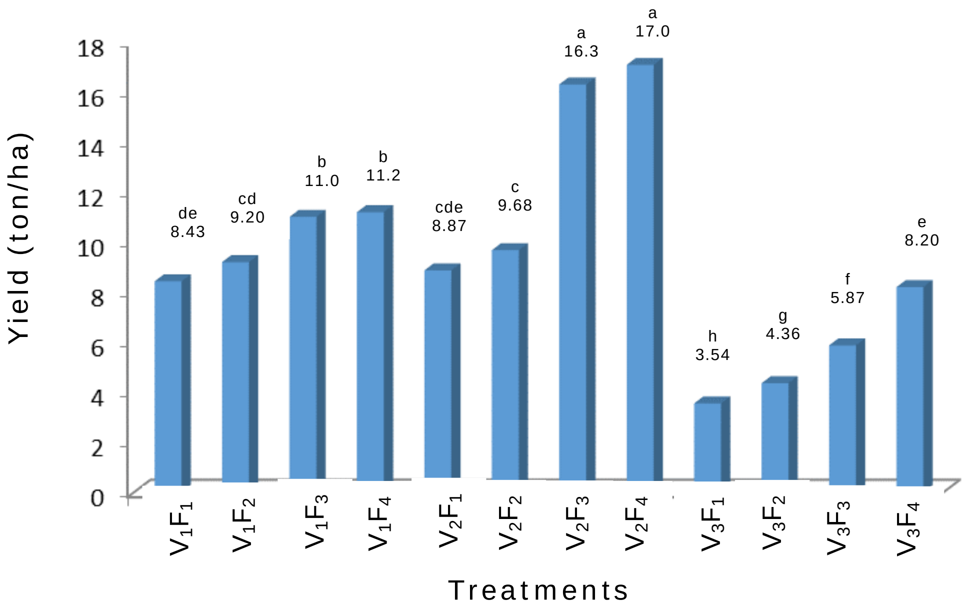


Figure 7. Interaction effect of variety in association with fertilizer and manure applications on yield of chili.

4.4 Economic Analysis

Profitability of growing chili as inter-crop in mango 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 22.

4.4.1 Total cost of production

The values in Table 22. indicate that the total cost of production was maximum (143863 Tk. /ha) in those plots where chili was cultivated with using Kajli + chemical fertilizer (F_4) whereas the minimum cost of production (122824 Tk./ha) was recorded from those plots where Shity + no fertilizer (F_1) was applied.

4.4.2 Gross return

Gross return is an important indicator whether crop cultivation is profitable or not. It is varying with the variety of chili and production system of chili. The values in Table 22

Table 22: Economics of chili production under mango 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	Chili				
V_1F_1	150600	168600	319200	125448	193752	2.54
V_1F_2	150600	184000	334600	132249	202351	2.53
V_1F_3	150600	220200	370800	129537	241263	2.86
V_1F_4	150600	224000	374600	141741	232859	2.64
V_2F_1	150600	177400	328000	126088	201912	2.60
V_2F_2	150600	193600	344200	134371	209829	2.56
V_2F_3	150600	240000	390600	131659	258941	2.97
V_2F_4	150600	341800	492400	143863	348537	3.42
V_3F_1	150600	70800	221400	122824	98576	1.80
V_3F_2	150600	87200	237800	131107	106693	1.81
V_3F_3	150600	117400	268000	128395	139605	2.08
V_3F_4	150600	164000	314600	140599	174001	2.23

Note: Chili 20 Tk kg^{-1}, Mango 1600 Tk per Tree per Year

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 DMRT) at 5% level of probability.

V_1F_1 = Hybrid + No fertilizer, no manure & no pesticide, V_1F_2 = Hybrid + Cow-dung manure and neem oil sprayed as bio-pesticide, V_1F_3 = Hybrid + Poultry manure and neem oil sprayed as bio-pesticide, V_1F_4 = Hybrid + Recommended chemical fertilizer & chemical pesticide, V_2F_1 = Kajli + No fertilizer, no manure & no pesticide, V_2F_2 = Kajli + Cow-dung manure and neem oil sprayed as bio-pesticide, V_2F_3 = Kajli + Poultry manure and neem oil sprayed as bio-pesticide, V_2F_4 = Kajli + Recommended chemical fertilizer & chemical pesticide, V_3F_1 = Shity + No fertilizer, no manure & no pesticide, V_3F_2 = Shity + Cow-dung manure and neem oil sprayed as bio-pesticide, V_3F_3 = Shity + Poultry manure and neem oil sprayed as bio-pesticide, V_3F_4 = Shity + Recommended chemical fertilizer & chemical pesticide.

indicate that the highest value of gross return (492400 Tk. /ha) was obtained in those plots where Kajli + chemical fertilizer (F_4) was applied. On the other hand, the lowest value of gross return (221400 Tk./ha) was obtained in those plots where Shity + no fertilizer (F_1) was applied.

4.4.3 Net return

Results presented in the Table 22 show that net return (348537 Tk./ha) was comparatively higher in producing chili under Kajli + chemical fertilizer (F_4). At the same time, the lowest net return (98576 Tk./ha) was received from those plot where Shity + no fertilizer (F_1) was applied.

4.4.4 Benefit-cost ratio (BCR)

The values in Table 22 indicate that the highest benefit-cost ratio (3.42) was recorded from the treatment Kajli + chemical fertilizer (F_4). On the other hand, the lowest benefit-cost ratio (1.80) was observed in those plots where Shity variety when grown with no fertilizer (F_1).

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

A field experiment was carried out at the Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, during October, 2016 to March, 2017 to evaluate the varietal performance of chili and organic chili production under mango based agroforestry system. The experiment was conducted in the mango orchard where the tree saplings were planted at the spacing 6 m×6 m in the year 2006. The experiment was laid out in two factorial RCBD with 3 (three) replications. Factor A (three chili varieties) viz. V_1 = Hybrid, V_2 = Kajli and V_3 = Shity and Factor B (fertilizer & manure applications) viz. no fertilizer (F_1), cow-dung (F_2), poultry manure (F_3) and chemical fertilizer (F_4). So, the treatment combinations of the experiment were: V_1F_1 (Hybrid + no fertilizer), V_1F_2 (Hybrid + cow dung), V_1F_3 (Hybrid + poultry), V_1F_4 (Hybrid + chemical fertilizer), V_2F_1 (Kajli + no fertilizer), V_2F_2 (Kajli + cow dung), V_2F_3(Kajli + poultry), V_2F_4 (Kajli + chemical fertilizer), V_3F_1 (Shity + no fertilizer), V_3F_2 (Shity + cow dung), V_3F_3 (Shity + poultry) and V_3F_4 (Shity + chemical fertilizer). The total numbers of experimental plots were 36. The land of experimental plot was opened in the first week of September 2016 with a power tiller and it was made ready for planting on 4 October 2016. 25 days old healthy seedlings were uprooted from the nursery beds and were transplanted in the experimental plots during late afternoon on 15 October, 2016. In each plot there were 15 plants. The spacing was 50cm x 40cm. The data were recorded on two broad heads, i) growth stage ii) harvesting stage. The data were analyzed statistically and means were adjudged by DMRT (Duncan's Multiple Range Test).

In case of the main effect of variety on the growth, yield contributing characters and yield of chili, the result was found significant in respect of plant height (30, 45, 60, 75 and 90 DAT), leaf length (30, 45, 60, 75 and 90 DAT), leaf breadth (30, 45, 60, 75 and 90 DAT), number of leaf/plant (30, 45, 60, 75 and 90 DAT), number of shoot/plant (45, 60, 75 and 90 DAT), number of fruit/plant, weight of fruit/plant (g), total number of fruit/plot, total weight of fruit/plot (kg), fruit length (cm), fruit breadth (cm), fruit number yield (t/ha), % dry weight of fruit, yield (ton/ha). The tallest plant height (11.16cm) at 30 DAT was recorded from the variety Shity (V_3) and tallest plant height (13.70cm, 22.95cm, 36.65cm and 54.77cm) at 45, 60, 75 and 90 DAT was recorded from the variety of Kajli (V_2). On the other hand, the shortest plant height (10.49cm, 12.43cm, 17.96cm, 28.06cm and 40.17cm) at 30, 45, 60, 75 and 90 DAT was recorded from the variety of Hybrid (V_1). Leaf length of chili was significant due to different varietals effect. However, the longest leaf (4.56cm, 5.30cm, 6.77cm, 6.97cm and 7.98cm) at 30, 45, 60, 75 and 90 DAT was recorded from the variety of Kajli (V_2). On the other hand, the shortest leaf (3.66cm, 5.46cm, 6.34cm, and 6.71cm) at 30, 60, 75 and 90 DAT was recorded from the variety of Shity (V_3) and 5.30cm at 45 DAT from the variety Hybrid (V_1). Chili leaf breadth was also influenced due to their varietal characters. The widest leaf (1.93cm, 2.10cm, 2.36cm, 2.47cm and 2.80cm) at 30, 45, 60, 75 and 90 DAT was recorded from the variety of Kajli (V_2). On the other hand, minimum breadth of leaf (1.48cm and 1.87cm) at 30, 45 DAT was observed from the variety of Shity (V_3) and (1.94cm, 2.10cm and 2.36cm) at 60, 75 and 90 DAT was recorded from the variety of Hybrid (V_1). Number of leaf/plant of chili was found insignificant at 30 and 60 DAT. The maximum number of leaves per plant (16.64) at 45 DAT was recorded from the variety Hybrid (V_1) and (56.59 and 90.13) at 75 and 90 DAT was recorded from the variety Kajli(V_2). On the other hand, minimum number of leaves per plant (13.47, 41.06 and 64.93) at 45, 75 and 90 DAT was observed from Shity (V_3). Number of shoot/plant of chili was found significantly varied with different treatments. However, numerically, the maximum number of shoot/plant (3.74, 4.47, 4.88 and 4.95) at 45, 60, 75 and 90DAT was recorded from the variety Kajli(V_2). On the other hand, minimum number of shoot/plant (0.94, 1.21, 1.79 and 1.88) at 45, 60, 75 and 90 DAT was recorded from the variety Shity (V_3). The maximum number of fruit/plant (114.4) was obtained from the variety Kajli (V_2). On the other hand, minimum number of fruit/plant (40.58) was obtained from the variety Shity (V_3). The highest weight of fruit/plant (254.4g) was observed from the variety Kajli (V_2). On the other hand, lowest weight of fruit/plant (117.3g) was obtained from the variety Shity (V_3). The maximum total number of fruit/plot (1740) was obtained from the variety Kajli (V_2). On the other hand, minimum total number of fruit/plot (642.4) was obtained from the variety Shity (V_3). The highest total weight of fruit/plot (3.87kg) was observed from the variety Kajli (V_2). On the other hand, lowest total weight of fruit/plot (1.65kg) was obtained from the variety Shity (V_3). The highest fruit length (9.73cm) was obtained from the variety Shity (V_3). On the other hand, lowest fruit length (7.42cm) was recorded from the variety Kajli (V_2). The highest fruit breadth (0.97cm) was found from the variety Hybrid (V_1). On the other hand, lowest fruit breadth (0.69cm) was obtained from the variety Shity (V_3). The maximum fruit number yield (5801 t/ha) was obtained from the variety Kajli (V_2). On the other hand, minimum fruit number yield (2141 t/ha) was recorded from the variety Shity (V_3). The highest % dry weight of fruit (12.57) was found from the variety Shity (V_3). On the other hand, lowest % dry weight of fruit (10.15) was obtained from the variety Hybrid (V_1). The yield of chili (ton/ha) was significantly affected by the different varieties. The highest fruit yield (12.99 ton/ha) was recorded from the variety Kajli (V_2). On the other hand, lowest fruit yield (5.49 ton/ha) was obtained from the variety Shity (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 (30, 45, 60, 75 and 90 DAT), leaf length (30, 45, 60, 75 and 90 DAT), leaf breadth (30, 45, 60, 75 and 90 DAT), number of leaf/plant (30, 45, 60, 75 and 90 DAT), number of shoot/plant (45, 60, 75 and 90 DAT), number of fruit/plant, weight of fruit/plant (g), total number of fruit/plot, total weight of fruit/plot (kg), fruit length (cm), fruit breadth (cm), fruit number yield (t/ha), % dry weight of fruit yield (ton/ha).

The tallest plant height (12.02cm, 15.01cm, 24.56cm, 40.69cm and 55.68cm) at 30, 45, 60, 75 and 90 DAT was recorded from Chemical fertilizer (F_4). On the other hand, the shortest plant height (9.63cm, 11.22cm, 16.29cm, 24.47cm and 37.99cm) at 30, 45, 60, 75 and 90 DAT was observed in those plots where no fertilizer was applied (F_1). Leaf length of chili was insignificant due to different varietals effect. However, the longest leaf (4.66cm, 5.35cm, 6.60cm, 7.18cm and 8.04cm) at 30, 45, 60, 75 and 90 DAT was recorded from Chemical fertilizer (F_4). On the other hand, the shortest leaf (3.44cm, 4.11cm, 5.60cm, 5.88cm and 6.75cm) at 30, 45, 60, 75 and 90 DAT was observed in those plots where no fertilizer was applied (F_1). The widest leaf (1.99cm, 2.23cm, 2.42cm, 2.56cm and 2.85cm) at 30, 45, 60, 75 and 90 DAT was recorded from Chemical fertilizer (F_4). On the other hand, minimum breadth of leaf (1.46cm, 1.60cm, 1.81cm, 1.96cm and 2.25cm) at 30, 45, 60, 75 and 90 DAT was observed in those plots where no fertilizer was applied (F_1). The maximum number of leaves per plant (12.34, 18.79, 37.93, 71.41 and 115.9) at 30, 45, 60, 75 and 90 DAT was recorded from Chemical fertilizer (F_4). On the other hand, minimum number of leaves per plant (8.57, 11.80, 19.38, 34.24 and 54.27) at 30, 45, 60, 75 and 90 DAT was observed in those plots where no fertilizer was applied (F_1). The maximum number of shoot/plant (3.98, 4.63, 5.30 and 5.42) at 45, 60, 75 and 90 DAT was recorded from Chemical fertilizer (F4). On the other hand, minimum number of shoot/plant (1.64, 2.08, 2.49 and 2.55) at 45, 60, 75 and 90 DAT was observed in those plots where no fertilizer was applied (F_1). The maximum number of fruit/plant (96.02) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum number of fruit/plant (39.80) was obtained from the plot where no fertilizer (F_1) was applied. The maximum weight of fruit/plant (262.1g) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum weight of fruit/plant (116.8g) was obtained from the plot where no fertilizer (F_1) was applied. The maximum total no. of fruit/plot (1329) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum total no. of fruit/plot (767.8) was obtained from the plot where no fertilizer (F_1) was applied. The maximum total weight of fruit/plot (3.65kg) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum total weight of fruit/plot (2.05kg) was obtained from the plot where no fertilizer (F_1) was applied. The maximum fruit length (9.34cm) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum fruit length (7.61cm) was obtained from the plot where no fertilizer (F_1) was applied. The maximum fruit breadth (0.98cm) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum fruit breadth (0.69cm) was obtained from the plot where no fertilizer (F_1) was applied. The maximum fruit no. yield (4320 t/ha) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum fruit no. yield (2559 t/ha) was obtained from the plot where no fertilizer (F_1) was applied. The maximum % dry weight of fruit (12.40) was obtained from the plot where chemical fertilizer (F_4) was applied. On the other hand, minimum % dry weight of fruit (9.86) was obtained from the plot where no fertilizer (F_1) was applied. The yield of chili (ton/ha) was significantly affected due to the applications of different fertilizer and manure. The highest fruit yield (12.16 ton/ha) was recorded from the plot where chemical fertilizer (F_4) was applied. On the other hand, lowest fruit yield (6.949 ton/ha) was obtained from the plot where no fertilizer (F_1) was applied.

Again, the interaction effect of variety and fertilizer & manure applications of chili had significant effect of plant height (30, 45, 60, 75 and 90 DAT), leaf length (30, 45, 60, 75 and 90 DAT), leaf breadth (30, 45, 60, 75 and 90 DAT), number of leaf/plant (30, 45, 60, 75 and 90 DAT), number of shoot/plant (45, 60, 75 and 90 DAT), number of fruit/plant, weight of fruit/plant (g), total number of fruit/plot, total weight of fruit/plot (kg), fruit length (cm), fruit breadth (cm), fruit number yield (t/ha), % dry weight of fruit, yield (ton/ha) respectively. At 30 DAT, the highest plant height (12.75cm) was obtained from the treatment V_3F_4 (Shity + chemical fertilizer). The tallest plant height (15.43cm, 27.57cm, 52.23cm and 68.75cm) at 45, 60, 75 and 90 DAT was recorded from V_2F_4 (Kajli + chemical fertilizer). On the other hand, lowest plant height (9.32cm and 10.98cm) was obtained from the treatment V_2F_1 (Kajli + no fertilizer) at 30 and 45 DAT. Again, the shortest plant height (14.77cm, 21.75cm and 32.47cm) at 60, 75 and 90 DAT was observed in V_1F_1 (Hybrid + no fertilizer). The longest leaf (5.30cm, 5.61cm, 7.16cm, 7.74cm and 8.80cm) at 30, 45, 60, 75 and 90 DAT was recorded from V_2F_4 (Kajli + chemical fertilizer). On the other hand, the shortest leaf (3.09cm, 5.03 cm, 5.45cm and 6.09cm) at 30, 60, 75 and 90 DAT, was observed from V_3F_1 (Shity + no fertilizer) and 3.73 cm was found at 45 DAT in V_1F_1 (Hybrid + no fertilizer). The widest leaf (2.36cm, 2.41cm, 2.70cm, 2.89cm and 3.12cm) at 30, 45, 60, 75 and 90 DAT was recorded from the V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum breadth of leaf (1.33cm, 1.32cm, 1.69cm, 1.82cm and 2.15cm) at 30, 45, 60, 75 and 90 DAT was observed from V_3F_1 (Shity + no fertilizer). The highest number of leaves per plant (13.33 and 21.10) at 30 and 45 DAT was obtained from the treatment V_1F_4 (Hybrid + chemical fertilizer). Again, the maximum number of leaves per plant (43.57, 102.3 and 166.0) at 60, 75 and 90 DAT was recorded in V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum number of leaves per plant (8.30, 30.13 and 45.61) at 30, 75 and 90 DAT was observed from the treatment V_3F_1 (Shity + no fertilizer) and (9.93 and 17.30) at 45 and 60 DAT was obtained from V_2F_1 (Kajli + no fertilizer). The maximum number of shoot/plant (5.57, 6.57, 7.27 and 7.37) at 45, 60, 75 and 90 DAT was recorded from V2F4 (Kajli + chemical fertilizer). On the other hand, minimum number of shoot/plant (0.70, 0.80, 1.20 and 1.27) at 45,60, 75 and 90 DAT was observed V_3F_1 (Shity + no fertilizer). The maximum number of fruit/plant (167.4) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum number of fruit/plant (21.67) was obtained from the treatment V_3F_1 (Shity + no fertilizer). The maximum weight of fruit/plant (337.7g) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum weight of fruit/plant (67.87g) was obtained from the treatment V_3F_1 (Shity + no fertilizer). The maximum total number of fruit/plot (2363) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum total number of fruit/plot (469.7) was obtained from the treatment V_3F_1 (Shity + no fertilizer). The maximum total weight of fruit/plot (5.13kg) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum total weight of fruit/plot (1.06) was obtained from the treatment V_3F_1 (Shity + no fertilizer). The maximum fruit length (10.30cm) was obtained from the treatment V_3F_4 (Shity + chemical fertilizer). On the other hand, minimum fruit length (5.86cm) was obtained from the treatment V_2F_1 (Kajli + no fertilizer). The maximum fruit breadth (1.11cm) was obtained from the treatment V_1F_4 (Hybrid + chemical fertilizer). On the other hand, minimum fruit breadth (0.57cm) was obtained from the treatment V_3F_1 (Shity + no fertilizer). The maximum fruit number yield (7878 t/ha) was obtained from the treatment V_2F_4 (Kajli + chemical fertilizer). On the other hand, minimum fruit number yield (1566 t/ha) was obtained from the treatment V_3F_1 (Shity + no fertilizer).

In case of economic analysis, the total cost of production was maximum (143863 Tk./ha) in those plots where chili was cultivated with using Kajli + chemical fertilizer (F_4). Whereas, the minimum cost of production (122824 Tk./ha) was recorded from those plots where Shity + no fertilizer (F_1) was applied. The highest value of gross return (492400 Tk. /ha) was obtained in those plots where Kajli + chemical fertilizer (F_4) was applied. On the other hand, the lowest value of gross return (221400 Tk./ha) was obtained in those plots where Shity + no fertilizer (F_1) was applied. Net return (348537 Tk./ha) was comparatively higher in producing chili under Kajli + chemical fertilizer (F_4). At the same time, the lowest net return (98576 Tk./ha) was received from those plot where Shity + no fertilizer (F_1) was applied. The highest benefit-cost ratio (3.42) was recorded from Kajli + chemical fertilizer (F_4). On the other hand, the lowest benefit-cost ratio (1.80) was observed in those plots where Shity + no fertilizer (F_1) was applied.

5.2 Conclusion

From the findings of this experiment, it may be concluded that among three chili varieties Kajli gave best performance in terms of yield. Again among the four fertilizer and manure application packages, chemical fertilizer gave best yield. Moreover, in case of economic return variety Kajli with the application of chemical fertilizer gave maximum BCR. However, using poultry manure with Kajli variety gave 4.45% yield reduction compare to chemical fertilizer application. So, if we consider the benefit of organic manure applications in terms of environmental benefit, soil health and safe chili production then cultivation of chili variety Kajli at the floor of mango orchard with poultry manure applications may be a promising orchard based agroforestry system in the northern part of Bangladesh.

5.3 Recommendations

1. The chili variety named Kajli can be grown at the floor of young mango orchard successfully using organic manure.
2. The present study opened the new avenue for further investigation with the combination of fruits and chili production simultaneously using organic manure.
3. Organic chili + mango based agroforestry systems are economically viable under mango based agroforestry system. 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.

4.This study should be repeated in different location of the country using different aged mango orchard to obtained valid recommendation.

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 (%	30
Clay(%	5
Textural class	Sandy loam
CEC (meq/ 100g)	8.07
pH	5.1
Organic matter (%)	1.06
Total nitrogen (%)	0.10
Sodium (meq/ 100g)	0.06
Calcium (meq/ 100g)	1.30
Magnesium (meq/ 100g)	0.40
Potassium (meq/ 100g)	0.26
Phosphorus (µg/g)	24.0
Sulphur (µg/g)	3.2
Boron (µg/g)	0.27
Iron (µg/g)	5.30
Zinc (µg/g)	0.90

Source: Soil Resources Development Institute, Dinajpur (2016)

Appendix-II: Weather data of the experimental site during the period from October, 2016 to March, 2017.

Months	* Air Temperature (^0C)			* Minimum Rainfall (mm)	* Relative Humidity (%)
	Maximum	Minimum	Average		
October 2016	30.15	19.99	25.01	06.00	89.45
November 2016	29.85	19.68	24.77	05.00	88.50
December 2016	28.70	18.45	23.56	18.00	85.92
January 2017	27.20	16.10	21.65	12.00	83.45
February 2017	26.95	15.78	21.37	00.00	82.20
March 2017	29.61	20.57	25.09	18.50	80.61

Note * Monthly average

Source: Meterological Station, Wheat Research Center, Noshipur, Dinajpur.

Appendix- III: Production cost analysis of chili cultivation under mango based agroforestry system.

Treatment	Input cost										Total input cost (tk/ha)	Over head cost			Total cost of production (tk/ha)
	Non material cost (Tk/ha)			Material cost (Tk/ha)											
	Litchi Tree	Chili	Total nonmaterial cost	Seed	Fertilizer	Pesticide	Irrigation	Maintenance cost of trees	Initial plantation cost of trees	Total material cost (tk/ha)		Interest of input cost @ 8% for the crop season (tk/ha)	Interest 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)	
V_1F_1	11675	85494	46035	12010	0	0	3260	6850	23850	45970	92005	8843	20000	4600	125448
V_1F_2	11675	85494	46035	12010	5650	1680	3260	6850	23850	53300	99335	7947	20000	4967	132249
V_1F_3	11675	85494	46035	12010	3250	1680	3260	6850	23850	50900	96935	7755	20000	4847	129537
V_1F_4	11675	85494	46035	12010	10860	4870	3260	6850	23850	61700	107735	8619	20000	5387	141741
V_2F_1	11675	85494	46035	13888	0	0	3260	6850	23850	47848	93883	7511	20000	4694	126088
V_2F_2	11675	85494	46035	13888	5650	1680	3260	6850	23850	55178	101213	8097	20000	5061	134371
V_2F_3	11675	85494	46035	13888	3250	1680	3260	6850	23850	52778	98813	7905	20000	4941	131659
V_2F_4	11675	85494	46035	13888	10860	4870	3260	6850	23850	63578	109613	8769	20000	5481	143863
V_3F_1	11675	85494	46035	11000	0	0	3260	6850	23850	44960	90995	7280	20000	4550	122824
V_3F_2	11675	8549	46035	1100	5650	1680	3260	6850	23850	52290	98325	7866	20000	4916	131107

		4		0											
V_3F_3	11675	85494	46035	11000	3250	1680	3260	6850	23850	49890	95925	7674	20000	4796	128395
V_3F_4	11675	85494	46035	11000	10860	4870	3260	6850	23850	60690	106725	8538	20000	5336	140599

Note: Chili 20 Tk kg^{-1}, Mango 1600 Tk per Tree per Year

Appendix IV: Some plates of the research

Plate 1a. Land preparation for transplanting of chili seedling.

Plate 1b. Transplanting of chili seedling

Plate 1c. Tagging of chili plant

Plate 1d. Measurement of plant height at different DAT

Plate 1e. Measurement of number of leaf/plant, number of shoot/plant

Plate 1f. Chili research field

Plate 1g. Drying of chili

REFERENCES

Abedin, Z., Aktar, S., Haque, F. and Alam, S., 1987, November. Uses of multipurpose trees on the small farms of the low-rainfall Ganges floodplain soils of Bangladesh. In *Proceedings of an international workshop held in Pataya, Thailand,* pp. 31-47.

Akinyosoye, V. O., 1977. Senior tropical agriculture for West Africa. Macmillian Education Ltd. London, pp.100-101.

Alam, M. and Sarker, S.K., 2011. Homestead agroforestry in Bangladesh: dynamics of stand structure and biodiversity. *Journal of sustainable forestry*, 30(6), pp.584-599.

Alao, J. S. and Shuaibu, R. B.2013. Agroforestry practices and concepts in sustainable land use systems in Nigeria. Journal of Horticulture and Forestry. 5(10): 156-159.

Aliyu, L, Yahaya, R. A, Arunah, U.L and Haruna, I.M., 2012. Response of two Chili Pepper Varieties (*Capsicum frutescens* L.) to Harvesting Frequency. Available online at www.elixirpublishers.com. Elixir International Journal, 42(2012):6493-6495.

Bahadur, M.M., Azad, A.K.M., Hakim, M.A., Hossain, S.M.M. and Sikder, S.P., 2000. Effect of different spacing and potassium levels on the growth and yield of turmeric var. sinduri. *Pakistan J. Biol. Sci*, 3, pp.593-595.

BBS. 2015. Statistical Pocket Book of Bangladesh Bureau of Statistic, Ministry of Planning, Govt. of peoples' Republic Bangladesh.

Bhattacharya, A., Chattopadhyay, A., Mazumdar, D., Chakravarty, A. and Pal, S., 2010. Antioxidant Constituents and Enzyme Activities in Chili Peppers. International journal of vegetable science, 16, 201 – 211.

Bonato, O. and Ridray, G., 2007. Effect of tomato deleafing on mirids, the natural predators of whiteflies, Agron. Sustain. Dev. 27, 167–170.

Bosland, P.W. and Botava, E.J., (2000). Peppers: vegetable and spice capsicums. CABI. Publishing, Wallingford, United Kingdom, 204 p.

References

Brundtle and Commission,1987. Brundtle and Commission Report of the World Commission on Environment and Development, United Nations, http:/www.un.org/documents /ga/ res/42/areas42-187.htm.

Chakraborti, S., 2000. Neem-based integrated schedule for the control of vectors causing apical leaf curling in chili. *Pest Management and Economic Zoology*, 8(1), pp.79-84.

Chanda G., Kumar B., Goutam C. S., Kumar., 2011. The effect of vermicompost and other fertilizers on cultivation of tomato plants. *Journal of Horticulture and Forestry,* 3(2): 42-45.

Costa LV, Lopes R, Lopes MTG, de Figueiedo AF, Barros WS, Alves SRM., 2009. Cross compatibility of domesticated hot pepper and cultivated sweet pepper. Crop Breeding and Applied Biotechnology 9: 37-44.

Das, D.K., Chaturvedi, O.P., Jha, R.K. and Kumar, R., 2011. Yield, soil health and economics of aonla (*Emblica officinalis Gaertn*.)-based agri-horticultural systems in eastern India. *Current Science*, pp. 786-790.

Deore, G.B., Limaye, A.S., Shinde, B.M. and Laware, S.L., 2010. Effect of novel organic liquid fertilizer on growth and yield in chili (*Capsicum annum* L.). *Asian Journal of Experimental Biological Sciences (2010 Spl issue)*, pp.15-19.

Dias GB, Gomes VM, Moraes TM, Zottich UP, Rabelo GR, Carvalho AO, Moulin M, Gonçalves LS, Rodrigues R, Da Cunha M (2013). Characterization of Capsicum species using anatomical and molecular data. Genet Mol Res.

El-Ghoraba AH, Javedb Q, Anjumb FM, Hamedc SF, Shaabana HA., 2013. Pakistani Bell Pepper (*Capsicum annum* L.): Chemical Compositions and its Antioxidant Activity. International Journal of Food Properties, 16(1):18-32

Erinle,I.D. (1989). Present status and prospects increases production of tomatoes and pepper in Nigeria. In: AVRDC Edu. Prac. Inter. Symp. Integrated Manad. Practices. pp. 536- 547

References

FAO (2010). FAOSTAT Database. Food and Agriculture Organization, Roma, Italy. Available online at URL: www.fao.org

FAO, 2001.World Forestland Report, Rome.

Fertilizer Recommendation Guide. 2014. Bangladesh Agricultural Research Institute, Dhaka, Bangladesh.

Gold, M.A. and Hanover, J.W., 1987. Agroforestry systems for the temperate zone. *Agroforestry Systems*, 5(2), pp.109-121.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agriculture Research Int. Rice Res. Inst. John Wiley and Sons, New York. pp 139-240.

Hanif, M.A., Amin, M.H.A., Bari, M.S., Ali, M.S. and Uddin, M.N., 2010. Performance of okra under litchi based agroforestry system. *J. Agrofor. Environ*, 4(2), pp.137-139.

Hasanuzzaman, M., Hossain, M. and Saroar, M., 2014. Floristic composition and management of cropland agroforest in southwestern Bangladesh J. of Forestry Res., 25(3): 597-604.

Heeb,A.;Lundegardh,B.;Savage,G.P.;Ericsson,T.Impactoforganicandinorganicfertilizersonyield,taste, and nutritional quality of tomatoes. J. Plant Nutr. Soil Sci. 2006, 169, 535–541. [CrossRef]

Hossain, A., M., Akamine, H., Ishimine, Y., Teruya, R., Aniya, Y. and Yamawaki, K., 2009. Effects of relative light intensity on the growth, yield and curcumin content of turmeric (*Curcuma longa* L.) in Okinawa, Japan. *Plant production science*, *12*(1), pp.29-36.

Howard LR. 2000. Changes on phytochemical antioxidant activity of selected pepper cultivars (*Capsicum* Species) as influenced by maturity. Journal of Agricultural Food chemistry 48(5), 17131720.

Huez López, M.A., Ulery, A.L., Samani, Z., Picchioni, G. and Flynn, R.P., 2011. Response of chile pepper (*Capsicum annuum* L.) to salt stress and organic and inorganic nitrogen sources: I. growth and yield. *Tropical and Subtropical Agroecosystems*, 14(1).

References

Islam, K.K., Pervin, M.J., Rashid, M.H., Mondol, M.A. and Rahim, M.A., 2008. Performance of winter vegetables grown under coconutlemon based multistrata agroforestry system. *Tropical and Subtropical Agroecosystems*, 8(2), pp. 165-170.

Islam, M. A., Islam,S., Akter,A., Rahman, M. H.and Nandwani, D., 2017.Effect of Organic and Inorganic Fertilizers on Soil Properties and the Growth, Yield and Quality of Tomato in Mymensingh, Bangladesh.

Kan, E., LAMERS, J.P., Eshchanov, R. and Khamzina, A., 2008. Small-scale farmers'perceptions and knowledge of tree intercropping systems in the khorezm region of uzbekistan. *Forests, trees and livelihoods*, 18(4), pp. 355-372.

Karungi J, Obua T, Kyamanywa S, Mortensen CN, Erbaugh M., 2013. Seedling protection and field practices for management of insect vectors and viral diseases of hot pepper (*Capsicum chinense* Jacq.) in Uganda. International Journal of Pest Management. DOI:10.1080/09670874.2013.772260 (online first)

Kassa, G., 2015. Profitability analysis and determinants of fruit tree based agroforestry system in Wondo District, Ethiopia. *African Journal of Agricultural Research*, 10(11), pp.1273-1280.

Khan HA, Ayub CM, Pervez MA, Bilal RM, Shahid MA, Ziaf K., 2009. Effect of seed priming with NaCl on salinity tolerance of hot pepper (*Capsicum annum* L.) at seedling stage. Environ. Exp. Bot., 60: 7785.

Khan, S.A., Hussain, M., Noureen, N., Fatima, S., Ane, N.U. and Abbas, Z., 2015. Yield performance of turmeric varieties intercropped with mulberry plantations. *Am Eurasian J Agric Environ Sci*, 15, pp. 2076-2079.

Kumar Devendra, Mehera B, Kalra Alok and Bijalwan Arvind. 2014. Yield and oil quality of Patchouli [*Pogostemon cablin* (Blanco) Benth.] under Teak (*Tectona grandis* Linn.f.) based agroforestry system in

India. *Research Journal of Forest and Environmental Protection,* 1(2): 81-89.

Leakey, R.1996. Definition of agroforestry Revisited. Agroforestry Today,8:1.

Long, C., Cai, K., Marr, K., Guo, X., and Ouyang, Z.2003. Lacquer-based agroforestry system in western Yunnan, China. Agroforestry Systems 57: 109–116.

MacDicken KG, Vergara NT (1990) Agroforestry: classification and management. Wiley, New York

Madhu, M., Nalatwadmath, S.K., Seshachalam, N., Samraj, P. and Raghunath, B., 2005. Effect of lopping interval on growth and biomass production of *Eucalyptus globulus* and yield of intercrops in the high hills of Nilgiris. Indian J. Soil-Cons.

Miah, M.M.U., Islam, M.S., Sikder, M.S.I., Mondol, M.A.S. and Huda, S., 2008. Performance of tomato under Ghoraneem and Sissoo based agroforestry systems. *J Innov Dev Strategy*, 1, pp.39-42.

Michon, G., Mary, F. and Bompard, J.1986. Multistoried agroforestry garden system in West Sumatra, Indonesia. Agroforestry Systems 4: 315-338.

Mutanal, S.M., Patil, S.J. and Girish, S., 2009. Performance of arable crops in a teak based agroforestry system. *Karnataka Journal of Agricultural Sciences*, 22(4), pp. 854-856.

Narain, P., Singh, R.K., Sindhwal, N.S. and Joshie, P., 1997. Agroforestry for soil and water conservation in the western Himalayan Valley Region of India 1. Runoff, soil and nutrient losses. *Agroforestry Systems*, 39(2), pp. 175-189.

Oladokun, M.A.O., 1990. Tree crop based agroforestry in Nigeria: a checklist of crops intercropped with cocoa. *Agroforestry systems*, 11(3), pp. 227-241.

Pouliot, M., Bayala, J. and Ræbild, A., 2012. Testing the shade tolerance of selected crops under Parkia biglobosa (Jacq.) Benth. in an agroforestry parkland in Burkina Faso, West Africa. *Agroforestry systems*, 85(3), pp. 477-488.

Pramila, A.V. and Singh, J.P., 2016. Potential of turmeric and zinger in poplar based agroforestry. *Agroforestry*, p. 227.

Rahman, M.A., Rahman, M.M., Begum, M.F. and Alam, M.F., 2012. Effect of bio compost, cow dung compost and NPK fertilizers on growth, yield and yield components of chili. *International Journal of Biosciences*, 2(1), pp. 51-55.

Rahman, S.A., Imam, M.H., Snelder, D.J., and Sunderland, T. 2012. Agroforestry for livelihood security in Agrarian landscapes of the Padma floodplain in Bangladesh small scale forestry,11(4):529-538.

Rathore, A.C., Saroj, P.L., Lal, H., Sharma, N.K., Jayaprakash, J., Chaturvedi, O.P., Raizada, A., Tomar, J.M.S. and Dogra, P., 2013. Performance of mango based agri-horticultural models under rainfed situation of Western Himalaya, India. *Agroforestry systems*, 87(6), pp. 1389-1404.

Salvin, J.L. and Lloyd, B., 2012. Health benefits of fruits and vegetable advances in nutrition.

Schoch, P.G. (1972) Effects of shading on structural characteristics of the leaf and yield of fruit in *Capcicum*. J. Amer. Soc. Hort. Sci.,97(4):461-464.

Segnou J, Amougou A, Youmbi E. and Njoya J. 2013. Effect of Chemical Treatments on Pests and Diseases of Pepper (*Capsicum annuum* L.). Greener Journal of Agricultural Sciences, 3 (1): 12-20

Shinde, A.K., Jadhav, B.B., Dalvi, V.V., Yadav, J.K. and Ban, Y.G., 2010. Correlation and path coefficient analysis in finger millet (*Eleusine coracana Gaertn*.) under mango based agroforestry system. *Journal of Maharashtra Agricultural Universities*, 35(2), pp. 221-224.

Singh, N.I. and Chauhan, J.S., 2009. Response of French bean (*Phaseolus vulgaris* L.) to organic manures and inorganic fertilizer on growth and yield parameters under irrigated condition. *Nature and Science*, 7(5), pp. 52-54.

Ullah, M.S., Islam, S., Islam, M.A. and Haque, T., 2010. Effects of organic manures and chemical fertilizers on the yield of brinjal and soil properties. *Journal of the Bangladesh Agricultural University*, 6(2), pp. 271-276.

Umrao, M.S.; Islam, S.; Islam, M.A. and Haque, T.,2013. Effects of organic manures on the yield of garlicunder *Tectona grandis* based Agroforestry System. J. Bangladesh Agric. Univ. 2013, 6, 271–276. [CrossRef]

Vimala, P., Melor, R., Shokri, O.A. and Balasubramaniam, P., 2007. Effect of organic and inorganic fertilizers on growth, yield and nutrient content of bird chili (*Capsicum frutescence*). *Journal of Tropical Agriculture and Food Science*, 35(1), p. 29.

Vitkar, M.N., Manolikar, R.R., Vasmate, S.D., Kalalbandi, B.M. and Patil, M.F., 2007. Effect of organic and inorganic fertilizers on growth and green fruit yield of chili (*Capsicum annum* L.). *Asian Journal of Horticulture*, 2(2), pp. 273-276.

Wahyuni Y, Ballester A.R, Sudarmonowati E, BinoRJ, Bovy AG., 2013. Secondary Metabolites of Capsicum Species and Their Importance in the Human Diet. J. Nat. Prod., DOI: 10.1021/np300898z (online first)

Zhani, K., Hermans N., Ahmad, R. and Hannachi, C., 2013. Evaluation of Salt Tolerance (NaCl) in Tunisian Chili Pepper (*Capsicum frutescens* L.) on Growth, Mineral Analysis and Solutes Synthesis. Journal of Stress Physiology and Biochemistry, 9(1):209-228.