SUITABILITY OF MANGO BASED AGROFORESTRY SYSTEMS FOR ORGANIC CARROT PRODUCTION

A THESIS

BY

SHAMIMA AKTAR

Student No.: 1605113

Session: 2016

Thesis Semester: January-June, 2017

MASTER OF SCIENCE (M.S.)

IN

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DEPARTMENT OF AGROFORESTRY AND ENVIRONMENT

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

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June, 2017

Dedicated

To My

Beloved Parents

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June, 2017 ***The author***

SUITABILITY OF MANGO BASED AGROFORESTRY SYSTEMS FOR ORGANIC CARROT PRODUCTION

ABSTRACT

A field experiment was carried out at the Agroforestry and Environment Research Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, during January to March 2017 in order to evaluate the suitability of mango based agroforestry systems for organic carrot production. The experiment was laid out in two factorial RCBD with 3 (three) replications. Factor A: was five Fertilizer and Manure Applications viz. F_1 = No fertilizer & no pesticide, F_2 = Recommended chemical fertilizer & normal pesticide, F_3 = 100% cowdung manure + neem oil spray as bio-pesticide, F_4 = 100% poultry manure + neem oil spray as bio-pesticide, F_5 = 50%cowdung with 50%poultry + neem oil spray as bio-pesticide and Factor B: was two production system viz. S_1 = Open/sole cropping of carrot, S_2 = Mango + carrot. So there were ten fertilizer and manure applications combinations such as, S_1F_1, S_1F_2, S_1F_3, S_1F_4, S_1F_5, S_2F_1, S_2F_2, S_2F_3, S_2F_4 and S_2F_5. The results of the experiment revealed that there was a significant effect of the fertilizer and manure applications consider pesticide managements practices on the growth, yield contributing characters and yield of carrot. In case of main effects of fertilizer and manure applications, the result was found significant variation in respect of plant height, number of shoot, root length, root diameter, weight of root/plot, hulm weight/plot, yield ton/ha respectively but dry weight(g) was varied insignificantly. The highest yield (17.15 t/ha) was recorded when carrot cultivated with chemical fertilizer and the lowest yield (9.58 t/ha) was found when carrot cultivated with no fertilizer. Again the significant effect of production systems was also found on plant height, number of shoot, hulm weight/plot, yield ton/ha of carrot respectively. But root length, root diameter, weight of root/plot, dry weight (g) were not significantly varied. Yield of carrot was lower when it was grown under mango based agroforestry systems, whereas the yield was higher in sole cropping of carrot and it was 25.62% more as compare to mango based agroforestry system. In case of interaction effect of the carrot production systems and fertilizer & manure applications, it was found that yield of carrot was higher when it was grown with chemical fertilizer under open, whereas the yield was lower with no fertilizer in open condition. However, the suitability of the cultivation of carrot considering fertilizer and manure applications under mango based agroforestry systems might be ranked as Chemical fertilizer > Cowdung + poultry> Cowdung > Poultry > No fertilizer. From the economic analysis, it was observed that the higher BCR (3.04) was recorded in Mango + Carrot based agroforestry system where chemical fertilizer was applied. On the other hand, the lower BCR (1.42) was received from the sole cropping of carrot where fertilizer was not applied. Finally, it may be concluded that, the application of organic manure gave less production as compared to chemical fertilizer application. But, if we consider the benefit of organic manure application in terms of environmental benefit, soil health and safe carrot production then cultivation of carrot at the floor of mango orchard with organic manure application like Cowdung + poultry may be a promising orchard based agroforestry system in the northern part of Bangladesh.

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INTRODUCTION

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INTRODUCTION

Carrot (*Daucus carota* L.) is an important vegetable which is ranked third among the succulent vegetables in world production (Yamaguchi, 1983). It belongs to the family Apiaceae and originated in south Asia, in what are now known as Afghanistan, Iran and Pakistan. Now a days this vegetable is cultivated in many countries throughout the world such as the Americans, Europe, south-west Asia and Africa (Rubatzky *et al*., 1999). In all these countries, carrots are one of the vegetables cultivated for their high nutritional value (Al-Harbi *et al*., 1997; Munro and Small, 1997). The plant is a biennial, i.e. it grows vegetatively in the first season and produces seed in the second. For root production the plant is grown as an annual. Carrot is the second most popular type of vegetable after potatoes in Bangladesh. Carrot is good source of vitamins A and C & prevents heart diseases (Joubert *et al*.,1980). It are delicious eaten raw, in salads or on sandwiches, and take on a wonderful sweetness when cooked. In Bangladesh recent statistics shows that carrot was grown in 4155 acre of land and the total production was approximately 14145 metric tons in 2014-2015. Thus the average yield of carrot was 3404 kg per acre. In case of Dinajpur, carrot was grown in 108 acre of land and the total production was approximately 198 metric ton and the yield was 1833 kg per acre in 2014-2015 (BBS, 2015). However, the yield of the crop is very low compared to those obtained in some advanced country. But Bangladesh is one of the most densely populated countries in the world with more than 155 million people. Due to its very small territory (147,570 square kilometers), the amount of additional land available to be brought into cultivation is very limited (BBS, 2006). The country has 8.20 million hectare arable land against the huge population (Hassan, 2011). More than 70% of the population depends on agriculture (Jensen, 2000). So there is limited scope to increase carrot production horizontally due to agricultural land scarcity. So, we should give more emphasis of vertical expansion of carrot production and this may be done through proper carrot based agroforestry system.

Indeed, agroforestry may be the best alternative to minimize the gap between demand and production of vegetables like carrot. Actually, agroforestry is a land use system in order to the integration of tree and crops on the same area of land which is a promising production system for maximizing yield (Nair, 1990) and maintaining eco-friendly environment. Growing vegetables in association with trees is becoming popular day by day for its higher productivity. Agroforestry has the potentiality to utilize the light resources as well as improves the production levels and can maintain soil quality. But the main thing is selection of suitable understorey crop and tree species for agroforestry system. The selection of crop species as understorey crop depends on several factors such as shade tolerance, behavior of crop species, characteristics of the upperstorey tree species and the resources availability. In Bangladesh, a large number of vegetables are now grown of which most of them are grown in winter season. Among the different winter vegetables, carrot is the important one. Though carrot is very common to all and has good production potential in Bangladesh climate, but it was not systematically tested in agroforestry system or in natural shade condition to see its production ability under partial shade condition. A very little scientific research work was done in this field. Moreover, which carrot fertilizer and manure application gives good production under tree is yet not identified clearly. So, different carrot fertilizer and manure application should be screened out in terms of their adaptability and yield under different tree canopies of various shade levels.

Again to ensure food for the giant population, ‘green revolution’ was appeared in 1960s with the concept of ‘producing more food’ and within very short period, it was implemented in Bangladesh like other Asian countries. It has created a terrible stress on limited land resources. New crop varieties (HYV), as well as chemical fertilizers, pesticides and groundwater irrigation were introduced. As a result, urgent need of more production has achieved. A suicidal policy of just extraction of soil was followed, while soil fertility conservation issue was totally ignored (Charkarborty, 2008). And the current global scenario firmly emphasizes the need to adopt eco-friendly agricultural practices for sustainable food production. The cost of inorganic fertilizers is increasing enormously to an extent that they are out of reach of small and marginal farmers. The problems associated with the use of hazardous chemicals for crop protection, weed control and soil fertility are receiving increasing attention worldwide since pests, diseases and weeds become resistant to chemical pesticides. And continuous application of synthetic fertilizers and other chemicals had created many problems such as topsoil depletion and degradation, reduced soil microbial activities, groundwater contamination. The use of chemicals is increasing over the years in Bangladesh but farmers are not getting as much production as they should have. The unrecovered fertilizers and pesticides are often leached to groundwater supplies or transported in runoff to surface water and environmental pollution and ecological imbalances may occur. It is said that a good soil should have an organic matter content of more than 3.5%, but in Bangladesh most soils have less than 1.7%, and some soils have even less than 1% organic matter (BARC, 1997). Thus, the indiscriminate uses of chemical inputs has been considered as the foremost reason for stagnating or declining crop productivity, loss of bio-diversity and have threatened the sustainability of agriculture, affecting the quality and safety of produce and health and well being of humanity. Application of organic fertilizers has been a noble and traditional practice of maintaining soil health and fertility. The use of this organic fertilizers results in higher growth, yield and quality of crops. They contain macro nutrients, essential micronutrients, many vitamins, growth promoting factors like IAA, GA and beneficial microorganisms (Natarjan, 2007; Sreenivasa *et al*, 2010). Organic manures can improve soil-water-plant relations through modifying bulk density, total porosity, soil water relation and consequently, increasing plant growth and water use efficiency (Obi and Ebo, 1995). Addition of organic manure enhance microbial activity and increase their ability to conserve fertigation and consequently increasing their fertility and fertilizers use efficiency as a final goal (Nanwai *et al*, 1998). Awadm *et al* (2002) stated that organic manure contains high levels of relatively available nutrients elements, which are essentially required for plant growth. Moreover it plays an important role for improving soil physical properties. Sustainability in agro-ecosystems involves environmental friendly techniques based on biological and non- chemical methods (Bonato and Ridray, 2007).

However, Mango (*Mangifera indica* L.) is a member of the family Anacardiaceae. The mango is one of the most common, important and popular fruits in Bangladesh. Mango is regarded as one of the kings of sub-tropical fruits. Besides, having delicious taste, captivating flavor with multifarious color, it is an excellent source of nutritive values. It is good source of Vitamin A,B6,E, K & C (Slavin 2012). It contains rich in fiber & prevents night blindness & dry eyes. It decreases risk of cancer. The calorific value of mango is mostly derived from the sugars. It is as high as that of grapes and even higher than that of apple, pears or peaches. The protein content is generally a little higher than that of other fruits except the avocado. Mangos are also a fairly good source of thiamine and niacin and contain some calcium and iron. Further research is still ongoing but some studies have already revealed that mangoes are a great natural remedy for diabetics.

Again there is a great diversity of mango fruit types which permits considerable manipulation for various purposes and markets: juice, chutney, pickles, jam/jelly, fresh fruit, canned and/or dried fruit etc. given the multiple products, it is therefore a potential source of foreign exchange for a developing country. It is also a source of employment for a considerable seasonal labour force. Bangladesh is one of the major mango producing countries along with India, Pakistan, Mexico, Brazil, the Philippines, etc. (Alexander, 1989). In Bangladesh, mango occupies about an area of 50,491 ha with a production of 187220 tones according to BBS, 2003. It is now in an increasing trend in area by 112% and in production by 116% in the year of 2000-01 compared to 1984-85 (BBS, 2002). So, increase of production are now a time-demand. Now mango orchards are increasing day by day in the northern part of Bangladesh. The owners of mango orchard also using the floor of young orchard for different vegetables and spices cultivation. But usually they are using chemical fertilizer and pesticide for this mango based agroforestry system. Whereas there are huge scope of organic vegetable like carrot production at the floor of young mango orchard. Information regarding organic carrot production under mango based agroforestry system is very scant in Bangladesh. So, considering the above circumstances the propose study will be conducted in order to evaluate organic carrot production possibility under mango orchard.

Keeping this view in the mind the present study was undertaken to investigate the following objectives:

1. To compare the chemical fertilization and organic manuring for carrot production under mango based agroforestry system.
2. To find out the best fertilizer and manure application for carrot production in both sole cropping and mango based agroforestry system in term of economic benefits.

CHAPTER 2

REVIEW OF LITERATURES

CHAPTER 2

REVIEW OF LITERATURE

Carrot is the most important and popular vegetable crop of the world as well as in Bangladesh. Experiment regarding different aspects of carrot production have been conducted in various parts of the world. But research on the effects of organic and inorganic fertilizers in agroforestry system on the growth and yield of carrot is sporadic in scientific literature. In Bangladesh, available literature regarding organic and inorganic fertilizers for carrot are insufficient and conflicting. However some of the literature to organic and inorganic fertilizers in agroforestry system on carrot production are reviewed in this chapter.

2.1 Significance of Agroforestry
2.2 Effects of organic manures on the growth and yield of carrot
2.3 Use of Organic Manures
2.4 Effects of inorganic fertilizers on the growth and yield of carrot
2.5 Mango based Agroforestry systems
2.6 Temperature influences on growth, yield and quality of carrots
2.7 International trade in organic products

2.1 Significance of Agroforestry

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

The emergence of Agro forestry was mainly influenced by the need to maximize the utilization of soil resources through the "marriage of forestry and agriculture" (PCARRD, 1983).

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

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

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

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).

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 the present needs without sacrificing the needs of future (Brundtl and Commission, 1987).

Farmers of Bangladesh are conscious about environment but they are illiterate, resource poor and highly dependent on purchased inputs. A small portion of farmers realise the importance of ecological agriculture and there are some farmers who never use synthetic fertilizer or pesticide. They are struggling for their survival and even don't know the meaning of organic farming. Overall, as stated by Byerlee *et al*. (2010), the agriculture-for-development mission remains substantially incomplete.

The benefits of agroforestry systems can be significantly enhanced through traditional soil and water conservation techniques, as seen in Burkina Faso, where farmers practicing such techniques (e.g., stone dykes and soil pits filled with organic matter) were found more likely to regenerate and protect trees in their fields. Trees can be beneficial for cash crops such as coffee and cacao as well. Coffee is sensitive to microclimate fluctuations—e.g., the optimal temperature range for Arabica coffee is 18–

21°C. Lin BB. Agroforestry management as an adaptive strategy against potential microclimate extremes in coffee agriculture. Agric Forest Meteorol 2007, 144:85–94.

Shade trees control temperature and humidity fluctuations and can also provide protection from wind and storm events that defoliate coffee trees. Lin BB, Perfecto I, Vandermeer J. Synergies between agricultural intensification and climate change could create surprising vulnerabilities for crops. Bioscience 2008, 58:847–854.

Research in coffee systems In Chiapas, Mexico, showed that shade decreases temperature and humidity fluctuations and reduces vulnerability to water stresses. Lin BB. The role of agroforestry in reducing water loss through soil evaporation and crop transpiration in coffee agroecosystems. Agric Forest Meteorol 2010, 150:510–518.

In Sulawesi, Indonesia, a study showed that cacao systems shaded by Gliricidia trees are not significantly affected by drought because of shade and water uptake from the trees. Schwendenmann l, Veldkamp E, Moser G, Holscher D, Kohler M, Clough Y, Anas I, Djajakirana G, Erasmi S, Hertel D. Effects of an experimental drought on the functioning of a cacao agroforestry system, Sulawesi, Indonesia. Glob Change Biol 2010, 16:1515–1530.

The reviewed studies show that trees have the potential to improve soil fertility, soil moisture, and microclimate in agriculture and make crop production more resilient to climate variability. The studies provide evidence from biophysical field measurements, agronomic surveys, and yield measurements in different agricultural systems during rainy seasons and dry spells. The degree of effectiveness of trees in sustaining agricultural production, however, varies across regions and crop types due to differences in soil properties, rainfall, and other characteristics. Garrity DP, Akinnifesi FK, Ajayi OC, Weldesemayat SG, Mowo JG, Kalinganire A, Larwanou M, Bayala J. Evergreen agriculture: a robust approach to sustainable food security in Africa. Food Secur 2010, 2:197–214.

2.2 Effects of organic manures on the growth and yield of carrot

Optimum organic manure is one of most important and uncontroversial factors for maximizing the yield of a crop. It influences the physical, chemical and biological properties of soil though its nutrient quantity present in the soil is less. The response of crops to the applied organic manure is slow but its residual effects last for a long period.

Krupkin *et al*. (1994) made an investigation using poultry manure, a mixture of poultry manure plus hydrolysis lignin, and a compost of poultry manure plus hydrolysis lignin as organic fertilizers for potatoes, carrots, cabbage etc. with and without irrigation. The results showed that these organic manures improved the yield and quality of the crop, especially on soil having a low content of nitrate N, but had only little effect on soils well supplied with nitrate N. the lignin based fertilizers i.e. mixture of poultry manure and hydrolysis lignin and a compost of poultry plus hydrolysis lignin were similar in their effect of poultry manure.

Sediyama *et al*. (1998) carried out a field experiment of carrot (cv. Brasilia) with seven types of organic compounds which were produced from liquid swine manure and straw materials: crushed sugarcane, napier grass (*Pennisetum purpurenum*) and coffee straw and crushed sugarcane with or without gypsum or triple superphosphate; dry swine manure; chemical fertilization and an untreated control. Both a greater plant height and aerial part yield were obtained from fertilizer and manure applications with organic compounds and dry swine manure. The organic compound produced from coffee straw and liquid swine manure provided a greater yield of total and commercial roots. Enrichment of the organic compound crushed sugarcane plus liquid swine manure with gypsum or triple superphosphate did not affect root yield.

Lebedeva *et al*. (1998) found that the effect of liming and organic fertilization on the lead content in agricultural crop and reported on the basis of field and laboratory studies in the Moscow region of Russia on dernopodzolic soils contaminated with lead (up to 500 mg/kg soil), the soil pH and content of organic manure was determined which would enable the safe production of dill (*Anethum graveolens*), red beet and carrot.

A field experiment was conducted by Damagala *et al*. (1998) on 3 sites near Rzeszow, poland with carrot cultivars Joba and Flacore. Ammonium sulfate was applied at seed sowing by broadcasting or placement or at the 3 to 4 leaf stage by placement. Placement involved application in rows 7-10 cm deep in the middle of every second inter row of plants. Ammonium sulfate was applied at a rate calculated to achieve a soil N content of 75 mg/dm3. On all sites carrot yields harvested from placement fertilizer and manure applications were significantly higher than that from broadcast fertilizer and manure applications. Irrespective of fertilizer application method, the lowest contents of nitrates were detected in roots cultivated in heavy soil containing 1.8% organic manure.

Nielsen *et al*. (1998) carried out a field experiment to test the potential of various organic wastes as soil amendments in horticultural production, in British Clumbia, Canada. They grew swiss chard (*Beta vulgaris*) and carrot during 1993-1995 under irrigation in a coarse textured soil. British Clumbia soil to which annual application of 45 t/ha of various organic amendments included biosolids, biowastes and peat. Yield of both chard and carrot were increased for some organic fertilizer and manure applications plus fertilizer relative to lots receiving commercially recommended rates of NPK-fertilizer only. The evidence suggested that many locally produce biosolids and biowastes have the potential to improve soil quality and the growth of high value horticultural crops, especially carrot.

Schuch *et al*. (1999) worked on the effects of organic manure (chicken and quail) on yield and quality of carrot cv. Nantes Forto, Flakkese, Fuyumaki, Nantes Superior and Harumaki Kinko in 1993 and 1995. In 1995, cv. Nantes superior and Harumaki Kinko were replaced by Brasilia and Tin Ton. Manure was applied at 4.5, 6.5 and 15 t/ha in 1993 followed by 2.1, 2.6 and 15 t/ha in 1995. In the 1993 experiment, Nantes produced the highest root yield. Root number, weight, diameter and length varied with different amounts of manure applied. Application of organic manure generally increased all the parameters evaluated.

Hasan (2014) evaluates performance of two winter vegetables viz. Kangkong and Indian spinach in alley cropping system with Ipil-ipil tree (*Leucaena leucocephala*) under different treatments. Different treatments of the experiment were T_0 = Control (without fertilizer and manure), T_1 = Ipil-ipil leaf biomass (ILB) as manure, T_2 = ILB + 1/4 RFD (Recommended Fertilizer Dose), T_3 = ILB + 1/2 RFD (Recommended Fertilizer Dose). It was found that growth parameters viz. plant height (cm), number of branches per plants, number of leaves per plants, leaf size (length × breadth, cm2), stem girth (cm) and weight per plant (g) of both Kangkong and Indian spinach were almost similar in all manure/fertilizer treated plots. Yield of both Kangkong and Indian spinach was statistically similar with all fertilizer treated plots but it was drastic reduced in without fertilizer treated plots. The highest yield of Kangkong and Indian spinach 41.2 and 53.5 t/ha, respectively in ILB and ½ RFD treated plot and lowest was 15.5 and 18.5 t/ha, respectively in control plot. Yield of all Kangkong and Indian spinach was 5-7 % and 10-12 % lower in ILB+1/4RFD treated condition and only ILB treated condition, respectively.

Uddin *et al.* (2013) conducted a field experiment with the aim of evaluating the growth performance of winter crop viz. Carrot (Daucus carota) grown under 3 years' old Akashmoni tree saplings. The Experimental design was 2 Factorial RCBD Design with three replications. The 1st factor was4 different distances viz. 0 (open field), 0-1.5, 1.5-3 and 3-4.5 feet distant from tree sapling bases and the 2nd factor was 4 different fertilizer doses viz. RFD (Recommended Fertilizer Dose), OM (Organic Manure), ½RFD+½OM, NF (Non Fertilizer). The result showed that the highest value of yield was 28t/ha at RFD in control. The lowest value of yield was 11.2t/ha recorded under NF in control. Among different distance groups in association with Akashmoni yield of Carrot was ranking as 3-4.5 ft.> 1.5-3 ft.> 0-1.5 ft. distances from tree base. Total yield of Carrot along with Akashmoni in RFD in T_3, T_2, T_1 treatment were 27.16, 23.80 and 21 t/ha, respectively, in OM in T_3, T_2, T_1 treatment were 23.09, 20.23 and 17.85t/ha, in ½RFD+½OM in T_3, T_2, T_1 treatment were 26.29, 23.09 and 20.37 t/ha and in NF in T_3, T_2, T_1 treatment were 10.86, 9.52 and 8.4 t/ha, respectively.

Fujime *et al.* (2001) observed that carrot yield was increased by the application of sewage sludge ash at 0, 8, 16 and 24 kg/3m2to the carrot plots while the pH values remained neutral.

Oliveria *et al.* (2001) studied the effect of earthworm compost and mineral fertilizers on root production in carrot and found that the different levels (0, 15, 20, 25 and 30 t/ha) of earthworm compost, in the presence or absence of mineral fertilizers, on the production (cv. Brasilla Nova Selocoa) of root was evaluated in a field experiment conducted in Areia (Praibaj), Brazil during July-October, 1997. Earthworm compost at 25 t/ha produced the highest total (70.1 t/ha) And marketable (31.1 t/ha) yields and the lowest non-marketable yield of roots (39.0 t/ha). The production of Extra-A and Extra grade roots was increased linearly as earthworm compost rates increased. Production of Extra-

A and Extra grade roots was increased by approximately 0.6 and 0.16 t/ha for each of tons of earthworm compost added in the soil. The presence of mineral fertilizers increased root yields and increased the production of Extra-A a Extra grade, special and first grade roots by 4.9, 5.6, 1.7 and 19.4 t/ha respectively, compered to its absence.

Mesquita *et al*. (2002) conducted an experiment on a clayey yellow Red Oxisol to evaluate the residual effects of the application of phosphorus and urban waste compost of the previous two years on the root production of carrot cv. Brasilia in Brazil. Carrot plants were harvested 90 days after planting. After the harvest a linear and quadratic effect for phosphorus and urban waste compost ($p \leq 0.01$) was observed. The linear interaction P X quadratic urban compost was highly significant. The maximum root production was 26.5 t/ha corresponding to 18.5 t/ha of P_2O_5 and 53.2 t/ha or urban waste compost.

Rahman *et al*., (2013) evaluated the growth performance of three winter vegetable crops (Chilli, Radish and Sweet gourd) grown under two years old Akashmoni tree of different distances. The morphological characters and also yield contributing characters were increased gradually in treatments where vegetable distance was more from Akashmoni tree base. The lowest Akashmoni tree growth was found under Tree- Radish based agroforestry system. Among the three vegetable crops the higher Akashmoni tree growth was found in association of Chilli compared to other tree-crop associations.

Rakib *et al*. (2013) studied the performance of radish in association with three fruit tree species during winter season. The result showed that yield of Radish association with Guava, Lemon and Mango as vegetables and seed production was gradually increased with increasing distance from the tree base. Both as vegetable or seed production of Radish in association of these three fruit trees are rank as Mango > Guava > Lemon. Growth of all fruit trees was observed as height and girth increment. Height and girth increment of Mango, Guava and Lemon tree was little bit higher under control (without Radish) condition.

The chicken manure fertilizer and manure applications probably improved the physical soil properties and increased the levels of soil nutrients which improved plant growth and increased the root size. Asiedu *et al*. (2007) also reported increased yield of carrot with the application of poultry manure and cowdung compared to the control.

Carrot is usually cultivated as an annual crop in the tropics (De Lannoy, 2001). The crop is tolerant to soil pH of 5.5 to 6.5 and it requires a deep and well-drained loamy soil with high amount of organic matter (Yayock *et al*., 1988). Therefore, judicious and proper use of organic manures is very essential not only for obtaining higher yield and quality produce but also to maintain soil health and sustainability for longer period.

Kahangi (2004) has recommended the application of 10-20 t/ha poultry manure for improved growth and yield of carrot in the tropics. Vegetables that are produced by using organic manures are gaining importance because of less chemical residues and better taste. Considering the adverse effects on soil health and environment, besides the residual effect, luxurious usage of inorganic fertilizers is not advisable.

Bali (2012) conducted research on effect of guava and lemon yield of okra produced as agroforestry practice. The result showed that yield of okra was gradually increased with increasing distance from both of tree base. Yield of okra was height in open field condition. However, yield of okra in association with Guava Reduced by 2.25, 22.26 and 38.89% yield in 5-7.5ft, 2.5-5ft and 0-2.5ft distance respectively. On the other hand, okra yield reduced 6.8, 26.6 and 43.7%yield in 5-7.5ft, 2.5-5ft, and 0-2.5ft distance respectively from lemon tree base The okra yield differences was 5-7% higher in association with Guava.

Among the oil cakes, neem and castor cakes are quickacting though insoluble in water and they provide slow and steady nourishment and protection from nematodes and improve yield and quality of produce (Gaur *et al*., 1992). Keeping the importance of organic manures in view, the present experiment was undertaken to study the effect of different organic manures in comparison with inorganic fertilizers on yield and quality of carrot.

2.3 Use of Organic Manures

Many studies have demonstrated that application of manure will produce crop yields equivalent or superior to those obtained with chemical fertilizers (Xie and MacKenzie, 1986; Motavalli *et al*., 1989). Crop quality has also been improved by manure application (Eck *et al*., 1990; Pimpini *et al*., 1992). Manure improves the physical condition of the soil and increases P and biological activity (Sommerfeldt and Chang, 1985; Chang *et al*., 1990; CAST, 1996). The organic matter, total N and micronutrient content of the surface soil are increased as a result of manure application.

The application of manures improves soil fertility and increases crop yield. It makes both macro and micro nutrients available to plants and also improves soil structure and enhances root growth. Manures also promote the activities of soil micro-organisms which convert organic matter into humus and promote plant growth (Dupriez and De Leener, 1988).

Although chicken manure is the most frequently used organic manure in peri-urban vegetable production in Ghana, the quantities applied by farmers are often not based on research recommendations. Frempong *et al*. (2006) found that the levels of organic matter, soil nutrients and cation exchange capacity increased with chicken manure and this led to improvement in the vegetative growth of okra.

The use of organic inputs such as crop residues, manures and compost has great potential for improving soil productivity and crop yield through improvement of the physical, chemical and microbiological properties of the soil as well as nutrient supply (Tandon, 1992; Stone and Elioff, 1998).

In Kenya, the value of manure is approximately five times that of its chemical fertilizer equivalent value (Lekasi *et al*., 1998). This is presumably related to the effect of manure on the physical properties of soil as well as its role in plant nutrient supply. The addition of organic materials either in the form of manures or crop residues has beneficial effects on the soils chemical and physical properties. Compost is also a slow-release fertilizer. Compared with fresh manure, its N is in a more stable form and not susceptible to loss as NH3 gas (Leonard, 1986). Leonard (1986) reported NPK ranges for composted materials as 0.75 – 1.5 % N, 0.25 – 0.5 % P_2O_5 and 0.5 – 1.0 % K_2O.

Animal manures are valuable sources of nutrients and the yield-increasing effect of manure is well established. Apart from the nutrients in manure, its effects on the improvement of soil organic matter, soil structure and the biological life of the soil are well recognized particularly at high rates of application in on-station trials. There is also some evidence that it may contain other growth-promoting substances like natural hormones and B vitamins (Leonard, 1986). Plants can only use nutrients that are in an inorganic form. Manure N and P are present in organic and inorganic forms, and are not totally available to plants. The organic forms must be mineralized or converted into inorganic forms over time before they can be used by plants. The availability of K in manure is considered similar to that in commercial fertilizer since the majority of K in manure is in the inorganic form (Motavalli *et al*., 1989). In general, 90 to 100 % of K in manure is available during the first year of application.

Organic Agriculture is an agricultural classification that promotes environmentally, socially and economically sound production of food, fibre, timber etc. In this system, maintenance of soil fertility is considered as the key to successful production…. "It avoids the use of chemo-synthetic fertilizers, pesticides and pharmaceuticals. It also includes social considerations (IFOAM, 2005b).

The people all over the world are expressing great concern over the indiscriminate use of chemicals. Therefore, emphasis is now focussed on the use of organic and other by products of agriculture and industries (Mishra, 2005). Scientific researches have proved that the reduction or non-use of synthetic chemicals can reduce environmental hazards and possible adverse effects. For a sound future, organic farming offers a dynamic interaction between soils, plants, humans, ecosystem and environment (IFOAM, 1996).

Agriculture before the industrial revolution was by definition mostly organic because agricultural chemicals were not available (Jordan, 2004). Modern organic farming was founded as a reaction against agricultural practices that had the potential to harm nature and human health. The organic farm movement has provided consumers the option to purchase healthier foods produced in a sustainable, environmentally friendly way, thereby giving them an opportunity to contribute to sustainable agriculture (McCann *et al.*, 1997).

2.4 Effects of inorganic fertilizers on the growth and yield of carrot

In modern agriculture fertilizers are very essential for the production of crops. Inorganic fertilizer today holds the key to the success of the crop production system of Bangladesh Agriculture, being responsible for about 50% of the total production (BARC, 1997)

Dhesi *et al*. (1964) reported that the application of N at 28, 56 or 84 kg/ha, P2O5 at 28 kg/ha and K at 28 or 56 kg/ha significantly increased the plant height, leaf number, root diameter and length. Nitrogen and potassium at 56 kg/ha gave the highest yield of carrot.

Solov'ev and Lapushkina (1978) found that nitrogen had great effect on carrot yield and vitamin accumulation. Phosphorus and potash had no appreciable effect of accumulation of vitamin, carotene, thiamin and riboflavin. The response of carrot to nitrogen was greater than that of phosphorus. The highest increase (62%) in root production was obtained when 160 kg of P2O5 per hectare was applied.

Cole (1984) carried out an experiment to observe the effect of N, P, K and Cu on the yield of carrot and that root formation was very poor in the absence of potassium. White *et al*. (1984) reported that application of NPK at the rate of 1.1 t/ha did not affect the total number, marketable number, per cent marketable and total weight but marketable weight was increased. It was observed that, reduction in the application of potassium fertilizer significantly increased the total production and root yield in Iraq (Salmman, 1985).

Michalik (1985) carried out an experiment at Skierieasce, Poland, to determine the effect of fertilization with macro and micronutrients on the dry matter, sugar and carotene content of carrot and found that nitrogen as ammonium nitrate or urea had no significant effect on dry matter production of root and shoot of carrot.

Jacobson *et al*. (1986) studied the effect of fertilizer in a field trial on carrot involving NPK at 16-5-12 or 14-4-17 with N at 60,120, 80 and 240 kg/ha. Yield was not significantly affected, but the incidence of cavity spot was least at the lowest rate of N and at all rates of N were less with the formulation containing the lower level of K.

Skrbic (1987) trailed over 2 years with 2 cultivars where basal P2O5:K2O at 60:90 kg/ha were applied with varying N rates (0 to 150 kg/ha). N at 30 kg/ha gave the highest total and marketable yields. The cv. Formula gave a higher yield of marketable carrots than Scarlet Nantes, and it also had a higher dry matter content.

Evers (1988) noticed that the shoots reached their maximum weight after 3 months of sowing whereas roots grew slowly during the first 2 months but grew considerably more during both the third and fourth months. The placement of granular NPK fertilizer increased the growth and yield compared to broadcast granular NPK fertilizer. The yield was also increased by the placement of P and K, compered to without placement of fertilizers. There was no difference in yields between single application and split applications. At harvest, fertilization did not affect the root DM content significantly, compared with under fertilized fertilizer and manure applications. The fertilizer and manure applications comprising PK placement with N fertirrigations yielded carrots with a higher DM content than did the NPK fertirrigation fertilizer and manure applications.in addition to the fertilization experiment, there was no appreciable difference in root DM content but the shoot: root ratio was higher than in the conventionally fertilized crops. Yield were smaller for the organically grown crops.

Sarker (1989) carried out an experiment with different levels of nitrogen, phosphorus and potassium on yield components of carrot and noted that application of nitrogen significantly effected on the root length individual root weight and had no significant effect on root diameter.

Evers (1989) observed that the N, P and K content of carrot roots were increased with different levels of NPK fertilizer management. He also reported that unfertilized fertilizer and manure applications had a tendency to higher glucose and fructose content and thus also total sugar contents than did the fertilized fertilizer and manure applications.

Islam, (2014) evaluates performance of two winter vegetables viz. Amaranth and Red Amaranth in alley cropping system with Ipil-ipil tree (*Leucaena leucocephala*) under different treatments. Different treatments of the experiment were T0 = fertilizer and manure, T_1 = Ipilipil leaf biomass (ILB) as manure, T_2 = ILB + 1/4 RFD (Recommended Fertilizer Dose), T_3 = ILB + 1/2 RFD (Recommended Fertilizer Dose) T_4= Control (without fertilizer and manure). Growth and yield of these two crops was recorded in this alley cropping system. It was found that growth parameters viz. plant height (cm), number of leaves per plants, leaf size (length × breadth, cm2), stem girth (cm) and weight per plant (g), Weight of leaves per plant and leaf stem ratio of both Amaranth and Red amaranth were almost similar in all manure/fertilizer treated plots Performance of these two summer vegetables in terms of growth and yield parameters remarkably lower in control plot i.e., without manure/fertilizer treated plot. Yield of both Amaranth and Red amaranth was statistically similar with all fertilizer treated plots but it was drastic reduced in without fertilizer treated plots. Yield of all Amaranth and Red amaranth was 5-7 % and 10-12 % lower in ILB + 1/4RFD treated condition and only ILB treated condition, respectively.

Sadhu (1990) reported that, in most of the varieties of carrot, root grew first in length and then in diameter at a faster N effect. Ultimately the roots became thicker with age. The increase in diameter was most rapid at the crown and was comparatively slow towards the tip.

Sarker *et al*. (1991) noticed that application of N and K significantly increased the yield of carrot. The increasing trend was noticed with an increase in the doses of N and K. Application of phosphorus could not produce any significant effect on yield. Maximum yield (35.91 t/ha) was obtained when NPK was applied at the ratio of 120:120:60 kg/ha.

Balooch *et al*. (1993) carried out an experiment during 1988-89 on Tandojam carrot with 75 or 100 kg P2O5 and 75, 100 or 125 kg K2O /ha. All plots received 100 kg N in 3 split applications during seed bed preparation. They observed that root yield was maximum at the highest NPK rate. This was due to increased root size and weight.

Sharangi and Paria (1995) conducted a field experiment of carrot on a loamy soil with nitrogen fertilizer at 0, 5, 10 or 60 kg/ha and potassium at 0, 40, 50 or 60 kg K2O/ha, phosphorus applied at 60 kg/ha and they found the shoot growth and root diameter were increased with the increasing rate of nitrogen. An interection effect between nitrogen and potassium was significant in relation to the plant height, root breadth and root diameter.

Konopinski (1995) carried out a field experiment at Lublin, Poland on carrot cv. Perfection. The plants received N:P:K at 150:150:300 kg/ha or super fertilizer of French manufacture containing 11% organic matter, 14% Ca, 3.5% Mg, 4% P2O5, 2.5% So3 plus all essential micro nutrients. Super fertilizer was applied at 50 or 100 kg/ha. Using 100 kg/ha rate gave the best yield viz., 70 and 30% over the control.

Volkova (1996) observed that plant nitrate content depends on the various conditions under which the plants are grown. Application of increasing rates of nitrogen in the form of (NH4) NO3 increased the content of nitrates in the carrots. The optimum fertilizer rate to obtained acceptable crops on this soil was 120 kg N+120 kg P+120 kg K producing a yield of 40-50 t/ha.

Leonard, 1986.Stated that Chemical fertilizers are used in modern agriculture to correct known plant nutrient deficiencies; to provide high levels of nutrition, which aid plants in withstanding stress conditions; to maintain optimum soil fertility conditions; and to improve crop quality. Adequate fertilization programmes supply the amounts of plant nutrients needed to sustain maximum net returns. In essence, fertilizers are used to make certain that soil fertility is not a limiting factor in crop production.

Fordham and Biggs (1985) recommended the application of 70-120 kg/ha N, 30-35 kg/ha P and 0-55 kg/ha K for high yield of carrots. Again Schollar and Rober, 1985, stated that carrot is a heavy feeder of nutrients and removes 100 kg N, 50 kg P2O5 and 180 kg K_2O/ha.

2.5 Mango based Agroforestry systems

Gupta and Awasthi (1999) stated that to evaluate the possibility of coffee production in the non-traditional and tribal area of Madhya Pradesh, India, yield variation in *Coffea robusta* cv. Sanramon under different canopy shades was carried out. The experiment was conducted on 5 year old plants grown without shade, or with shade provided by mango, mango+banana, guava, guava+banana or teak (*Tectona grandis*). Mango, guava and teak were aged 50, 10 and 45 years, respectively. The coffee yield was highest (mean for 5 years of 345 kg/ha) under mango+ banana, followed by guava + banana (294 kg/ha), with lower yields in pure stands of mango, guava and teak. Yield was zero under control conditions (no shade).

Bhuva *et al*. (1989) conducted by, mango cv. Rajapuri was planted in 1979 at 6×6m, and was interplant from 1980 with (a)banana, (b)cassava, (c)tomato followed by cluster bean (*Cyamopsis tetragonoloba*), or (d) brinjal followed by cowpea (*Vigna unguiculata*). They reported that mango grown with tomato and cluster bean as intercrops gave the greatest financial return per hectare.

Leucaena leucocephala (var.K8) growth (height, collar diameter and diameter at breast height) and yield data (fresh and dry weight of fodder and fuel) are reported by Gill *et al*. (1992) from the first year investigation (1990-91) of an intercropping trial at Jhansi, Uttar Pradesh, with mango (*Mangifera indica* 4 varieties, 'Amrapali' 'Mallika', 'Deshari' and 'Langra' were tested) which also included various other crops. Each 10×10m subplot included one mango tree, 2 leucaena trees and one of 4 intercrops: a fallow control; fodder crops (cowpea and oats); grain crops [(peanut and wheat); and vegetables okra (*Abelmoschus esculentus*) and onions]. They reported that the above ground biomass yields of *L. leucocephala* ranged from 0.87 to 1.22 dry t/ha. Best leucaena fodder yields were in plots intercropped with vegetables and best fuelwood yields in plots intercropped with grain crops (this system also supported the best total biomass yields). Both leucaena and mango (height, collar diameter and canopy width) growth were better in plots with intercrops than in fallow-plots.

Emebiri and Nwufo (1994) carried out experiments at the Teaching and Research farm of the Federal University of Technology, Nigeria (Lake Nwaebere campus) during 1991-92 cropping season to study the yield of *Telfairia occidentalis* (a leafy vegetable fluted pumpkin) grown at various distances (3,4,5 and 6m) from a row of mango trees. The results support the suggestion that crops whose harvestable parts are vegetative tend to be less affected when grown in proximity to tress, provided adequate water is supplied.

Orwa *et al.* (2009) observed that its umbrella-shaped crown makes the M. indica tree a suitable shade for people and their livestock; it also acts as a firebreak. M. indica leaves improved soil fertility when used as mulch for crops. Young M. indica is often inter-planted with other fruits and vegetables and the tree is a valued component of the traditional home garden agroforestry system. The coconut based mixed species system in the tropics often aims at improved resource capture by incorporating several trees and field crops. Productivity of palms and the associated tree components in such mixed systems are, however, known to vary in response to the tree characteristics, planting pattern/geometry and shade tolerance of the components.

Arya *et al*. (2011) suggested that in growth and yield performances of trees as well as annual crops grown in combination under tree-crop farming. Plant growth and yield of all component crops were higher when grown under conjugation as compared to their sole cropping.

Field trials on the performance of mango-ginger (*Curcuma amada*) conducted at the college of Agriculture, Vellayani (Kerala, India) by Jayachandran and Nair (1998) for 2 seasons under varying levels of shade revealed that the rhizome yield under open and 25% shade were similar indicating that the crop is shade tolerant and is suitable for intercropping situations. In another field trial at Coimbatore, Tamil Nadu, Babu and Nagarajan (1993) studied the growth and development of 7 soyabean cultivars under shade in a coconut plantation. Greater shoot height, intermodal elongation and lower leaf area index were the most significant growth changes noticed under shade. Leaf net photosynthesis, CGR and seed yield were also reduced under shade. Cv. Co 1, UGM 30 and UGM 37 recorded higher yield under shade when compared with other cultivars tested.

2.6 Temperature influences on growth, yield and quality of carrots

Growth parameters among others include, leaf number, plant height and leaf growth. Yield parameters include root fresh and dry mass. Quality of carrots can be classified by external quality parameters such as root length, diameter, colour and absence of defects, as well as internal quality parameters such as firmness, sensory quality, carotene, sugars and terpene content (Mazza, 1989; Rubatzky *et al*., 1999).

Yield and quality characteristics of carrots benefit from cooler growing conditions (10 to 15°C). Moderate day and relatively low night temperatures during storage root formation improve carbohydrate accumulation in carrots. At temperatures above 25°C during storage root formation, the respiration rate of the plant increases, resulting in lower yields (Rubatzky *et al*., 1999).

South Africa has different climatic agricultural regions for carrot production, with specific cultivars utilized for pre-packing. Recently, consumers are paying more attention to the physical and chemical properties of carrots. Consumers generally prefer sweet carrots without a harsh, aftertaste or bitter taste (Simon *et al*., 1980). If carrots are grown under high temperatures, terpene synthesis increases, resulting in carrots with a bitter taste or aftertaste (Rosenfeld *et al*., 2002). Terpenes comprise out of a vast diverse group of natural products and are present in various forms in most organisms where they fulfill a broad range of functions. It ranges from volatile monoterpenes to steroid hormones, carotenoids and polymers, such as rubber (Harrewijn *et al*., 2002). Terpenes blocks the sweet taste of carrots (Rosenfeld *et al*., 2004) and some, when present at a high concentration cause carrots to taste bitter, not favoured by consumers (Rosenfeld *et al*., 2002).

Carrots are a cool-season root crop, although they can tolerate high summer temperatures. Quality and yield however, are the best under cooler conditions (Alam *et al*., 2004; Petzoldt, 2008; Alam *et al*., 2010). The optimum temperature for growth, yield and quality range between 10 and 25°C (Joubert *et al*., 1994; Rubatzky *et al*., 1999). Alam *et al*. (2004) also indicated that the optimum day and night temperatures for plant growth are between 21 and 22°C and 18 and 20°C, respectively. Temperature is one of the most vital climatic factors affecting carrot yields. Carrots that were planted under 12ºC had larger and wider taproots and a higher dry matter content (20%) than those grown at 25ºC (González *et al*., 2009). Temperatures below 15°C encourage thin, long, conical pointed roots (Joubert *et al*., 1994). Carrot root tips were more round and less cylindrical at temperatures above 25°C(Rubatzky *et al*., 1999). Vegetables are vital for a healthy diet, and their texture along with physical appearance and attributes such as colour is essential to the consumers.

Bhale (2004) mentioned that high temperatures may cause heat damage or injury to plant tissue that may influence the texture and structure.

Forked and cracked roots are more common in summer when temperatures are high than in the cooler times of the year (Joubert *et al*., 1994; Alam *et al*., 2004).

The internal quality of carrot roots, particularly sugar content,improves with long photoperiods. The colour of carrot roots also reduced when the number of light hours is reduced and temperatures are above or below the optimum (10 to 25°C) (Anon., 2008b).

2.7 International trade in organic products

The growing demand for organic produce has led to the development of international trade. Countries which have less internal demand, but a favourable climate, are producing to satisfy export markets. Europe is the world's leading market for organic produce, a considerable amount of which is imported from outside. Large volume of cereals and soya are exported from North America (USA and Canada) into Europe. Israel is also anther important supplier. Other sources are Turkey (figs, nuts and dried fruits), Morocco (oranges), the West Indies and Canary Islands (bananas), India (tea) and Bangladesh (tea). Within Europe there is considerable cross-frontier trade in cereals, wine and fresh organic vegetables. The most important direction is from south to north because northern Europe needs Mediterranean citrus fruits, grapes and other delicate fruits and early vegetables. The countries with the largest deficit in fresh organic produce as a whole are Germany and the UK, while the two with the greatest surplus are France and the Netherlands (Tate, 1994).

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in conducting the experiment.

3.1 Experimental site and duration

The experiment was set up at the Experimental Field of Agroforestry and Environment Science Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during January 2017 to March 2017. The experimental site was under Dinajpur Sadar Upazila and located at 25°39' N latitude and 88°41'E longitude with an elevation of 37.58 meter above the sea level.

3.2 Climate

The experimental site was situated in the sub-tropical region characterized by heavy rainfall during the months from May to September and scantly rainfall in the rest of the year. Comparatively low temperature and plenty of sunshine characterize rabi season. Details of the metrological data of average maximum and minimum air temperature, relative humidity, and rainfall during the period of the experiment were collected from the Wheat Research Centre, Dinajpur and presented in Appendix II.

3.3 Soil

The experimental field was a medium high land belonging to the non-calcarious dark gray floodplain soil under the agro-ecological zone (AEZ-1) of Old Himalayan Piedmont plain. The soil was sandy loam under the Order Inceptisol. The pH of the soil was 6.3. The characteristics of the soil under experimental plot were analyzed in the soil Testing laboratory, SRDI, Nashipur, Dinajpur and presented in Appendix I.

3.4 Planting materials

3.4.1 Carrot

The seeds of the variety "KURODA 35" of Lal Teer Seed Limited were used in this experiment. The seeds were collected from "Vai Vai" seed store, Shashtitola, Dinajpur.

3.4.2 Trees

Mango is one of the finest (Amropali) Indian cultivar. It is annual and quick growing in nature. Fruits are very attractive, medium elongated in shaped. The test is superb, with an excellent sugar acid blend .In mango + carrot production system, mango was an upper layer tree and carrot was grown in the floor on mango orchard. The details of mango tree were-

Planting orientation	:	North-South
Mango variety	:	Amropali
Age of mango tree	:	7 years
Spacing	:	6m×6m
Average plant height	:	6.11m
Average basal diameter	:	13.06cm
Average canopy diameter	:	255.6cm

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 30. The size of each unit plot was 2m x 2m.

The experiment were two factors are -

Factor A: (Fertilizer & Pesticide Application)

F_1 = No fertilizer & no pesticide

F_2 = Recommended chemical fertilizer & normal pesticide

F_3 = 100% cowdung manure + neem oil spray as bio-pesticide

F_4 = 100% poultry manure + neem oil spray as bio-pesticide

F_5 = 50%cowdung with 50%poultry + neem oil spray as bio-pesticide

Factor B: Production System

S_1= Open/sole cropping of carrot

S_2 = (Mango + carrot)

So there were 10 treatment combinations such as,

S_1F_1= Open/sole cropping of carrot + No fertilizer & no pesticide

S_1F_2= Open/sole cropping of carrot + chemical fertilizer & normal pesticide

S_1F_3= Open/sole cropping of carrot + cowdung manure + neem oil

S_1F_4= Open/sole cropping of carrot + poultry manure + neem oil

S_1F_5= Open/sole cropping of carrot + 50% cowdung with 50%poultry + neem oil

S_2F_1= (Mango + carrot) + No fertilizer & no pesticide

S_2F_2= (Mango + carrot)+ chemical fertilizer & normal pesticide

S_2F_3= (Mango + carrot) + cowdung manure+ neem oil

S_2F_4 = (Mango + carrot) + poultry manure + neem oil and

S_2F_5= (Mango + carrot) + 50%cowdung with 50%poultry+ neem oil

3.6 Layout of the experiment

The experiment was laid out two factors Randomized complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the fertilizer and manure applications considerably sole cropping and mango orchard. Both mango and sole land block were divided into 15 plots where 5 different fertilizer and manure applications were allocated at random. So there were 30 unit plots in the experiment. The size of the unit plot was 2m×2m. The distance between two blocks and two plots were kept 50cm. the number of plant per plot was 145. The layout of the experiment is shown in Figure 1.

3.7 Preparation of the main field

The experimental plot was opened in the 2nd week of December 2016 with a tractor and was exposed to the sunlight for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed from the field and bigger clods were broken by laddering and finally to obtain a desirable tilth of soil for sowing of carrot seed. Special care was taken to remove rhizomes, durba grass and mutha. Well decomposed cowdung ,manures and fertilizers were mixed with the soil and the land was uniformly leveled and the soil particles were finally pulverized.

Block 1	Block2	Block3
$R_1S_2F_1$	$R_2S_2F_2$	$R_3S_2F_3$
$R_1S_2F_2$	$R_2S_2F_3$	R_3 S_2F_4
$R_1S_2F_3$	$R_2S_2F_4$	R_3 S_2F_5
$R_1S_2F_4$	$R_2S_2F_5$	R_3 S_2F_1
$R_1S_2F_5$	$R_2S_2F_1$	R_3 S_2F_2

Carrot under mango tree

Block 1	Block2	Block3
$R_1S_2F_1$	$R_2S_2F_2$	$R_3S_2F_3$
$R_1S_2F_2$	$R_2S_2F_3$	R_3 S_2F_4
$R_1S_2F_3$	$R_2S_2F_4$	R_3 S_2F_5
$R_1S_2F_4$	$R_2S_2F_5$	R_3 S_2F_1
$R_1S_2F_5$	$R_2S_2F_1$	R_3 S_2F_2

Sole cropping

Figure 1: Layout of the experiment

3.8 Application of manures and fertilizers

Fertilizer and manures were applied as per the treatments. The dose of the fertilizer and manure were followed by FRG (2012). And it were-

Fertilizers	Nutrients	Nutrients dose (kg/ha)
Urea	N	150
TSP	P_2O_5	25
MP	K_2O	75
Cowdung		10 ton/ha
Poultry		8 ton/ha

Source: Fertilizer Recommendation Guide (FRG). 2012. Half of urea and full doses of cowdung, poultry, TSP, MP were applied during the final land preparation. On the other hand, the remaining urea was applied at 30DAP. The sources of N, P and K were taken from Urea, TSP and MP respectively.

3.9 Seed soaking

Before sowing, the seeds were soaked in water for 24 hours and then they were spread over polythene sheet for 2 hours to dry out the surface water. This fertilizer and manure applications hastens seed germination.

3.10 Sowing of seeds

Seeds were sown on 6 January 2017 in the experimental plot. Seeds were sown after mixed with sand. After placing the seeds immediately covered with the soil.

3.11 Thinning out

Emergence of seedling started after 7days from the date of sowing. Seedling were thinned out. Thinning was done after 25 days of sowing. Keeping only healthy seedling to grow in each hill.

3.12 Irrigation

Irrigation was applied before land preparation and second time after one month.

3.13 Weeding

Weed was found in the plots which was removed at the optimum time in each plot.

3.14 Disease and pest management

The crop was not infected with any disease but the infestation with cutworm (*Agrotis ypslin*) during the early stage of seedling that is not serious.

3.15 Harvesting

Harvesting of the crop was done on 30 March,2017 after 85 days of sowing when the foliage leaf turned pale yellow (Bose and Some,1990). Harvesting of the crop was done by uprooting the plants manually. The soil and fibrous roots adhering to the conical roots were removed and cleaned.

3.16 Data collection

The data were collected from the inner rows of plants of each fertilizer and manure applications to avoid the border effect. In each unit plot, 10 plants were selected at random for data collection. Data were collected in respect of the plant growth characters and yield of carrot. Data on plant height, and number of leaves/plant were counted at 30,45,60,75 days after sowing and at harvest. However, for yields per plot all the 10 plants of each unit plot were considered. All other parameters were recorded at harvest. The following parameters were set up for recording data and for the interpretation of the results:

3.16.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at 30, 45, 60, 75 days after sowing (DAS) by using a meter scale. The height was measured from the ground level to the tip of the leaf of an individual plant. Mean value of the ten selected plants was calculated for each unit plot.

3.16.2 Number of leaves per plant

Number of leaves per plant was recorded from randomly 10 selected plants at 30, 45, 60, 75 days after sowing (DAS). The mean value was counted and was expressed in numeric value.

3.16.3 Fresh weight of root/plant (g)

The fresh weight of roots were recorded after harvest and cleaning from the average of 10 plants and expressed in gram. The weight of the roots was recorded immediately after harvest using electric balance.

3.16.4 Fresh weight of leaves/plant (g)

The fresh weight of leaves was recorded after harvest and cleaning from the average of 10 plants and expressed in gram. The weight of the leaves was recorded immediately after harvest using electric balance.

3.16.5 Root length (cm)

The length of root was measured in centimeter (cm) with a meter scale as the vertical distance from one side to another side of the widest part of the sectioned root and mean value was recorded.

3.16.6 Root diameter (cm)

To measure the diameter of the root a slide calipers was used. The diameter of roots was measured in centimeter after harvest at middle portion of the root.

3.16.7 Dry matter content of root (g)

A sample of 100 g chopped root from 10 selected plants was dried in the direct sunlight for two days and then it was dried in oven at 650C for 72 hours, until constant weight was achieved. The dry weight of the sample was recorded in gram and the mean value was calculated.

3.16.8 Yield per plot (kg/plot)

Yield of carrot per plot was recorded as the whole plant weight of all the plants within a plot and was expressed in kilogram. Yield included the weight of root.

3.17 Bio- economics of the carrot based agroforestry system

In order to work out the economic profitability of the agroforestry systems, the economic yield of carrot and trees was subjected to economic analysis by calculating the cost of cultivation, gross and net returns per hectare and benefit-cost ratio. All these parameters were calculated on the basis of market prices prevailing at the time of the termination of experiment.

3.17.1 Total cost of production

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

3.17.2 Gross return

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

3.17.3 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 (Kundu, 2002).

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

3.17.4 Benefit- cost ratio (BCR)

Benefit cost ratio is the ratio of gross return with total cost of production. It was calculated by using the following formula (Islam *et al*., 2004).

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

3.18 Data analysis

Data were statistically analyzed using the (ANOVA) “Analysis of Variance” technique with the help of the computer package STATISTIX 10. The mean differences were adjudged by the Tukey HSD test.

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

The results of the performance of five fertilizer and manure applications of carrot under mango based Agroforestry system are presented in Table 1 to 6. The findings of the study and interpretation of the results under different critical sections comprising growth, yield contributing characteristics, yield and quality parameters discussed in this chapter under the following sub-headings to achieve the objective of the study.

4.1 Main effect of fertilizer and manure applications on growth, yield contributing characters and yield of carrot

4.1.1 Plant height (cm)

Plant height is an important growth parameter considering its productivity performance. Plant height of carrot was recorded from the ground surface to the tip of the leaf in all the fertilizer and manure applications. At different days after planting (DAP), plant height was found significantly varied with different fertilizer and manure applications (Table 1). At 30 DAP, the tallest plant (12.83 cm) was recorded from chemical fertilization (F_2) that was similar to that of F_5. Whereas the shortest plant (7.33 cm) was observed where no fertilizations (F_0) were applied. Similarly, at 45 DAP, the tallest plant (31.50 cm) was observed from the chemical fertilization (F_2) followed by F_5, F_3 (plat1). On the other hand, at 45 DAP the shortest plant height (20.66 cm) was recorded from no fertilizations (F_0). Similar trend of increasing plant height was observed at 60 DAP and the highest plant height (51.84cm) was recorded from the chemical fertilization (F_2) and similar to F_5.The lowest plant height (40cm) was observed from no fertilizations (F_0). Finally at 75 DAP the highest plant height (62.66cm) was also recorded from chemical fertilization (F_2) and the lowest plant height (49.5cm) was observed from no fertilizations (F_0).

4.1.2 Number of shoot

Significantly, number of shoot of carrot was varied at different DAP among the fertilizer and manure applications (Table 1). At 30DAP, the maximum number of shoot (3.3) was recorded from chemical fertilization (F_2) and the minimum number of shoot (2.5) was observed from no fertilizations (F_0). At 45 DAP, maximum number of shoot (6.16) was recorded from the chemical fertilization (F_2) followed by F_3,F_5,F_4 whereas minimum

Chemical Fertilizer

Cowdung

Poultry

No Fertilizer

Cowdung + Poultry

Plate 1: Plant height of carrot by different fertilizer and manure applicatuions

number of shoot (4.66) was observed from no fertilizations (F_0). Again at 60 DAP, the maximum number of shoot (8) was observed from chemical fertilization (F_2) followed by F_3. On the other hand, minimum number of shoot (6) was recorded from no fertilizations (F0). And at last stage 75 DAP, the maximum number of shoot (9.16) was observed from chemical applications (F_2) followed by F_5. On the other hand, minimum number of shoot (7.83) was recorded from no fertilizations (F_0) followed by F_4, F_3. These happened due to the effect of sunlight because more sunlight gave more photosynthesis resulting more shoot.

Table 1: Main effect of fertilizer and manure on morphological characteristics of carrot

Fertilizer and manure applications	Plant height cm				Number of shoot			
	30 (DAP)	45 (DAP)	60 (DAP)	75 (DAP)	30 (DAP)	45 (DAP)	60 (DAP)	75 (DAP)
T_1 (No fertilizer)	7.33b	20.66c	40.00b	49.50b	2.50b	4.66b	6.00c	7.83c
T_2 (Chemical fertilizer)	12.83a	31.50a	51.84a	62.66a	3.33a	6.16a	8.00a	9.16a
T_3 (Cowdung manure)	10.5ab	27.33ab	48.66ab	58.33ab	3.00ab	5.66ab	7.16ab	8.16bc
T_4 (Poultry manure)	10.17ab	24.50bc	45.16ab	53.33ab	3.00ab	5.33ab	7.00b	8.33bc
T_5 (Cowdung + poultry)	12.67a	30.16ab	51.00a	58.66ab	3.33a	5.50ab	7.00b	8.83ab
Level of Significance	***	***	**	**	**	**	**	**
CV%	17.18	14.7	12.69	10.5	13.2	11.6	7.4	5.7

In a column, figures having similar letter(s) do not differ significantly whereas figure bearing dissimilar letter(s) differ significantly (as per Tukey HSD)

***= significant level at 0.01%, **= significant level at 1%

4.1.3 Root length /plant

Carrot root length/ plant was not influenced by the Fertilizer and manure applications (Table 2). The maximum carrot root length (8.83 cm) was observed in those plots where Chemical fertilizer was applied (F_2) and the minimum carrot root length (8.16cm) was recorded in those plots where no fertilizer was applied (F_1). It may be inorganic fertilizers supplied adequate nutrients for better growth. On the other hand, organic manure increased the water holding capacity and porosity of the soil which is desirable for the increase in length of roots in carrot. So, inorganic and organic fertilizers probably lead to better performance of the crop resulting in producing maximum length of root in carrot.

4.1.4 Root diameter / plant

Carrot root diameter/ plant was also influenced by the Fertilizer and manure applications (Table 2). The maximum carrot root diameter (3.11cm) was observed in those plots where Chemical fertilizer was applied (F_2) followed by F_5,F_3,F_4 and the minimum carrot root diameter (2.18cm) was recorded in those plots where no fertilizer was applied (F_1). These results are in partially agreement with the results of Parraga *et al.* (1995). They reported that application of organic matter with NPK increased the diameter of root per plant.

4.1.5 Weight of carrot / plant

Weight of carrot/ plant was also influenced by the Fertilizer and manure applications (Table 2). The maximum weight of carrot (44.17 g) was observed in those plots where Chemical fertilizer was applied (F_2) and the minimum weight of carrot (29.67g) was recorded in those plots where no fertilizer was applied (F_1). It was probably due to fact that the inorganic fertilizers provided good physical soil condition for better growth as well as supplied sufficient plant nutrients, while organic fertilizers supplied readily available more nutrients that helped in maximum weight of root / plant.

4.1.6 Weight of carrot hulm / plot

Weight of carrot hulm / plot was also influenced by the Fertilizer and manure applications (Table 2). The maximum weight of carrot hulm (42.83 g) was observed in those plots where Chemical fertilizer was applied (F_2) similar to F_5 and the minimum weight of carrot hulm (25.8g) was recorded in those plots where no fertilizer was applied (F_1). Dhesi *et al.* (1964) reported that the application of NPK significantly increased the fresh weight of leaves per plant. Above results were also supported by Lenka *et al.* (1990). The higher fresh weight of leaves per plant with the inorganic fertilizers + Mustard oil cake treatments were achieved due to higher vegetative growth which perhaps resulted from better nutrient supply at the growing stage of the plants.

Table 2: Main effect of fertilizer and manure on the yield and yield attributes of carrot

Fertilizer and manure applications	Root length /plant	Root diameter /plant	Weight of root/plant	Hulm weight /plot	Dry weight /100g
T_1 (No fertilizer)	8.16	2.18b	29.67b	25.83b	5.48
T_2 (Chemical fertilizer)	8.83	3.11a	44.17a	42.83a	6.21
T_3 (Cowdung manure)	8.66	2.85a	40.5ab	32.33ab	6.41
T_4 (Poultry manure)	8.30	2.80a	39.33ab	34.83ab	5.58
T_5 (Cowdung + poultry)	8.43	2.95a	43.17ab	42.00a	5.58
Level of Significance	N/S	**	*	**	N/S
CV%	10.5	8.3	11.1	13.5	9.66

In a column, figures having similar letter(s) do not differ significantly where as figure bearing dissimilar letter(s) differ significantly (as per Tukey HSD)

**= significant level at 1%, *= significant level at 5%, n/s= not significant

4.1.7 Yield (ton/ha)

The yield of carrot (ton/ha) was significantly affected by the Fertilizer and manure applications (Figure 2). The highest yield was found (17.15 ton/ha) in Chemical fertilizer (F_2) followed by F_5. The lowest yield (9.56 ton/ha) was found in those plots where no fertilizer was applied (F_1). Kropisz (1992) mentioned that yield of carrot was usually increased by the application of manures in addition to NPK fertilizer. Varu *et al.* (1997) mentioned similar results in onion bulb production. The present result of the experiment is also partially supported by the findings of Vieira *et al.* (1998) who obtained higher marketable yield of carrot with P and poultry house litter. It might due to the fact that inorganic fertilizer supplied readily available major plant nutrients for quick root development.

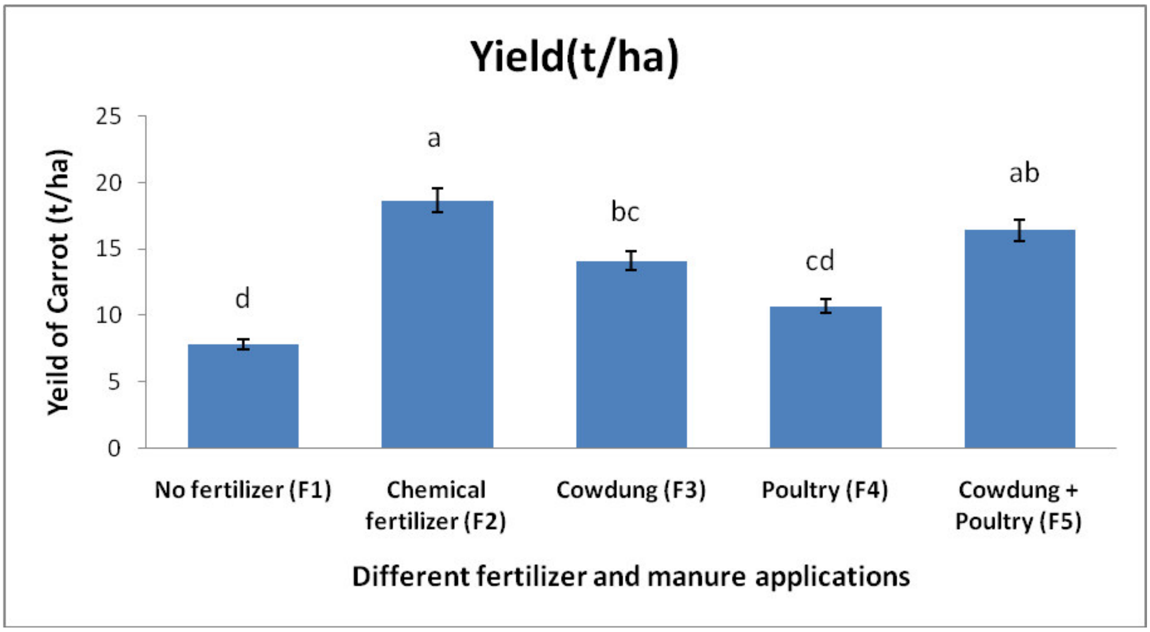

Figure 2: Yield (ton ha-1) of Carrot influenced by different Fertilizer and manure applications

4.1.8 Carrot dry weight / 100g

Carrot dry weight/100g was not influenced by the Fertilizer and manure applications (Table 2). The maximum carrot dry weight (6.41 g) was observed in those plots where cowdung was applied (F_3) and the minimum carrot dry weight (5.48g) was recorded in those plots where no fertilizer was applied (F_1).

4.2 Main effect of the production system on the growth, yield contributing character and yield of carrot

4.2.1 Plant height (cm)

Carrot grown under mango based agroforestry systems was vigorous than those grown in sole cropping i.e. in full sun light conditions (Table 3). At 30 DAP plant height was statistically similar for both production system. At 45 DAP the tallest plant (29.2 cm) was observed in mango + carrot based agroforestry system (S_2) whereas the shortest plant (24.47cm) was observed in sole cropping of carrot (S_1). Similarly at 60 DAP the tallest plant (51.53 cm) was observed in mango + carrot based agroforestry system (S_2) whereas the shortest plant (43.27cm) was observed in sole cropping of carrot (S_1). At 75 DAP the tallest plant (59.73cm) was observed in mango + carrot based agroforestry system (S_2) whereas the shortest plant (53.27cm) was observed in sole cropping of carrot (S_1). The present study revealed that the plant height increased with the decrease of light levels plant height depends on a number of factors such as availability of required quality of water, mineral nutrients, quantity, quality and duration of light, temperature, area of growing space and genetic set-up of the plants. Hillman (1984) reported that, plant grown in low light levels was found to be more apical dominant than those grown in high light environment resulting in taller plants under shade.

4.2.2 Number of shoot

At 30 DAP number of shoot was statistically similar for both production system. At 45 DAP number of shoot was statistically similar for both production system. Again at 60 DAP number of shoot was statistically similar for both production system. But at 75 DAP the highest number of shoot (8.73) was observed in sole cropping (S_1) whereas the lowest number of shoot (8.2) was observed in mango + carrot based agroforestry system (S_2). Similar result was also reported by Ali (1999). The Lowest number of shoot per plant at the heaviest shade condition may be due to lower production of photosynthesis under low light conditions for a longer period (Miah, *et al.*, 1999). Also similar result was reported by (Miah, 2001).

Table 3: Morphological characteristics of carrot under mango based agroforestry

Fertilizer and manure applications	Plant height (DAP)cm				Number of shoot			
	30	45	60	75	30	45	60	75
Carrot open (F_1)	9.73	24.47b	43.27b	53.27b	3.20	5.66	7.26	8.20b
Carrot + Mango (F_2)	11.67	29.20a	51.53a	59.73a	2.86	5.26	6.80	8.73a
Level of Significance	N/S	*	***	*	N/S	N/S	N/S	*
CV%	19.2	18.1	12.4	11.7	15.3	13.9	11.45	7.3

In a column, figures having similar letter(s) do not differ significantly whereas figure bearing dissimilar letter(s) differ significantly (as per Tukey HSD).

*= significant level at 5%, ***= significant level at 0.01%, n/s= not significant

4.2.3 Root length /plant (cm)

Root length were not influenced by different agroforestry system (Table 4). Root length of sole cropping and mango+carrot agroforestry system was statistically same.

4.2.4 Root diameter/plant (cm)

Root diameter/ plant were not influenced by different agroforestry system (Table 4). Root diameter of sole cropping (2.8) and mango + carrot agroforestry system (2.77) was statistically same. The lower fruit diameter under shade condition may be associated with the lower mobilization of reserved assimilates to reproductive organ. Similar findings in case of Mungbean were also reported by Ali (1998).

4.2.5 Weight of root/plant

Again weight of root/plant were not influenced by different agroforestry system (Table 4).Weight of root/plant of sole cropping (40.37) and mango + carrot agroforestry system (39) was statistically same. Similar findings in case of potato were also reported by Miah (2001).

4.2.6 Hulm weight /plot

Hulm weight/plot was also influenced by different agroforestry system (Table 4). The maximum weight of hulm (39.13g) was recorded under sole cropping. The maximum weight of leaves is due the increase in photosynthesis rate in open condition. Significantly, the minimum hulm weight (31.6g) was recorded under mango+carrot based agroforestry system.

Table 4: Yield and yield attributes of carrot under mango based agroforestry systems

Production	Root length /plant	Root diameter /plant	Weight of root /plant	Hulm weight /plot	Dry weight /100g
Carrot Open (S_1)	8.64	2.80	40.73	39.13a	6.06
Carrot + Mango (S_2)	8.32	2.77	39.00	31.60b	5.65
Level of Significance	N/S	N/S	N/S	**	N/S
CV%	10.17	14.5	12.3	15.1	10.2

In a column, figures having similar letter(s) do not differ significantly whereas figure bearing dissimilar letter(s) differ significantly (as per Tukey HSD).

**= significant level at 1% and n/s= not significant

4.2.7 Yield ton/ha

Yield ton/ha was also influenced by different agroforestry system (Figure 3). The maximum yield ton/ha (15.18) was recorded under sole cropping. Significantly, the minimum yield ton/ha (11.29) was recorded under mango+carrot based agroforestry system. Similar results also observed by Tanni *et al.*, 2010) and Habib *et al.*, (2012) in different winter and summer vegetable in association with Lohakat (Zylia dolabiformis) tree. Similar findings in case of potato were also reported by Malik *et al.* (2005), the lowest amount of yield was found under kala koroi + potato based agroforestry system was due to minimum rate of photosynthesis, which results in lower amount of food materials deposited in the tuber.

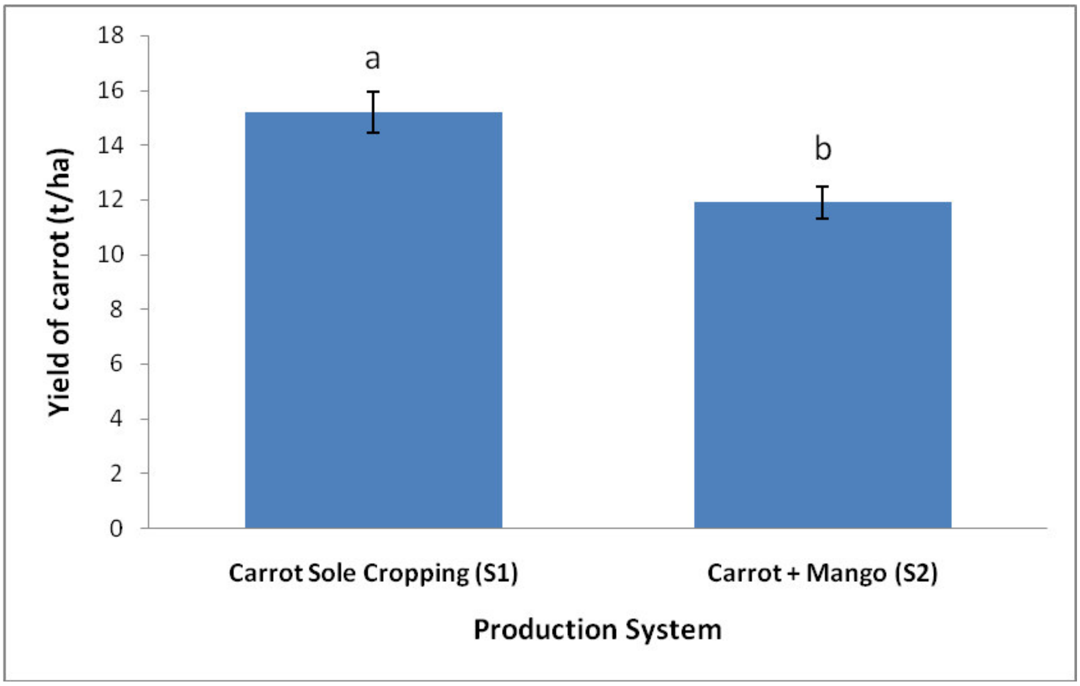

Figure 3: Yield (Ton ha-1) of Carrot influenced by different production systems

4.2.8 Dry weight /100g

Dry weight /plot were not influenced by different agroforestry system (Table 4). Dry weight/plot of sole cropping and mango + carrot agroforestry system was statistically same.

4.3 Interaction effect of fertilizer and manure applications and production system on the growth, yield contributing and yield of carrot

4.3.1 Plant height (cm)

The interaction effect, of fertilizer and manure applications and production system on the plant height of carrot was found significantly different at different days after planting (Table 5). At 30 DAP the tallest plant of carrot (14.33 cm) was recorded where chemical fertilizer was applied at mango based agroforestry system that was similar to that of fertilizer and manure applications F_5 at mango based agroforestry system. On the other hand, the shortest plant height of carrot (7.33cm) in open condition where no fertilizer was applied and similar in mango based agroforestry system where no fertilizer was applied. At 45 DAP the plant height is statistically similar. Numerically tallest plant height of carrot (34.33cm) at open condition where chemical fertilizer was applied. On the other hand, the shortest plant of carrot (18.66cm) was observed where no fertilizer was applied in mango based agroforestry system. At 60 DAP the plant height is statistically similar. Numerically the tallest plant of carrot (56.66 cm) was recorded where cowdung was applied in open condition whereas the shortest plant of carrot (36cm) was recorded at control condition in mango based agroforestry system. Significantly at 75 DAP the tallest plant of carrot (63.66 cm) was recorded where chemical fertilizer was applied in mango based agroforestry system. Whereas the shortest plant of carrot was recorded in F_1 + S_2 (mango +carrot). Similarly taller plant height under heavy shade in Okra was reported by Ali (1999). Plant grown in low light levels was found to be more applicably dominant than those grown in high light environment resulting in the taller plant under shade (Hillman, 1984).

4.3.2 Number of shoot

The interaction effect, of fertilizer and manure applications and production system on the number of shoot of carrot was found significantly different at different days after planting (Table 5). At 30 DAP the maximum number of shoot of carrot (3.66) was recorded in chemical fertilization under open condition. On the other hand, the minimum number of shoot of carrot (2.33) was recorded where no fertilizer was applied in mango based agroforestry system. At 45 DAP the number of shoot is statistically similar. Numerically maximum number of shoot of carrot (6.33) where chemical fertilizer was applied at open condition. On the other hand, the minimum number of shoot of carrot (4.33) was observed where no fertilizer was applied at mango based agroforestry system. At 60 DAP the number of shoot is statistically similar. Numerically maximum number of shoot of carrot (8.33) was recorded where normal fertilizer was applied in open condition. Whereas the minimum number of shoot of carrot (5.66) was recorded where control condition is applied at mango based agroforestry system. Significantly at 75 DAP the maximum number of shoot of carrot (9.3) was recorded where chemical fertilizer was applied in open condition. Whereas the minimum number of shoot of carrot was recorded where no fertilizer was applied at carrot + mango based agroforestry system. Similar result was also reported by Ali (1999). The Lowest number of shoot per plant at the heaviest shade condition may be due to lower production of photosynthesis under low light conditions for a longer period (Miah, *et al*., 1999). Also similar result was reported by (Miah, 2001).

Table 5: Interaction effect of fertilizer and manure applications and production system on the morphological characteristics of carrot

Fertilizer and manure applications	**Plant height (DAP) cm**				**Number of shoot**			
	30 (DAP)	45 (DAP)	60 (DAP)	75 (DAP)	30 (DAP)	45 (DAP)	60 (DAP)	75 (DAP)
(No fertilizer+ Open)	7.33b	22.66	44.00	56.33a	2.66ab	5.00	6.33	8.00bc
(Chemical fertilizer+ Open)	11.33ab	34.33	55.66	63.66a	3.66a	6.30	8.33	9.30a
(Cowdung+ Open)	11.66ab	30.33	53.33	60.66a	3.00ab	6.00	7.33	8.30abc
(Poultry+ Open)	10.66ab	25.66	48.00	55.66ab	3.00ab	5.33	7.00	8.60abc
(Cowdung & Poultry+ Open)	11.00ab	33.00	56.66	62.33a	3.66a	5.66	7.33	9.30a
(No fertilizer +Mango)	7.33b	18.66	43.00	42.66b	2.33b	4.33	5.66	7.60c
(Chemical fertilizer+Mango)	14.33a	28.66	47.00	61.66a	3.00ab	6.00	7.66	9.00ab
(Cowdung+Mango)	9.33b	24.33	44.00	56.00ab	3.00ab	5.33	7.00	8.00bc
(Poultry+Mango)	9.66b	23.33	42.33	51.00ab	3.00ab	5.33	7.00	8.00bc
(Cowdung & Poultry+Mango)	14.33a	27.33	47.00	55.00ab	3.00ab	5.33	6.66	8.30abc
Level of Significance	*	N/S	N/S	*	*	N/S	N/S	*
CV%	14.5	10.5	8.5	8.6	11.53	11.89	6.87	4.60

In a column, figures having similar letter(s) do not differ significantly whereas figure bearing dissimilar letter(s) differ significantly (as per Tukey HSD).

*=significant level at 5% and n/s= not significant

4.3.3 Root length/plant (cm)

Root length of carrot were not significantly different by fertilizer and manure applications and production systems (Table 6). Numerically, the maximum root length of carrot (9.13 cm) was recorded where chemical fertilizer was applied under open condition. And the minimum root length of carrot (7.86cm) was recorded where poultry manuring was applied in mango based agroforestry system. It was probably due to fact that the inorganic fertilizers provided good physical soil condition for better growth as well as supplied sufficient plant nutrients, while organic fertilizers supplied readily available nutrients that helped in maximum root length / plant.

4.3.4 Root diameter (cm)

Root diameter of carrot were significantly different by fertilizer and manure applications and production systems (Table 6). The maximum root diameter of carrot (3.30cm) was recorded where chemical fertilizer was applied under open condition. The minimum root diameter of carrot (2cm) was recorded where no fertilizer was applied in open condition. These results are in partially agreement with the results of Parraga *et al*. (1995). They reported that application of NPK increased the diameter of root per plant.

4.3.5 Weight of root/ plant

Weight of root/ plant of carrot were significantly different by fertilizer and manure applications and production systems (Table 6). The maximum weight of root/ plant of carrot (52.3 g) was recorded where chemical fertilizer was applied under open condition followed by F_4+S_1. And the minimum weight of root/ plot of carrot (27.33g) was recorded where no fertilizer was applied in open condition similar to F_1+S_2. It was probably due to fact that the inorganic fertilizers provided good physical soil condition for better growth as well as supplied sufficient plant nutrients, while organic fertilizers supplied readily available more nutrients that helped in maximum weight of root / plant.

4.3.6 Weight of hulm/plot

Weight of hulm/ plot of carrot were significantly different by fertilizer and manure applications and production systems (Table 6). The maximum weight of hulm / plot of carrot (47.66 g) was recorded where chemical fertilizer was applied under open condition. And the minimum weight of hulm/ plot of carrot (21.33g) was recorded where no fertilizer was applied in mango based agroforestry system. Dhesi *et al*. (1964)

reported that the application of NPK significantly increased the fresh weight of leaves per plant. Above results were also supported by Lenka *et al*. (1990). The higher fresh weight of leaves per plant with the inorganic fertilizers + Mustard oil cake treatments were achieved due to higher vegetative growth which perhaps resulted from better nutrient supply at the growing stage of the plants.

Table 6: Interaction effect of fertilizer and manure applications and production system on the yield and yield attributes of carrot under mango based agroforestry systems

Fertilizer and manure applications	Root length /plant	Root diameter /plant	Weight of root /plant	Hulm weight /plot	Dry weight /100g
(No fertilizer+ Open)	8.00	2.00c	27.33e	24.00fg	6.00ab
(Chemical fertilizer+ Open)	9.13	3.30a	52.3a	47.66a	6.43a
(Cowdung+ Open)	8.93	2.96a	40.00bc	38.33bc	6.50a
(Poultry+ Open)	8.73	2.86ab	46.00ab	42.66ab	5.26ab
(Cowdung & Poultry+ Open)	8.36	2.90ab	39.66bc	40.33bc	6.10ab
(No fertilizer +Mango)	8.30	2.36bc	29.00e	21.33g	4.96b
(Chemical fertilizer+Mango)	8.53	2.93ab	45.00bc	37.00cd	6.00ab
(Cowdung+Mango)	8.40	2.73ab	38.33cd	31.66e	6.33a
(Poultry+Mango)	7.86	2.83ab	32.33de	33.00de	5.90ab
(Cowdung & Poultry+Mango)	8.50	3.00a	40.66bc	28.00ef	5.06b
Level of Significance	N/S	*	***	**	**
CV%	11.16	7.27	5.88	5.06	7.24

In a column, figures having similar letter(s) do not differ significantly where as figure bearing dissimilar letter(s) differ significantly (as per Tukey HSD).

* = significant level at 5%, **= significant level at 1% ***= significant level at 0.01% n/s= not significant

4.3.7 Yield ton/ha

Yield ton/ha of carrot were significantly different by fertilizer and manure applications and production systems (Figure 6). The maximum yield ton/ha of carrot (21.25ton) was recorded where chemical fertilizer was applied under open condition. On the other hand, the minimum yield ton/ha of carrot (6.91) was recorded where no fertilizer was applied in mango based agroforestry system. It is clear that the yield was affected by the shade of the Mango tree due to the reduction of the sunlight which affects negatively photosynthesis process. Similar results also observed by Tanni *et al*. (2010) and Habib *et al*., (2012) in different winter and summer vegetable in association with Lohakat (Zylia dolabiformis) tree.

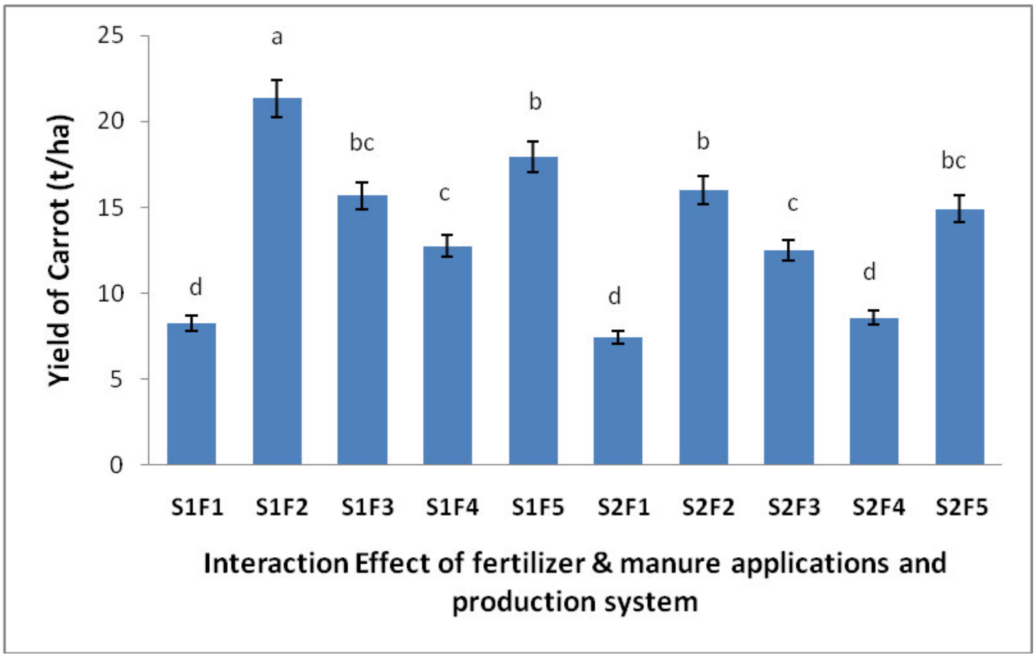

Figure 4: Interaction Effect in yield (Ton ha-1) of fertilizer and manure applications and production system

4.3.8 Dry weight/100g

Dry weight/100g of carrot were significantly different by fertilizer and manure applications and production systems (Table 6). Numerically, the maximum dry weight/100g of carrot (6.50) was recorded where cowdung was applied under open condition. And the minimum dry weight/plot of carrot (4.96) was recorded where no fertilizer was applied in mango based agroforestry system.

4.4 Economic analysis

Profitability of growing carrot as inter-crop in mango based agroforestry system was calculated based on local market rate prevailed during experiment. The cost of production of carrot and cost of production of tree plantation and management of trees have been summarized in appendix IV. The return of produce and profit per taka i.e. Benefit Cost Ratio (BCR) also have been presented in Table 7.

4.4.1 Total cost of production

The values in Table 7 indicate that the total cost of production was maximum 166906 tk/ha in sole cropping of carrot where chemical fertilizer was applied (F_2S_1). Whereas the minimum cost of production 115633 tk/ha was recorded from the sole cropping of carrot where no fertilizer was applied (F_1S_1).

4.4.2 Gross return

Gross return is an important indicator whether crop cultivation is profitable or not. The values in table 7 indicate that the height value of gross return 440260 tk/ha was obtained from Mango + carrot based agroforestry system where chemical fertilizer was applied (F_2S_2). On the other hand, the lowest value of gross returns 165000 tk/ha was obtained from sole cropping of carrot where no fertilizer was applied (F_1S_1).

Table 7: Economics of carrot production under mango based agroforestry system

Fertilizer and manure applications	Return (Tk./ha)		Gross Return (tk./ha)	Total cost of production (Tk./ha)	Net Return (Tk./ha)	BCR
	Carrot	Mango tree				
(No fertilizer+ Open)	165000	-	165000	115633	49367	1.42
(Chemical fertilizer+ Open)	426600	-	426600	166906	259694	2.55
(Cowdung+ Open)	313200	-	313200	139363	173837	2.24
(Poultry+ Open)	255000	-	255000	131453	123547	1.93
(Cowdung & Poultry+ Open)	358200	-	358200	135408	222792	2.64
(No fertilizer +Mango)	148200	120260	268460	127861	140599	2.09
(Chemical fertilizer+Mango)	320000	120260	440260	144715	295545	3.04
(Cowdung+Mango)	250000	120260	370260	135810	234450	2.72
(Poultry+Mango)	171600	120260	291860	132936	158924	2.19
(Cowdung & Poultry+Mango)	298200	120260	418460	134373	284087	3.01

Note: Carrot 20tk/kg, Mango tree 1600tk/Tree/ Year

4.4.3 Net Return

Results presented in the table 7 show that net return 295545 tk/ha was comparatively higher in producing carrot under mango + carrot based agroforestry system where chemical fertilizer was applied (F_2S_2). At the same time, the lowest net return 49367 tk/ha was received from the sole cropping of carrot where no fertilizer was applied (F_1S_1). Higher net return was the result of higher gross return from the carrot cultivation together with mango trees.

4.4.4 Benefit-cost ratio

The values in table 7 indicate that the highest benefit cost ratio 3.04 was recorded from Mango + Carrot based agroforestry system where chemical fertilizer was applied (F_2S_2). On the other hand the lowest benefit cost ratio 1.42 was observed in sole cropping of carrot where no fertilizer was applied (F_1S_1). So, carrot can profitably be cultivated in mango based agroforestry systems.

CHAPTER 5

SUMMARY AND CONCLUSION

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5.1 Summary

The experiment was set up at the Experimental Field of Agroforestry and Environment Science Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during January 2017 to March 2017 to evaluate the performance of 5 (five) fertilizer and manure applications of carrot in mango based agroforestry system. The experiment was conducted in newly established mango orchard where the tree sapling were planted at the spacing 6 m× 6m in the year 2010. The experiment included five recommended fertilizer and manure applications viz; no fertilizer, normal fertilizer, cowdung, poultry, cowdung + poultry. The experiment was laid out in RCBD with 3 replications. The fertilizer and manure applications combinations of the experiment were S_1F_1= Open + No fertilizer, S_1F_2 = Open + Normal fertilizer, S_1F_3 = Open + Cowdung, S_1F_4 = Open + Poultry, S_1F_5 = Open + Cowdung and poultry, S_2F_1 = Mango + No fertilizer, S_2F_2 = Mango + Normal fertilizer, S_2F_3 = Mango + Cowdung, S_2F_4 = Mango + Poultry and S_2F_5 = Mango + Cowdung and poultry. In the production systems S_2, mango trees population were 278 trees/ha respectively. Carrot was planted as intercrop in the alleys between the two trees rows according to their cultural schedules. The plots of the ground layer crops were fertilized with fertilizers and manures according to the Fertilizer Recommendation Guide (FRG). 2012. Carrot seed were planting on 6 January 2017 in to the main plots. The data were recorded on two broad heads, i) growth stage ii) harvesting stage. The data were analyzed statistically and means were adjusted by STATISTIX 10.

In case of the main effect of fertilizer and manure applications on growth, yield contributing characters and yield of carrot the result was found significant in respect of Plant height (cm) at (30,45,60 and 75 DAP),number of shoot, root length, root diameter, weight of root/plot, hulm weight/plot, yield kg/plot, yield ton/ha, dry weight(g) respectively. At 30 DAP, the tallest plant (12.83 cm) was recorded from chemical fertilization (F_2) that was similar to that of F_5. Whereas the shortest plant (7.33 cm) was observed where no fertilizations (F_0) were applied. Similarly, at 45 DAP, the tallest plant (31.50 cm) was observed from the chemical fertilization (F_2). On the other hand, at 45 DAP the shortest plant height (20.66 cm) was recorded from no fertilizations (F_0).

Similar trend of increasing plant height was observed at 60 DAP and the highest plant DAP the shortest plant height (20.66 cm) was recorded from no fertilizations (F_0). Similar trend of increasing plant height was observed at 60 DAP and the highest plant height (51.84cm) was recorded from the chemical fertilization (F_2) and similar to F_5.The lowest plant height (40cm) was observed from no fertilizations (F_0). Finally at 75 DAP the highest plant height (62.66cm) was also recorded from chemical fertilization (F_2) and the lowest plant height (49.5cm) was observed from no fertilizations (F_0). However, at 30DAP, the maximum number of shoot (3.3) was recorded from chemical fertilization (F_2) and the minimum number of shoot (2.5) was observed from no fertilizations (F_0). At 45 DAP, maximum number of shoot (6.16) was recorded from the chemical fertilization (F_2), whereas minimum number of shoot (4.66) was observed from no fertilizations (F_0). Again at 60 DAP, the maximum number of shoot (8) was observed from chemical fertilization (F_2) followed by F_3. On the other hand, minimum number of shoot (6) was recorded from no fertilizations (F0). And at last stage 75 DAP, the maximum number of shoot (9.16) was observed from chemical applications (F_2) followed by F_5. On the other hand, minimum number of shoot (7.83) was recorded from no fertilizations (F_0). Again, the maximum carrot root length (8.83 cm) was observed in those plots where Chemical fertilizer was applied (F_2) and the minimum carrot root length (8.16cm) was recorded in those plots where no fertilizer was applied (F_1).In case of, Root diameter / plant the maximum carrot root diameter (3.11cm) was observed in those plots where Chemical fertilizer was applied (F_2) and the minimum carrot root diameter (2.18cm) was recorded in those plots where no fertilizer was applied (F_1). Again, the maximum weight of carrot (44.17 g) was observed in those plots where Chemical fertilizer was applied (F_2) and the minimum weight of carrot (29.67g) was recorded in those plots where no fertilizer was applied (F_1). In case of, weight of carrot hulm / plot the maximum weight of carrot hulm (42.83 g) was observed in those plots where Chemical fertilizer was applied (F_2) similar to F_5 and the minimum weight of carrot hulm (25.8g) was recorded in those plots where no fertilizer was applied (F_1). Again, The highest yield was found (17.15 ton/ha) in Chemical fertilizer (F_2) followed by F_5. The lowest yield (9.56 ton/ha) was found in those plots where no fertilizer was applied (F_1). Again, the maximum carrot dry weight (6.41 g) was observed in those plots where cowdung was applied (F_3) and the minimum carrot dry weight (5.48g) was recorded in those plots where no fertilizer was applied (F_1). Therefore it will be mentioned that most of fertilizer and manure applications suitable for yield; but their degree of suitability will be as Normal fertilizer> cowdung + poultry > cowdung > poultry > no fertilizer.

Again the results of the research were showed that main effect of the production system were significant in respect of Plant height (cm) at (30,45, 60 and 75 DAP), number of shoot, root length, root diameter, weight of root/plot, hulm weight/plot, yield kg/plot, yield ton/ha, dry weight(g) respectively. At 30 DAP plant height was statistically similar for both production system. At 45 DAP the tallest plant (29.2 cm) was observed in mango + carrot based agroforestry system (S_2) whereas the shortest plant (24.47cm) was observed in sole cropping of carrot (S_1). Similarly at 60 DAP the tallest plant (51.53 cm) was observed in mango + carrot based agroforestry system (S_2) whereas the shortest plant (43.27cm) was observed in sole cropping of carrot (S_1). At 75 DAP the tallest plant (59.73cm) was observed in mango + carrot based agroforestry system (S_2) whereas the shortest plant (53.27cm) was observed in sole cropping of carrot (S_1). However, at 30 DAP number of shoot was statistically similar for both production system. At 45 DAP number of shoot was statistically similar for both production system. Again at 60 DAP number of shoot was statistically similar for both production system. But at 75 DAP the highest number of shoot (8.73) was observed in sole cropping ($S_{1)}$ whereas the lowest number of shoot (8.2) was observed in mango + carrot based agroforestry system (S_2). Again, root length of sole cropping and mango+carrot agroforestry system was statistically same. In case of, root diameter/ plant of sole cropping (2.8) and mango + carrot agroforestry system (2.77) was statistically same. Again weight of root/plant of sole cropping (40.37) and mango + carrot agroforestry system (39) was statistically same. In case of, hulm weight/plot the maximum weight of hulm (39.13g) was recorded under sole cropping. Significantly, the minimum hulm weight (31.6g) was recorded under mango+carrot based agroforestry system. However, the maximum yield ton/ha (15.18) was recorded under sole cropping. Significantly, the minimum yield ton/ha (11.29) was recorded under mango+carrot based agroforestry system. Again, dry weight/plot of sole cropping and mango + carrot agroforestry system was statistically same.

Again, the Interaction effect of fertilizer and manure applications and production system of carrot had significant effect on Plant height (cm) at (30,45, 60 and 75 DAP), number of shoot, root length, root diameter, weight of root/plot, hulm weight/plot, yield kg/plot, yield ton/ha, dry weight(g) respectively. At 30 DAP the tallest plant of carrot (14.33 cm) was recorded where chemical fertilizer was applied at mango based agroforestry system that was similar to that of fertilizer and manure applications F_5 at mango based agroforestry system. On the other hand, the shortest plant height of carrot (7.33cm) in open condition where no fertilizer was applied and similar in mango based agroforestry system where no fertilizer was applied. At 45 DAP the plant height is statistically similar. Numerically tallest plant height of carrot (34.33cm) at open condition where chemical fertilizer was applied. On the other hand, the shortest plant of carrot (18.66cm) was observed where no fertilizer was applied in mango based agroforestry system. At 60 DAP the plant height is statistically similar. Numerically the tallest plant of carrot (56.66 cm) was recorded where cowdung was applied in open condition whereas the shortest plant of carrot (36cm) was recorded at control condition in mango based agroforestry system. Significantly at 75 DAP the tallest plant of carrot (63.66 cm) was recorded where chemical fertilizer was applied in mango based agroforestry system. Whereas the shortest plant of carrot was recorded in F_1 + S_2 (mango +carrot). Again, at 30 DAP the maximum number of shoot of carrot (3.66) was recorded in chemical fertilization under open condition. On the other hand, the minimum number of shoot of carrot (2.33) was recorded where no fertilizer was applied in mango based agroforestry system. At 45 DAP the number of shoot is statistically similar. Numerically maximum number of shoot of carrot (6.33) where chemical fertilizer was applied at open condition. On the other hand, the minimum number of shoot of carrot (4.33) was observed where no fertilizer was applied at mango based agroforestry system. At 60 DAP the number of shoot is statistically similar. Numerically maximum number of shoot of carrot (8.33) was recorded where normal fertilizer was applied in open condition. Whereas the minimum number of shoot of carrot (5.66) was recorded where control condition is applied at mango based agroforestry system. Significantly at 75 DAP the maximum number of shoot of carrot (9.3) was recorded where chemical fertilizer was applied in open condition. Whereas the minimum number of shoot of carrot was recorded where no fertilizer was applied at carrot + mango based agroforestry system. However, the maximum root length of carrot (9.13 cm) was recorded where chemical fertilizer was applied under open condition. And the minimum root length of carrot (7.86cm) was recorded where poultry manuring was applied in mango based agroforestry system. In case of, **r**oot diameter of carrot the maximum root diameter of carrot (3.30cm) was recorded where chemical fertilizer was applied under open condition. The minimum root diameter of carrot (2cm) was recorded where no fertilizer was applied in open condition. Again, **t**he maximum weight of root/ plant of carrot (52.3 g) was recorded where chemical fertilizer was applied under open condition followed by F_4+S_1. And the minimum weight of root/ plot of carrot (27.33g) was recorded where no fertilizer was applied in open condition similar to F_1+S_2. However, **t**he maximum weight of hulm / plot of carrot (47.66 g) was recorded where chemical fertilizer was applied under open condition. And the minimum weight of hulm/ plot of carrot (21.33g) was recorded where no fertilizer was applied in mango based agroforestry system. Again, the maximum yield ton/ha of carrot (21.25ton) was recorded where chemical fertilizer was applied under open condition. On the other hand, the minimum yield ton/ha of carrot (6.91) was recorded where no fertilizer was applied in mango based agroforestry system. In case of, dry weight/100g of carrot the maximum dry weight/100g of carrot (6.50) was recorded where cowdung was applied under open condition. And the minimum dry weight/plot of carrot (4.96) was recorded where no fertilizer was applied in mango based agroforestry system.

5.2 Conclusion

The findings of the present investigation indicate that diversification of farming system and growing carrot as ground layers crops in mango tree orchard is a viable option for increasing income of farmers. In case of carrot production under mango + carrot agroforestry system chemical fertilizer as well as cowdung + poultry manuring may be a good practice. The presence of tree canopies did not influence so much on the growth and yield of carrot. Despite some negative effects of upper layer tree like mango on the growth, yield and physiological attributes of carrot; carrot + mango based agroforestry system is still beneficial as it ensure higher returns because of diversified products in comparison to sole cropping. Finally it may be concluded from the results and foregoing discussion that open field is so good for the production of carrot but carrot production at the floor of mango tree with cowdung + poultry manuring may be a suitable and safe food production system.

5.3 Recommendations

1. Mango +carrot based Agroforestry system is economically viable under the conditions analyzed. To get considerable production of carrot and mango fruit, as well as to bring back equilibrium in the ecosystem, carrot + mango based agroforestry system is foreseeable.
2. The developed model may be applied in the young mango orchard of Bangladesh.
3. The carrot may be a good understory vegetable for mango using cowdung and poultry manuring.
4. The experiment should be repeated with different age grouped mango orchard in the different location of Bangladesh for a vital recommendation.

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APPENDICES

APPENDICES

Appendix I: Soil analysis data of the experimental plot

General characters	Description
Location	Agroforestry research farm, HSTU, Dinajpur
AEZ	Old Himalayan Piedmont Plain (AEZ-1)
General soil type	Non-Calcareous Brown Floodplain Soil
Parent material	Piedmont alluvium
Soil series	Ranishankail
Drainage	Moderately well drained
Flood level	Above flood level
Topography	High land

Physical analysis

Constituents	Value
Bulk density (g cm-3)	0.86-1.07
Particle size (%)	
Sand (2-0.02mm)	60.0
Silt (0.02-0.002mm)	27.0
Clay (<0.002mm)	13.0
Textural class	Sandy loam

Chemical analysis

Soil properties	Content	Interpretation
pH	6.3	Moderately acidic
Organic matter (%)	0.70	Very low
Total N (%)	0.04	Very low
Available P (ppm)	75	High
Available K(ppm)	65	High

Source: Analysis of soil samples was done in SRDI, Dinajpur, Bangladesh

Appendix II: Weather data for growing season of carrot, 2016-2017

Month	Relative humidity (%)	Temperature		Total rainfall (mm)
		Minimum (°C)	Maximum (°C)	
December	85	11.9	24	0.0
January	86	10.5	22	24
February	80	13.4	26.9	0.0
March	75	10.2	23	0.0

Source: Wheat Research Centre, Dinajpur

Appendix III: Cost of production for carrot in mango based agroforestry system

Fertilizer and manure applications	Input cost										Total input cost (TK/ha)	Over Head cost			Total cost of production (TK/ha)
	Non material cost (TK/ha)			Material cost											
	Tree	Car rot	Total Non Material cost	seed	Fertilizer	IrrI Gation	Pesticide	Main Tenance cost of trees	Initial plan-Ta-tion cost of trees	Total mate rial cost (TK/ha)		Interest of input cost@8% for the crop sea son (tk/ha)	Interest of the value of land (tk.30 0000 /ha) @ 8% for the crop season (tk/ha)	Miscella neous cost@5% of the input cost (tk/ha)	
s1f1	0	42250	42250	47500	0	0	5500	0	0	53000	95250	7620	8000	4763	115633
s1f2	0	42250	42250	47500	29250	16125	5500	0	0	98375	140625	11250	8000	7031	166906
s1f3	0	42250	42250	47500	15000	6000	5500	0	0	74000	116250	9300	8000	5813	139363
s1f4	0	42250	42250	47500	8000	6000	5500	0	0	67000	109250	8740	8000	5463	131453
s1f5	0	42250	42250	47500	11500	6000	5500	0	0	70500	112750	9020	8000	5638	135408
s2f1	6425	28450	34875	30450	0	0	2100	5120	12288	49958	84833	6787	32000	4242	127861
s2f2	6425	28450	34875	30450	10655	4260	2100	5120	12288	64873	99748	7980	32000	4987	144715
s2f3	6425	28450	34875	30450	5449	1585	2100	5120	12288	56992	91867	7349	32000	4593	135810
s2f4	6425	28450	34875	30450	2906	1585	2100	5120	12288	54449	89324	7146	32000	4466	132936
s2f5	6425	28450	34875	30450	4177	1585	2100	5120	12288	55720	90595	7248	32000	4530	134373

Note: $S_1F_{1=}$ Open/sole cropping of carrot + No fertilizer & no pesticide, S_1F_2= Open/sole cropping of carrot + chemical fertilizer & normal pesticide, S_1F_3= Open/sole cropping of carrot + cowdung manure + neem oil, S_1F_4= Open/sole cropping of carrot + poultry manure + neem oil, S_1F_5= Open/sole cropping of carrot + 50% cowdung with 50%poultry + neem oil, $S_2F_{1=}$ (Mango + carrot) + No fertilizer & no pesticide, S_2F_2= (Mango + carrot)+ chemical fertilizer & normal pesticide, S_2F_3= (Mango + carrot) + cowdung manure+ neem oil, S_2F_4 = (Mango + carrot) + poultry manure + neem oil and, S_2F_5= (Mango + carrot) + 50%cowdung with 50%poultry+ neem oil.

Appendix IV: Some plates of the research

Plate 2: Land preparation

Plate 3: Seed sowing

Plate 4: Measurement

Plate 5: Vegetative growth

Plate 6: Measuring vegetative growth

Plate 7: For weight measurement

Plate 8. Slice of carrot for air drying

Plate 9: Drying of carrot slices in oven