EFFECT OF MANURE AND MULCHING ON GROWTH AND YIELD OF CARROT (*Daucus carota* L.)

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This is to certify that thesis entitled, ***"EFFECT OF MANURE AND MULCHING ON GROWTH AND YIELD OF CARROT (Daucus carota* L.)*"*** *submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***HORTICULTURE****, embodies the result of a piece of bonafide research work carried out by* ***BITHI RANI BISWAS****, Registration No.* ***12-05117*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

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DEDICATED
TO
MY BELOVED PARENTS

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ABSTRACT

An experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2017 to February, 2018. The experiment consisted of two factors, Factor A: four levels of manure, O_0: no manure, O_1: Cowdung (20 t/ha), O_2: Vermicompost (10 t/ha) and O_3: Cowdung (10 t/ha) + Vermicompost (5 t/ha) and Factor B: four mulches, M_0: No mulch, M_1: Water hyacinth, M_2: Black polythene and M_3: Wood ash, respectively. The experiment was laid out in Randomized Complete Block Design with three replications. Manure and mulching influenced significantly all the studied parameters. In case of manure the maximum plant height (44.55 cm) root length (14.74 cm), root diamter (4.12 cm), root weight (124.50 g), root yield (24.90 t/ha) and marketable root yield (23.85 t/ha) were recorded from O_2 treatment. In case of mulches, maximum plant height (44.81 cm), root length (15.21 cm), root diameter (3.92 cm), root weight (117.85 g), root yield (23.57 t/ha) and marketable root yield (21.95 t/ha) found in M_2 treatment. The combined effect of highest root yield (29.07 t/ha) was obtained from O_2M_2 and lowest (13.20 t/ha) from O_0M_0 (control). The highest gross return (Tk. 563200), net return (Tk. 446355) and BCR (4.82) were obtained from the treatment combination from O_2M_2 where the lowest gross return (Tk. 207800), net return (Tk.112755) were obtained from O_0M_0 and lowest BCR (1.67) from O_1M_0. So, It can be concluded that 10 t/ha vermicompost with black polythene mulch was the best for carrot cultivation.

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SOME COMMONLY USED ABREVIATIONS

Full word	Abbreviation
Agro Ecological Zone	AEZ
Agriculture	Agric.
Agricultural	Agril.
Analysis of variance	ANOVA
Bangladesh Bureau of Statistics	BBS
Bangladesh	BD
Percentage of coefficient of variation	CV%
Degrees of freedom	Df
And others	*et al.*
Food and Agriculture Organization	FAO
Harvest Index	HI
Journal	J.
Duncan's Multiple Range Test	DMRT
Date After Transplanting	DAT
Mean sum of square	MS
Murate of Potash	MoP
Ministry of Agriculture	MoA
Randomized Complete Block Design	RCBD
Sher-e-Bnagla Agricultural University	SAU
Triple Super Phosphate	TSP

CHAPTER I

INTRODUCTION

Carrot (*Daucus carota* L.) is one of the most important vegetable grown in the world. It is grown in spring, summer and autumn in temperate countries and during winter in tropical and subtropical countries (Bose and Som, 1990) and extensively cultivated in North and South America, Europe, Asia, North Africa (Thompson and Kelly, 1957). It belongs to the family Apiaceae and said to be originated in Mediterranean region and its cultivation as a crop also began in that region (Shinohara, 1984).

It has high nutritive value and possible diversified use in making different palatable foods like soups, stews, curries, salad, pickles, halua and jam. It contains appreciable amount of carotene, which can contribute a lot to overcome blindness of children. The carrot is one of the profitable crops in Bangladesh. The edible part of this crop is characterized by its high beta carotene content, a precursor of vitamin A and acts as an excellent source of iron, calcium, phosphorus, vitamin B, sugar and folic acid (Chandha, 2003).

It has been reported that the entire production of carrot was 16306 metric tons under 4533 acres in Bangladesh during 2016-2017 year (BBS, 2017). An average yield of carrot is about 25 tons/ha in Bangladesh which are comparatively low from major carrot producer countries (FAO, 2004). It grows successfully in Bangladesh during Rabi season when temperature ranges from 11.17ºC to 28.9ºC (Alim, 1974) and mid November to early December is the best time for its cultivation to get satisfactory yield (Rashid, 1993).

The cultivation of carrot requires an ample supply of plant nutrient. Use of organic manure is essential for its proper growth and development. Organic matter content of

Bangladesh soil is below 1% in about 60% cultivable land as compared to an ideal minimum value of 5% organic matter. In the area of continuous cropping, organic matter is supplied to soil through cowdung, compost, poultry manure etc. Several attempts have been made to increase the yield potential of root crops, but farmers are concerned with the use of inorganic fertilizers which results in decrease fertility of soil, soil health, contents of organic matter and decreases the microbial activity of soil (Chen *et al.*, 2014). Vermicompost is regarded ecologically sound bio-fertilizer and also cost–effective and eco-friendly (Amooaghaie and Golmohammadi, 2017). Vermicompost is a potential source of readily available nutrients, growth enhancing substances and a number of beneficial micro-organisms like N-fixing, P-solubilizing and cellulose decomposing organisms (Archana and Anubha, 2011; Amooaghaie and Golmohammadi, 2017). It enhances soil fertility as it increases soil porosity, aeration, moisture holding capacity, available plant nutrients, acts as complex fertilizer granules and accelerates nitrogen mineralization (Amooaghaie and Golmohammadi, 2017). It has been studied that the vermicompost effects on the plant growth, yield and quality of crops considerably. As a result, the seed germination, vigour, flowering and fruiting of plant, tuberization, development of root size colour shelf life and quality are apparently improved (Ansari, 2008; Chanda *et al*., 2011). On an average Vermicompost contains 1.6% N, 0.7% P, 0.8% K, 0.5% Ca and 0.2% Mg. (Theunissen *et al*., 2010).

In Bangladesh cowdung is used as an organic manure. Due to inadequate knowledge about the merits of organic manure, the farmers habituated extensive use of inorganic fertilizers. On an average, well rotten cowdung contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O (Yawalkar *et al*., 1984).

In Bangladesh carrot is grown during winter season when the rainfall is scanty. So irrigation is essential for cultivation. But it increases the cost of cultivation. Under such condition mulching may be useful in reducing irrigation requirement. To serve

this purpose water hyacinth, wood ash and black polythene sheets may be used as mulching materials. Mulching is highly effective in checking evaporation loss of soil moisture. Mulching protects the loss of soil moisture by soil evaporation induced by wind and reduces the irrigation requirement (Roy *et al.* 1990). It increases the efficiency of applied N-fertilizer and irrigation (Rhee *et al*., 1990). Different mulches regulate soil moisture and temperature, suppress weeds and improve germination and emergence (Frazier, 1957). In addition, mulches increase microbial activity in the soil (Aldefer, 1946). Higher yield and better quality, less infestation of insects diseases, earliness, prolong growing season, higher nutritive value of the produced, improved storability are the advantages of mulching (Ahmed, 1999). In some extent, mulches reduce the invasion of insects and diseases (Brown *et al*., 1989).

Therefore, the present study was undertaken to study the effect of manure and mulching materials on growth and yield of carrot.

Objectives:

1. To find out the effect of manures on the growth and yield of carrot.
2. To select the appropriate mulching material for carrot production.
3. To determine the suitable combination of manure and mulching for ensuring the maximum yield of carrot.

CHAPTER II

REVIEW OF LITERATURE

Carrot (*Daucus carota* L.) is one of the most important vegetable crops of the world. From the nutritional point of view, it received much attention to the researches throughout the world to develop its production technology. Many Research works have been carried out in relation to the effect of different manure and mulches for the production of marketable size, maximizing the yield and quality of carrot in different countries. Yet, a few studies were found to have made in this regard in Bangladesh. However, literatures available in this respect at home and abroad are presented here.

2.1 Effect of manure on the growth and yield of carrot

Optimum manure is one of the most important and uncontroversial factors for maximizing the yield of a crop. The results of the researchers relating to organic manure of carrot are reviewed.

Dumitrescu (1965), reported the experiment on "compost as organic manure of high fertilizing value" that application of FYM at the rate of 20 t/ha gave higher total yield in carrot.

Sans *et al.* (1974) stated that organic compound reduced soil temperature on the soil surface and depth of 10 cm soil temperature disappeared of carrot cultivation.

Hochmuth and Howell (1983) reported that leaf area, leaf number, total dry weight and the highest marketable yield (18.6 t/ha) was obtained from organic cowdung raised beds with 'New Kuroda' where nonorganic mulched bed gave the lowest yield (7.0

t/ha) in carrot. Lang (1984) found that organic manure increased the yield of carrot (10-12 %) compared with control.

Koddus and Morgan (1986) worked on Spent Mushroom Compost (SMC) and deep litter fowl manure (FM) as a soil ameliorant for vegetable. Spent Mushroom compost and litter fowl manure were applied at 0, 10, 20, 40 and 80 t/ha prior to showing or transplanting Celery, Lettuce, Cauliflower and Carrot in a rotation. The thermal conductance and bulk density of soil decreased and its water stable aggregates (>0.25 mm) hydraulic conductivity, water retention, N, P, K and organic C increased with increasing rates of Spent mushroom compost and litter fowl manure . Neither material increased soil salinity to a harmful level. Spent mushroom compost was superior to deep litter fowl manure in increasing soil P^{H} and organic carbon. Both materials decreased the yields of the first three crops but not the fourth crop. Concentration of N, P, K in the plant tissue increased as the rates of spent mushroom compost and deep litter fowl manure increased. Deep litter fowl manure significantly increased the levels of Zn and Mn in the plant tissue.

Bohec (1990) studied on the use of cowdung for carrot production in 1980-1986 and reported that carrot were grown in rotation on land with annual application of cowdung. The highest total yield of carrot was 78.4 t/ha.

Almazov and Kholuyako (1990) worked with the application of organic manure and mineral fertilizers in productivity of a vegetable crop in 1982-86 and found that the effects of application of the NPK rates for each crop and/or 2 peat (organic manure) rates on yields and quality of 4 vegetable crops, Peat (organic manures) gave the highest yields in the all crops. Peat increased dry manure and sugar content in tomato fruits, carotene in carrot roots and vitamin C in cucumber and decreased dry matter, sugar and vitamin C and cabbage for vegetable crops in 1980-86.

Kale *et al.* (1991) observed that use of cowdung is helpful reducing basal dose of fertilizer to 25 % in carrot.

Kipkin *et al*. (1994) made 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, Carrot, Cabbage etc and without irrigation. The result should that these organic fertilizers proved the yield and quality of crop, especially on soil having a low content of nitrate N.

Datta and Chakrabarty (1995) conducted a field experiment in 1991-1993 at Sriniketan , West Bengal with 5 t/ha rise husk ash, 0.5 t/ha Mustard oil cake or 10 t/ha FYM . The highest potato tuber yield (27.6 t/ha) was obtained from the highest NPK rate used. Among the manures, the highest tuber yields were obtained from FYM followed by rice husk ash and Mustard oil cake.

Flynn *et al*. (1995) carried out an experiment to evaluate the suitability of reposted broiler chicken manure as a potting substrate using lettuce plants. They mentioned that the broiler manure containing peanut hulls as FYM material was composted and then combined with a commercially available potting substrate. The highest fresh yield was obtained when broiler chicken litter compost was mixed with commercially available potting substrate at 3:1 ratio. There was no evidence of physiological disorders from excessive nutrient concentrations.

Geweda *et al*. (1995) grew Lettuce (cultivars Syrens and Debata) and Carrot (cultivars Karo F_1 and Kama F_1) seedlings in soil containing 0, 3 or 8% organic manure (peat) and 0, 300 or 600 mg Pb dm^3 (as lead acetate). The inclusion of organic manure in the soil reduced the Pb content of lettuce leaves and carrot roots in the Pb treatments. In the investigation, no external symptoms of the Pb toxicity were observed but

difference in the mineral and organic composition of lettuce leaves and Carrot roots retarded Pb contamination, particularly in the soil without organic manure.

Zarate *et al*. (1997) evaluated rates and methods of application of poultry manure on Lettuce. They found in the absence of incorporated manure, surface application of manure 14 t/ha gave significantly higher yield (17.8 ton fresh manure per hectare) than other nutrients. When 7 t/ha incorporated, the rate of surface application had no significant effect on yield (13.3-17t/ha), whereas when 14 t/ha was incorporated, surface application of 7 t/ha manure gave the significantly highest yield (20 t/ha fresh matter).

Vieira *et al.* (1998) studied on a clayey Dusky Red Latosol in Dourados, Barzil, to evaluate the response of P fertilizer application at 4.5, 25.8, 43.0, 60.2 and 81.7 kg/ha as triple supper phosphate as well as the response to application of cowdung at 1, 6, 10, 14 and 19 t/ha. The treatments were defined by the plane puebla III experimental matrix, resulting in the following p (kg/ha) and cowdung (t/ha) combination: 4.3 × 6, 25.8 × 1, 25.6 × 6, 25.8 × 14, 43.0 × 10, 60.2 × 6, 60.2 × 14, 60.2 × 19 and 81.7 × 14. Each plot was 3.5 cm2 with 10 plants grouped in double rows. During the vegetative cycle, plant height was measured every 15 days. Harvesting was carried out 3 month after were between 31 cm (4.3 kg P/ha + 6 t cowdung/ha) and 37 cm (60.2 kg P/ha + 19 t cowdung /ha), 90 and 100 days after planting, respectively. Dry manure production of marketable root was independent of cowdung level but increased linearly with P dose ranging from 0.42 t/ha (4.3 kg P/ha) to 1.3 t/ha (81.7 kg P/ha). Marketable root yield of carrot increased linearly with P and cowdung rates, averaging 10 t/ha.

Levedeva *et al. (*1998) observed the effect of limning and organic fertilization on the lead content in agricultural crop and dernopodzolic soils contaminated with lead (up to

500 mg/kg soil). The soil P^{H} and content of organic manure was determined which would enable the safe production of red beet and carrot.

Sediyama *et al.* (1998) carried out an experiment to assess the plant nutritiontal status, root quality and yield of carrot cv. Brasilla, influenced by the following treatments: seven types of organic compounds which were produced from liquid swine manure and straw materials, crushed sugarcane, napier grass and coffee straw and crushed sugarcane with four replication from 3 May to 23 August, 1994 in Ponte Nova county, Minas Gerais State, Brazil. Generally, both a greater plant height and Arial part yield were obtained from compounds produced from coffee straw plus liquid swine manure, crushed sugarcane plus triple super phosphate and napier grass plus liquid swine manure provided yields of total roots higher than 50 t/ha. The organic compound 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 super phosphate did not affect root yield, neither Ca and P contents in leaves and roots. The carrot roots that received organic or mineral fertilization presented superior P and K contents and similar Ca content, when compared to those contents considered as standard foe human diets.

Nielsen *et al.* (1998) studied to test the essential of various organic wastes as soil amendments in horticultural production, in British Columbia, Canada. They were grown Swiss chard *(Beta vulgaris)* and carrot during 1993-1995 under irrigation in a coarse textured soil. British Columbia soil to which annual application of 45 t/ha of various organic amendments plus NPK fertilizers were applied. The amendments included bio solids, bio wastes and peat. Yield of both chart and carrot was increased for some organic treatments plus fertilizer relative to lots receiving commercially recommended rates of NPK fertilizer only. The evidence suggested that many locally produced bio solids and bio wastes might improve soil quality and the growth of high value horticultural crops, especially carrot.

Damagala *et al*. (1998) conducted on 3 sites near Rzeszow, Poland with carrot cultivars Joba and Flacore. Ammonium sulfate was applied at seed sowing. On all sites Carrot yield harvested from placements treatments were significantly higher than that from broadcast treatments of Ammonium sulfate. Irrespective of fertilizer application method, the lowest contents of nitrates were detected in roots cultivated in heavy soil containing 1.8% organic manure.

Schuch *et al.* (1999) worked on the effect of organic manure (cowdung and chicken) on yield and quality of carrot cv. 'Nastes Forto', ''Flakkese, 'Fuyumaki', 'Nastes superior', 'Harumaki Kinko' were studied in 1993 and 1995. In 1995, carrot cv. 'Nastes superior'and 'Harumaki Kinko' were replaced by Brasillia 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, 'Nastes' for to produce the highest root yield. Root number, weight, diameter and length varied different amount of manure applied. Application of organic manure generally increased all the parameters evaluated.

Oliveira *et al.* (2001) studied the effect of cowdung and mineral fertilizer on root production in carrot and found that the different levels (0, 15, 20, 25 and 30 t/ha) of cowdung, in the presence or absence of mineral fertilizers, on the production roots was evaluated in a field experiment conducted in Areia (Praibaj), Brazil during July-October, 1997. Cowdung 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 root (39.0 t/ha). The production of Extra-A and extra grade roots increased linearly as cowdung rates increased. Production of extra-A and extra grade roots increased by approximately 0.6 and 0.16 t/ha for each of tone of cowdung added in the soil. The presence of mineral fertilizers increased root yields and increased the production of Extra-A and Extra grade, special and first grade roots by 4.9, 5.6, 1.7 and 19.4 t/ha, respectively compared to its absence.

Salminen *et al.* (2001) reported that the application of digested poultry slaughter house waste as nitrogen source gave the higher yield carrot roots. Rahman (2000) carried out an experiment and reported that height of carrot seedling was significantly influenced by the application of cowdung. The highest plant height (75.28 cm) at 100 days was reported from the dose of cowdung (100t/ha).

Sehuch *et al.* (1999) studied on the effect of organic manure (chicken and quail) on yield and quality of carrot and reported that Nantes produced the height root yield, root number, weight, diameter and length when applied different amount of manure applied.

Mesquita *et al.* (2002) conducted an experiment on a clayey yellow red Oxisol to evaluate the residual effect of the application of phosphorous 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 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 of urban waste compost.

Akand (2003) conducted an experiment with mulching and organic manure trial on carrot in BAU. He reported that black polythene mulch and organic manure (cow dung) significantly resulted the highest yield of carrot.

Khadtare *et al.* (2006) conducted a field experiment in tomato and carrot at the college farm of Anand Agricultural University, Anand, during Rabi season of 2005- 2006. The experiment was laid out in a RCBD with four replications. Application of 25% recommended dose of fertilizer (RDF) through FYM gave the highest marketable yield.

Alam *et al.* (2007) carried out an experiment to study the effect of vermicompost and NPKS fertilizers on growth and yield of potato (cv. Cardinal) in Level Barind Tract

(AEZ-25) soils of Bangladesh. The organic matter of the experimental field soil was very low and in case of N, P, K and S also low. The land was medium fertile and P was 5.4. There were 12 treatments viz. control (T), vermicompost H 2 3 4 5 (VC) 2.5 t/ha (T), VC 5.0 t/ha (T), VC 10.0 t/ha (T), VC 2.5 t/ha+50% NPKS (T), VC 5 t/ha+50% NPKS 6 7 8 9 (T), VC 10 t/ha+50% NPKS (T), VC 2.5 t/ha+100% NPKS (T), VC 5 t/ha+100% NPKS (T), VC 10 11 1 2 10 t/ha+100% NPKS (T), 50% NPKS (T) and 100% NPKS (T). The experiment was laid out in RCBD with three replications. The doses of N-P-K-S were 90-40-100-18 kg/ha for potato. Application of v 10 ermicompost and NPKS significantly influenced the growth and yield of potato. The treatment T produced the highest (25.56 t/ha) tuber yield of potato. The lowest yield and yield contributing parameters 1 recorded in control (T). Application of various amounts of vermicompost (2.5, 5, 10 t/ha) with NPKS fertilizers (50% and 100%) increased the vegetative growth and yield potato. Vermicompost at 2.5 5 and 10 t/ha with 50% of NPKS increased tuber yield over control by 78.3, 96.9 and 119.5 t/ha respectively. And vermicompost at 2.5, 5 and 10 t/ha with 100% of NPKS increased tuber yield by 146.8, 163.1 and 197.9 %, respectively. The results indicated that vermicompost (10 t/ha) with NPKS (100%) produced the highest growth and yield of potato. The correlation matrix showed that tuber yield of potato had significant and positive correlation with plant height (r = 0.953**), number of main stem/hill (r = 0.732*), weight of haulm (r = 0.948**), yield of haulm (r = 0.935**), dry weight of haulm (r = 0.935**), number of tubers/hill (r = 0.909**), percentage of dry matter of tubers (r = 0.948**), weight of tubers/hill (r = 1.00***) and dry weight of tuber (r = 0.985**). It is suggested that 100% inorganic fertilizers with 5-10 t/ha of vermicompost is suitable for better production of potato but 10 t/ha of vermicompost may not economically profitable.

Chatterjee *et al*. (2014) conducted the present study on diverse vegetable wastes were recycled for vermicomposting and their effects were evaluated in field experiments in organic carrot production. The result showed that among different vegetable wastes,

substrate combining mixture of non-legume and legume wastes at 2:1 emerged best considering the nutrient contents, C/N ratio, earthworm biomass and vermicompost recovery. Use of such vermicompost recorded highest root length (19.26 cm), root volume (73 cm3), root weight (68.43 g) and root yield (16.07 Mg ha−1) of carrot. The quality of the root as judged by beta carotene and total soluble solids content was also found highest by the same vermicompost. The findings established the potentiality of earthworm for quality vermicompost production from vegetable wastes, and through intended selection and judicious mixture of different vegetable wastes the cast quality can be improved. The study demonstrated that vermicompost produced from the substrate, combining mixture of non-legume and legume vegetable waste at 2:1 will provide the major nutrients in more balanced proportion compared to sole individual family waste vermicompost (vermicompost obtained from the waste of one single plant family). The findings can be promoted as a sound vegetable wastes recycling technology for organic carrot production to conserve natural resources and to minimize the deleterious impact of vegetable wastes on mother earth.

Kumar and Gupta (2018) conducted an experiment to study the effect of vermicompost and chemical fertilizers on growth and yield of Radish (Raphanus sativus). From this experiment it is clear that vermicompost is better fertilizers than other fertilizers due to the availabilities of nutrients in vermicompost and also help in sustainability of agriculture sector. The sustainabilities of agriculture are more important for food securities of peoples of a country. The plant heights were found to be 50cm in vermicopmost, 41cm in cow dung, 39cm in urea and 17cm in control treatment. Weight of the tuber was observed to be 152gm in vermicompost, 133gm in cow dung, 120 gm in urea, and 49gm in control treatment. The number of fruits/ plant was found to be 44 in vermicompost, 36 in cow dung, 25 in urea and 15 in control treatment. The stem diameters was observed to be 1.40cm in vermicompost, 1.16cm in cow dung, 0.96cm in urea and 0.76cm in control treatment. The dry matters yield was 41.36 gm

in vermicompost, 39.92gm in cow dung, 35.25gm in urea and 21.50gm control treatment.

Hasan *et al.* (2018) conducted experiment and revealed that vermicompost and organic mulching is an environment friendly component used as a bio fertilizer in agricultural sector. The current study was conducted to determine the effects of vermicompost and organic mulching on growth yield and profitability of carrot (*Daucus carota* L.). Vermicompost was processed from waste and it was applied to field plots in the three different concentrations viz., 2t/ha (V_1), 4 t/ha (V_2) and 6 t/ha (V_3) with control (V_0), and four levels of mulching viz., control (M_0), rice straw (M_1), water hyacinth (M_2), and sawdust (M_3), respectively. Plant height, number of leaves, leaves fresh weight, root length, leaves dry matter content, root fresh weight, root dry matter content and root diameter, significantly differed among the vermicompost doses and mulching at different levels. Among the different level of vermicomposts, the highest marketable yield and gross yield (27.68 t/ha) of the root (26.35 t/ha) were recorded from V_2 while the lowest (18.71 t/ha) and (20.18 t/ha) from control (V_0). The highest marketable yield (27.89 t/ha) and the gross yield (29.48 t/ha) of root observed from M_2 while the lowest (15.81 t/ha) and (17.12 t/ha) from control (M_0) under mulching treatment. Similarly, the highest marketable yield (33.24 t/ha) and gross yield (34.45 t/ha) of root were marked from V_2M_2 and the lowest (17.46 t/ha) and (18.65 t/ha), respectively from V_0M_0 under combined treatment. The highest (3.64) benefit-cost ratio was recorded from V_2M_2 while the lowest (1.68) from V_3M_0 and it was indicated that vermicompost @ 4 t/ha with water hyacinth mulching was found suitable for carrot cultivation.

2.2 Effect of mulching on the growth and yield of carrot

Olfati *et al*. (2008) conducted an experiment on mulching affect in soils. The objectives of this study were to characterize the possibility of using organic based mulches to modify carrot (*Daucus carota* L.), cv. Forto Royal, plant growth and

determine effects on yield and quality. Mulch treatments included rice (*Oriza sativa* L.) hulls, sawdust (*Populus deltoids* Bartram ex Marshall var. *deltoides*), and chopped rice straw. Total yield, root weight, root length, and total soluble solids for plants grown with organic mulches were better than the bare soil control. No significant differences were found in plant height, root diameter, inner and outer core diameter, root color, dry matter, and ash percentage due to treatment. Mulching with organic materials provided some benefit to root development, yield, and total soluble solids content and its use is recommended to promote the carrot root development.

Rani *et al.* (2016) conducted experiment comprised of two factors such as -organic manures viz. F_0 (control), F_1 (cowdung), F_2 (vermi-compost), F_3 (poultry manure), and mulches viz. M_0 (control), M_1 (rice straw), M_2 (water hyacinth) respectively. It was laid out in Randomized Complete Block Design (RCBD) with three replications. The results of the experiment shown that different organic manures and mulches had significant influences of all the parameters studied. The fresh weight of root (121.31g), and dry matter of root (17.49%) were found the highest from cowdung treatment and the lowest 103.62g, 13.86% from control. Again, the highest fresh weight of root (122.34g), dry matter of root (17.06%) was found from water hyacinth mulch treatment and the lowest 109.29g and 15.78% were found from control. For combined effect, maximum fresh weight of root (134.51g) and dry matter of root (18.87%) were found from application of cowdung with water hyacinth mulch and minimum 103.27g and 13.82% from control treatment. In addition, the highest total yield (57.93 t/ha) and marketable yield (49.11 ton/ha) were recorded from cowdung treatment and the lowest 51.78 t/ha and 41.44 ton/ha were obtained from control. In case of mulching, the highest total yield (57.69 t/ha) and marketable yield (47.14 ton/ha) were found from water hyacinth mulch and the lowest 54.61 t/ha and 45.12 ton/ha were from control treatment. For combined effect, maximum total yield (59.83 t/ha) and marketable yield 49.80 ton/ha were observed from the treatment of cowdung with water hyacinth mulch and minimum total yield (51.61 t/ha) and marketable yield (41.30 ton/ha) were from

control treatment. It may be concluded that the combination of cowdung with water hyacinth mulch can be used to obtain higher growth and yield of carrot.

Daniel *et al.* (2018) was carried out an experiment to evaluate the contributions to the optimization of water use in a carrot crop under different forms of mulch using *Gliricidia sepium*, fertilization with castor bean cakes and irrigation water depths. The experiment was conducted in Seropédica, RJ, Brazil (22º 46' S and 43º 41' W), from June to September 2010. The experiment was conducted using a split-split-plot scheme (5 x 3 x 2), with four replicates. The five plots had irrigation depths corresponding to 0, 43, 72, 100 and 120% of crop evapotranspiration (ETc); the three subplots contained the different forms of mulch (whole leaves (WL) and chopped leaves and branches (CLB) and the absence of mulch (AM); and the two sub-subplots contained either the presence (PF) or absence of fertilization (AF). Using time domain reflectometry (TDR) in the irrigation management, water depths ranging from 67.8 to 285.5 mm were applied. The use of mulch in association with fertilization led to higher yields and water-use efficiency (WUE) of the carrot plants, and the mulch composed of WL performed best. The application of irrigation depths corresponding to 97% of ETc promoted the highest carrot yields, although the highest values of WUE were observed, with irrigation depths corresponding to a range from 51 to 68% of ETc.

Jaysawl *et al.* (2018) conducted research work at Research field, Department of Horticulture, School of Agriculture, ITM University, Gwalior (M.P.) during the winter season of 2016-17 of carrot. The experiment comprises of eight treatment viz.T_1-Control, T_2-Sugarcane straw mulch, T_3-Black polythene mulch, T_4-Leaves mulch (*Dalbergia sissoo*) T_5-Blue polythene mulch, T_6-Paddy straw mulch, T_7-Grass mulch (*Cynodon dactylon*) and T_8-White polythene mulch. The experiment was laid out in Randomized Block Design with three replications. The results revealed that the treatment T3-Black polythene mulch was found to be the best among the various treatment and recorded maximum plant height (61.70 cm), Length of leaf (26.78 cm),

number of leaves (9.84 plant-1), Fresh weight of leaves (39.38 plant^{-1}), Dry weight of leaves plant^{-1} (5.83 plant^{-1}), Fresh weight of root plant^{-1} (225.33 plant^{-1}), Dry weight of roots plant^{-1} (17.88 plant^{-1}), Fresh weight of plant (264.72 g), Dry weight of plant (23.71 g), Total root length (23.45), Total root diameter (5.54cm). The treatment T3 also recorded the maximum yield (1.43 kg/m2 and 54.69 t/ha) which was followed by T_5- Blue polythene mulch for these parameters.

Hasan *et al.* (2018) were conducted an experiment to determine the effects of vermicompost and organic mulching on growth yield and profitability of carrot (*Daucus carota* L.). Vermicompost was processed from waste and it was applied to field plots in the three different concentrations viz., 2t/ha (V_1), 4 t/ha (V_2) and 6 t/ha (V_3) with control (V_0), and four levels of mulching viz., control (M_0), rice straw (M_1), water hyacinth (M_2), and sawdust (M_3), respectively. Plant height, number of leaves, leaves fresh weight, root length, leaves dry matter content, root fresh weight, root dry matter content and root diameter, significantly differed among the vermicompost doses and mulching at different levels. Among the different level of vermicomposts, the highest marketable yield and gross yield (27.68 t/ha) of the root (26.35 t/ha) were recorded from V_2 while the lowest (18.71 t/ha) and (20.18 t/ha) from control (V_0). The highest marketable yield (27.89 t/ha) and the gross yield (29.48 t/ha) of root observed from M_2 while the lowest (15.81 t/ha) and (17.12 t/ha) from control (M_0) under mulching treatment. Similarly, the highest marketable yield (33.24 t/ha) and gross yield (34.45 t/ha) of root were marked from V_2M_2 and the lowest (17.46 t/ha) and (18.65 t/ha), respectively from V_0M_0 under combined treatment. The highest (3.64) benefit-cost ratio was recorded from V_2M_2 while the lowest (1.68) from V_3M_0 and it was indicated that vermicompost @ 4 t/ha with water hyacinth mulching was found suitable for carrot cultivation.

Rahman *et al.* (2018) conducted an experiment at the Horticulture Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur,

Bangladesh to find out the effects of mulch and different manures and fertilizers on the yield components and quality of carrot (*Daucus carota* L.). Twelve treatment combinations were evaluated in two factors Randomized Complete Block Design (RCBD) with three replications. Different doses of manures and fertilizers viz. F_0 = Control, F_1 = Cowdung (CD) @ 10 t ha^{-1}, F_2 = Mustard Oil Cake (MOC) @ 0.25 t ha^{-1}, F_3 = Cowdung (CD) @ 5.0 t ha^{-1} +Mustard Oil Cake (MOC) @ 0.125 t ha^{-1}, F_4 = Urea @ 326.08 kg ha^{-1} + Triple Super Phosphate(TSP) @ 93.75 kg ha^{-1} + Muriate of Potash (MoP) @ 200 kg ha^{-1} and F_5 = Cowdung (CD) @ 5 t ha^{-1} + Urea @ 163.04 kg ha^{-1} + Triple Super Phosphate (TSP) @ 46.87 kg ha^{-1} + Muriate of Potash(MoP) @ 100 kg ha^{-1} were applied under mulched (M_1) and non-mulched (M_0) conditions. Results from our study revealed that maximum fresh weight (3.57 kg plot-1), individual root weight (101.90 g), root length (14.64 cm), root diameter (3.27 cm), total yield (23.78 t ha^{-1}),marketable yield (20.53 t ha^{-1}) and beta-carotene content (8.78 mg 100^{-1} g) were recorded from F_5 treatment. The mulching also had a significantly positive effect on maximizing the root yield components as well as beta-carotene contents over non-mulched treatment. On the other hand, the interaction effect of M_1F_5 performed superior in producing yield components and beta-carotene content of root compared to other combinations. The highest marketable yield (25.10 t ha^{-1}) along with best economic gross return (TK. 2, 47,167 ha^{-1}) and the benefit-cost ratio (2.91) were also noted from M_1F_5. It was concluded that organic and inorganic sources of nutrients along with mulch effectively increase the carrot yield than the sole application of higher doses of manures and fertilizers.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The experiment was conducted at the Horticulture Farm of the Sher-e-Bangla Agricultural University, Dhaka during November, 2017 to February, 2018. Laboratory works were done at Horticulture Laboratory in Sher-e-Bangla Agricultural University, Dhaka-1207.

3.2 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix VII.

3.3 Soil

The experiment area was belonged to the Modhupur Tract and AEZ 28. The soil was sandy loam with a pH value 6.6. Soil samples were collected randomly from a depth up to 30 cm of the experimental plot and analyses were done and showed nitrogen 0.075%, phosphorus 13 ppm, exchangeable potassium 0.20 me/ 100 g soil and organic carbon 0.82%.

3.4. Planting materials

The carrot variety “New Kuroda” was used as experimental materials. The seeds of this variety were collected from Siddique Bazar, Dhaka.

3.5 Treatments of the experiment

The experiment was conducted to study the effect of four levels of manure and four levels of mulches. Different levels of two factors were as follows:

Factor A: Different types of manure

O_0 = No manure

O_1= Cowdung (20 t/ha)

O_2 = Vermicompost (10 t/ha)

O_3 = Cowdung(10 t/ ha) + Vermicompost (5 t/ha)

Factor B: Different type of mulches

M_0 = No mulch

M_1 = Water hyacinth

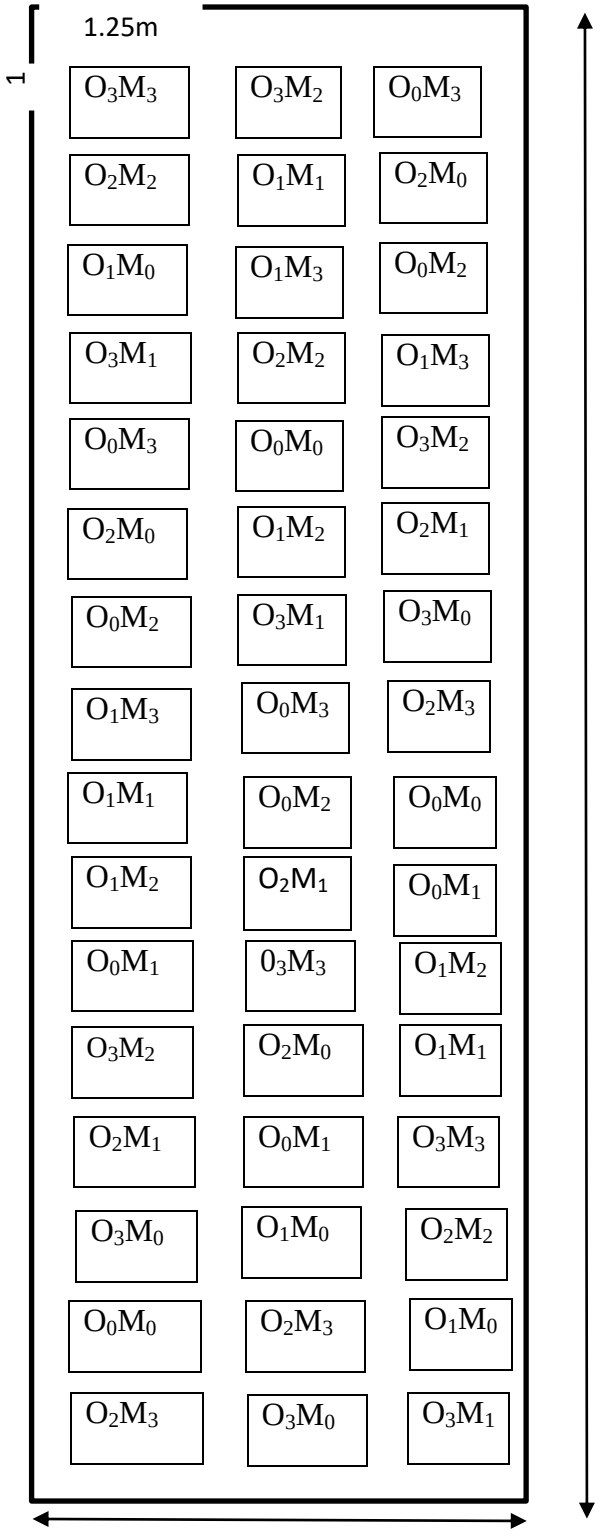
M_2 =Black polythene

M_3 = Wood ash

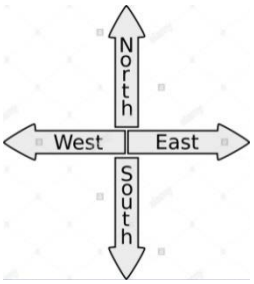
There were altogether 16 treatments.

Table 1. Two factors consist of sixteen (4×4=16) treatments combination. These are as follows:

Treatments	Description	
	Manure	Mulches
O_0M_0	No manure	No mulch
O_0M_1	No manure	Water hyacinth
O_0M_2	No manure	Black polythene
O_0M_3	No manure	Wood ash
O_1M_0	Cowdung (20 t/ha)	No mulch
O_1M_1	Cowdung (20 t/ha)	Water hyacinth
O_1M_2	Cowdung (20 t/ha)	Black polythene
O_1M_3	Cowdung (20 t/ha)	Wood ash
O_2M_0	Vermicompost (10 t/ha)	No mulch
O_2M_1	Vermicompost (10 t/ha)	Water hyacinth
O_2M_2	Vermicompost (10 t/ha)	Black polythene
O_2M_3	Vermicompost (10 t/ha)	Wood ash
O_3M_0	Cowdung (10 t/ha)+Vermicompost (5 t/ha)	No mulch
O_3M_1	Cowdung (10 t/ha)+Vermicompost (5 t/ha)	Water hyacinth
O_3M_2	Cowdung (10 t/ha)+Vermicompost (5ton/ha)	Black polythene
O_3M_3	Cowdung (10 t/ha)+Vermicompost (5t/ha)	Wood ash



Legend



Plot length: 1.25m,

Plot breadth: 1.0m,

Total length: 24.5 m

Total breadth: 5.75 m

Distance between plot: 0.5m

Replication distance: 1m

Figure 1. Layout of the experiment plot

3.6 Design of the experiment

The two factor experiment was laid out in a RCB design with three replications. The whole experimental area was 24.5m x 5.75 m which was divided into three blocks. Each block was again divided into 16 plots and hence there were 48 (16 x 3) unit plots. The treatments were assigned randomly in each block separately. The size of unit plot was 1.25m x 1.0m. The distance between two adjacent blocks and plots were 1.0 m and 0.5 m respectively.

3.7 Seed soaking and treatment

Carrot seeds were soaked into water for 12 hours and then wrapped with a piece of thin cloth prior to sowing. Then they were spread over polythene sheet in sun for two hours to dry. The seeds were treated with Bavistin 50DF@3g/100g seed.

3.8 Land preparation

The selected land for the experiment was first opened on November, 2017 by disc plough and it was exposed to sun for seven days prior to next ploughing. The land was ploughed six times by tractor to obtain good tilth. Laddering to break the soil clods and pieces was followed with each ploughing. All weeds and stubbles were removed and the land was finally prepared through addition of the basal doses of manure and fertilizers. Plots were prepared according to design and layout. Finally soil of each plot was treated by Sevin 80 WP @ 2kg/ha to protect the young plant from the attack of mole cricket, cutworm and ants, Irrigation channels were made around each block.

3.9 Manure and fertilizer application:

The sources of applied N, P_2O_5, K_2O were as cowdung, vermicompost. The entire amounts of cowdung and vermicompost were applied during the final land preparation as per treatments.

3.10 Application of mulching:

Before sowing of seeds mulching was done with water hyacinth, wood ash and black polythene as per treatments. Fresh water hyacinth as chopped into small pieces (8-10cm) and then placed over the plots with a thickness of 12cm approximately. Black polythene sheet with small holes at plant distance was spread over the plots accordingly so that the seedlings could emerge easily through the holes.

3.11 Seed rate and seed sowing

Seeds were used at the rate of 3 Kg/ha as narrated by Rashid (1993), consequently 60 g of seeds were used for the experimental area. Seeds were sown on different times as per treatments. The seeds were sown at a distance of 20 cm × 25 cm by making a shallow furrow at a depth 1.5 cm in each plot.

3.12 Intercultural operation

When the plants establishing in the plots they were always kept under careful observation. Various intercultural operations were accomplished for better growth and development of germinated plants.

3.12.1 Thinning

Emergence of seedlings started about six days after sowing. Different number of plants per plot was found due to different sowing. Thinning was done at two stages like 15 and 30 days after sowing in order to keep a healthy plant in each hill.

3.12.2 Weeding

Weeding was done at two times. First weeding was done after 15 days of sowing when seedlings were thinned. Second weeding was done after 30 days of sowing .

3.12.3 Insects and diseases management

Precautionary measure against Fusarium rot was taken by spraying Dithane M 45 @ 2g /litter water. The crop was ingested by cutworms (*Agrotis ipsilon*) during the early

stage of growth of seedlings in the month of February. This insect was controlled initially by beating and hooking, afterwards by spraying Dieldrin 20 EC @ 0.1%.

3.13. Harvesting

The crop was harvested after 90 days from seed sowing when leaves become pale yellow in color. Harvesting was done plot wise by uprooting the plants manually by hand. The soil and lateral roots adhering to the tuberized conical roots were properly cleaned.

3.14 Collection of data

3.14.1 Plant height

The plant height was measured with the help of a meter scale from the ground level of the root up to the tip of leaf at 30, 50, 70 and harvest days after sowing**.**

3.14.2 Number of leaves per plant

Number of leaves was counted 20 days interval and was started from 30 days after sowing and continued to harvest, i.e. 50, 70 and harvest DAS. Ten plants in each plot were used to count number of leaves per plant.

3.14.3 Length of root (cm)

Ten plants are uprooted and detached from foliage parts. Then the length of modified roots was measured by scale and recorded in centimeter.

3.14.4 Diameter of root (cm)

Ten selected plants are used to determine root diameter. Root diameter was measured at the time of harvesting with slide calipers and recorded in centimeter.

3.14.5 Fresh weight of leaves per plant (gm)

Leaves of ten fresh plants in each plot were detached by sharp knife and fresh weight was taken by using a balance and recorded in gram (g).

3.14.6 Weight of root per plant

Ten selected carrot roots were used to determine the fresh weight of root. Modified roots were detached by knife from the foliage part and fresh weight was taken by using balance and recorded in gram (g).

3.14.7 Dry matter percentage of root (%)

Ten selected carrot roots were used to determine root dry weight. Immediate after harvesting roots were weighed initially, then chopped and kept it in an oven at 70-800^0 C for 48 hours in order to get constant weight. (AOAC, 2965). The dry weight of root was measured by electric balance and was considered as dry weight and recorded in gram (g).

$$\% \text{ Dry matter content of root} = \frac{\text{Dry weight of root}}{\text{Fresh weight of root}} \times 100$$

3.14.8 Dry matter percentage leaves (%)

Leaves were detached from the root and kept in an oven at 70-800C for 72 hours until reached constant weight. After drying, the leaves were kept in a desiccators containing blur silica gel. Fifteen minutes later the samples were weighed by using electric balance and recorded in gram (g).

$$\% \text{ Dry matter content of leaves} = \frac{\text{Dry weight of leaves}}{\text{Fresh weight of leaves}} \times 100$$

3.14.9 Yield per plot (kg)

Root weight per plot was calculated by using the following formula-

$$\text{Root weight (kg/plot)} = \frac{\text{Area of single plot } (m^2) \times \text{Average yield per plant}}{\text{Spacing} \times 1000}$$

3.14.10 Yield per hectare (ton)

Gross yield of roots per hectare was calculated by using the following formula-

$$\text{Gross yield} = \frac{\text{Yield per plot (kg)} \times 10000\ m^2}{\text{Area of plot in square meter } (m^2) \times 1000\ \text{kg}}$$

3.14.11 Marketable yield per plot (kg)

Marketable yield was recorded excluding cracked and branched roots from each plot and expressed in kg.

Marketable yield (kg/plot) = Gross yield - Non marketable yield (number of cracked root and branched root).

3.14.12 Marketable yield per hectare

Marketable yield of roots per hectare was calculated by conversion of the marketable root weight per plot and recorded in ton.

3.14.13 Branched root per plot

After harvest the branched roots are counted and the percentage was calculated by the following formula-

$$\% \text{ of branched root} = \frac{\text{Number of branched root}}{\text{Total number of root}} \times 100$$

3.15 Statistical analysis

The recorded data on different growth and yield parameters were calculated for statistical analysis. Analyses of variances (ANOVA) for most of the characters under consideration were performed with the help of MSTAT program. Treatment means were separated by Duncane's Multiple Range Test (DMRT) at 5% level of significance for interpretation of the results.

3.16. Economic analysis

In computing economics, the varying levels of manure and different types

of mulches were taken into consideration apart from other costs common to all the treatments as per package of practices.

3.16.1 Cost of cultivation

The prices of all the inputs and the labour cost prevailed at the time of their use were taken into consideration while working out the cost of cultivation and expressed as taka per hectare.

3.16.2 Gross returns

Gross returns were calculated on the basis of the prevailing market price and the yield produced per hectare.

3.16.3 Net returns

Net returns were arrived after deducting the cost of cultivation from the gross returns of the marketable produce on hectare basis and expressed in taka per hectare

Net returns = Gross returns – cost of cultivation

3.16.4 Benefit cost ratio

It was obtained by dividing gross returns with cost of cultivation per hectare .

$$\text{Benefit Cost Ratio} = \frac{\text{Gross returns (tk.ha}^{-1)}}{\text{Cost of cultivation (tk.ha}^{-1})}$$

CHAPTER IV

RESULTS AND DISCUSSION

The results of the present experiment were presented in tables 2 to 16 and figures 2 to 5 on the effect of organic manure and mulching on the growth and yield of carrot. The analysis of variance of the data on different plant characters obtained from present investigation were presented in Appendices III to VIII. The tabulated results have been discussed below under the following headings.

4.1 Plant height

Plant height is one of the important growth contributing character for carrot. Plant height of carrot has measured at 30, 50, 70 days after sowing and at harvest. It was observed that different levels of manure application influenced significantly on plant height of carrot (Figure-2). During the growth period, plant height increased gradually and reached to peak at harvest. The maximum plant height was provided by O_2 at all observations. However the maximum plant height was found (44.55cm) from the O_2 (Vermicompost 10 ton/ha) treatment at harvest, while the minimum height was observed (38.99cm) from O_0 (control) treatment. The findings is in agreement with the result of Thompson and Kelly (1998) reported that manure of value as a source of humus, a source of both major and minor nutrients, as a carrier and promoter of beneficial organism and possible source of growth promoting substance. Rashid and Shakur (1986) reported similar trends of results in plant height (Appendix III).

Significant variation was observed on plant height influenced for different mulch materials in the growth period over control (Figure-3). Application of mulch in soil and it preserve the soil moisture and influence on plant height. Among the mulches materials treatment M_2(black polythene) mulch produced the tallest plant (18.88 cm, 33.81 cm, 41.01 cm and 44.81 cm) at 30, 50, 70 DAS and at harvest

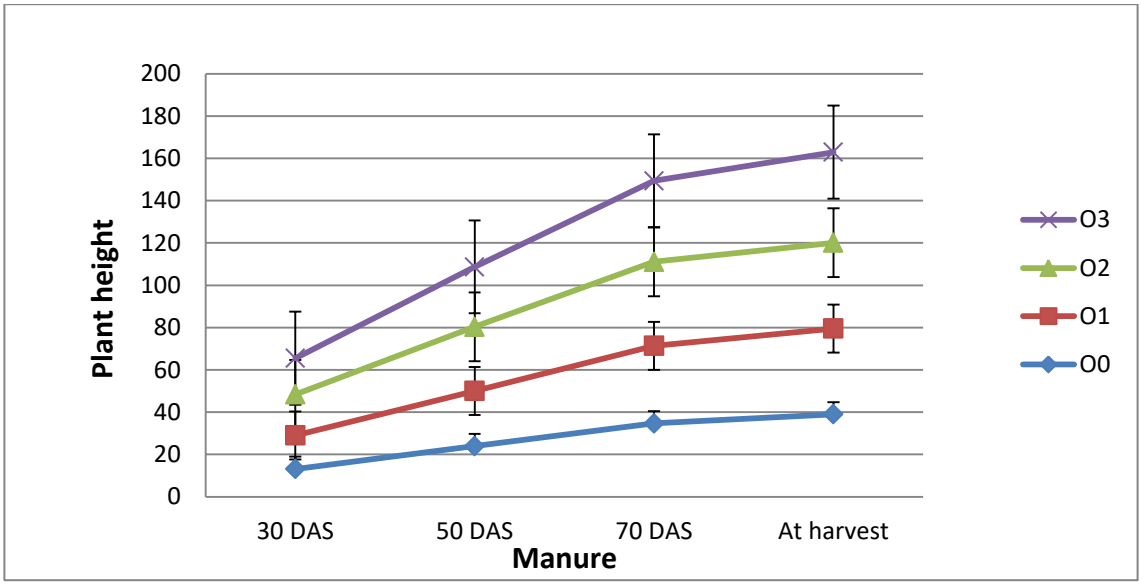


Figure 2: Effect of different manure on plant height at different days after sowing

Here, O_0 = No manure, O_1= Cowdung (20 t/ha), O_2 = Vermicompost (10 t/ha), O_3 = Cowdung (10 t/ha) + Vermicompost (5 t/ha)

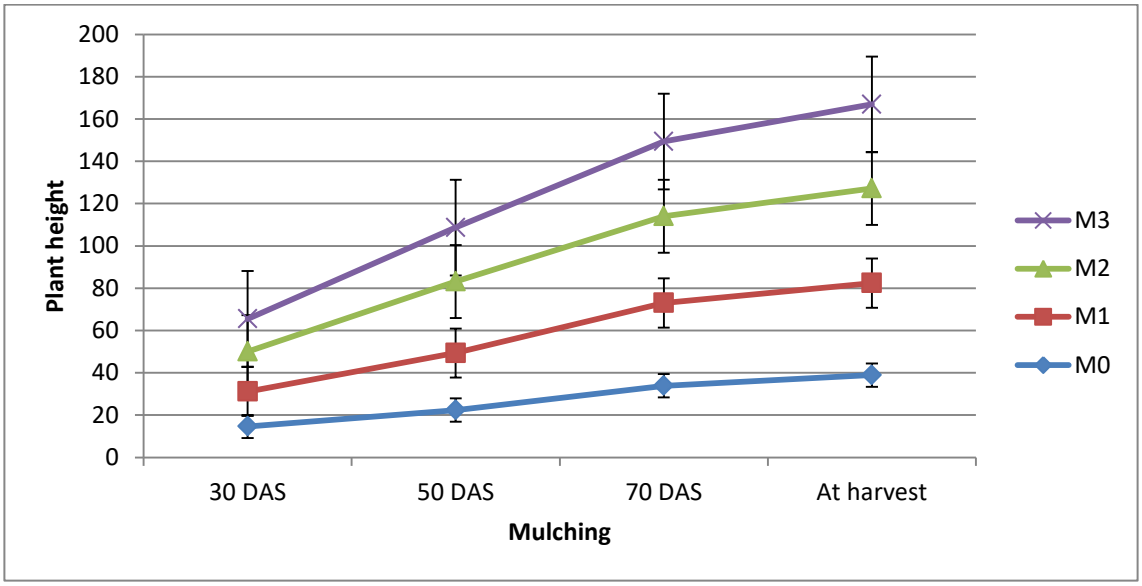


Figure 3: Effect of different mulches on plant height at different days after sowing

Here, M_0 = No mulch, M_1 = Water hyacinth, M_2 =Black polythene, M_3 = Wood ash

Table 2: Combined effect of manure and mulching on plant height at different days of carrot

Treatments	Plant height (cm)			
	30 DAS	50 DAS	70 DAS	At harvest
O_0M_0	12.00 h	17.22 g	30.93 d	35.43 f
O_0M_1	13.86 gh	24.47 d-f	37.47 bc	40.07 d-f
O_0M_2	14.36 f-h	32.20 b	39.33 b	42.33 c-e
O_0M_3	12.40 h	21.90 ef	31.07 d	38.13 ef
O_1M_0	13.47 gh	20.30 fg	31.67 cd	35.73 f
O_1M_1	16.73 d-f	26.90 cd	38.93 b	43.00 c-e
O_1M_2	17.57 c-e	32.40 b	40.67 ab	43.67 b-d
O_1M_3	15.73 e-g	24.80 de	35.53 cd	39.87 d-f
O_2M_0	17.87 cd	26.83 cd	37.13 b-d	43.53 b-d
O_2M_1	18.53 bc	29.50 bc	40.73 ab	46.07 ab
O_2M_2	23.16 a	36.37 a	42.77 a	48.13 a
O_2M_3	17.87cd	28.67 b-d	38.13 b	40.47 d-f
O_3M_0	15.20 e-g	25.10 de	35.67 cd	40.87 c-e
O_3M_1	16.87 d-f	27.00 cd	39.47 b	44.80 b-d
O_3M_2	20.47 b	34.26 a	41.27 ab	45.13 bc
O_3M_3	15.87 e-g	26.83 cd	36.73 cd	40.40 d-f
CV (%)	8.41	9.67	9.25	10.98
LSD (0.05)	2.53	2.21	4.29	4.04

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Here, O_0 = No manure, O_1= Cowdung (20 t/ha), O_2 = (Vermicompost (10 t/ha), O_3 = Cowdung(10 t/ha)+ Vermicompost (5 t/ha), M_0 = No mulch, M_1 = Water hyacinth, M_2 =Black polythene, M_3 = Wood ash

respectively and followed by the M_1 (Water hyacinth) mulch at the same DAS respectfully. The shortest plant was observed for the treatment M_0 (control). It was practically shown that the black polythene was the best mulch for more plant height

followed by water hyacinth, wood ash and control because the black polythene work as insulation system on soil and don`t permit soil water evaporation eventually soil microbial activity increased and improved the soil condition, and carrot plant can uptake more available nutrients from soil for its growth and development (Appendix III).

The combined effect of manure and mulching was found significantly influenced in terms of plant height of carrot (Table 2). The maximum plant height (23.16 cm, 36.37 cm, 42.77 cm and 48.13 cm) was recorded from O_2M_2 (Vermicompost, 10 ton/ha + black polythene mulch) treatment at 30, 50, 70 DAS and at harvest respectively. On the other hand, the minimum plant height (12.00 cm, 17.22 cm, 30.93 cm and 35.43 cm) was found in plants of control plot O_0M_0 (No organic + no mulch) treatment at 30, 50, 70 DAS and at harvest respectively (Appendix III). It was revealed that vermicompost and black polythene ensured maximum plant height. Hasan *et al*. (2018) reported that combined application of 6 ton/ha vermicompost with water hyacinth mulch in carrot was the best for obtaining plant height, number of leaves, root length, root fresh weight and highest marketable yield. This might be due to the fact that vermicompost with mulching provided some benefit to growth and root development.

4.2 Number of leaves per plant

The number of leaves per plant was significantly influenced by different level of manure application (Figure-4). The maximum number of leaves per plant (5.58, 10.48 and 11.72) was recorded from O_2 (Vermicompost, 10 ton/ha) treatment at 50, 70 DAS and at harvest respectively which was statistically significant different (5.04, 9.23 and 10.99) to O_3 (Cowdung, 10 ton/ha + Vermicompost, 5 ton/ha) treatment. The minimum leaf number (4.36, 8.25and 10.24) was found from O_0 (control) treatment respectively for same DAS (Appendix III). From the results of the present study it can be concluded that application of vermicompost 10 ton/ha provided better growing condition due to supply of adequate plant nutrients

resulting maximum number of leaves per plant. Azarmi *et al.* (2008) state that the addition of vermicompost at ratio of 15 t/ha, significantly increased plant growth and yield compared to control.

Significant variation was recorded due to different mulch materials in terms of number of leaves per plant of carrot at 50, 70 DAS and at harvest (Figure-5). At 50, 70 DAS and at harvest, the maximum number of leaves per plant (5.56, 10.55 and 12.08) was obtained from M_2 (Black polythene) treatment which was statistically significant different (5.07, 8.79 and 11.09) with M_1 (Water hyacinth), respectively at same DAS. While the minimum number of leaves per plant (4.55, 8.15 and 10.02) at the same DAS was found from M_0 (No mulch) treatment (Appendix III). Jaysawl *et al.* (2018) reported that the treatment black polythene mulch was best among the various mulch treatment and recorded maximum plant height, number of leaves per plant, leaf fresh weight, leaf dry weight, root weight, root length, root diameter and total root yield of carrot.

The combined effect of different manures and mulch materials showed significant differences due to their application on number of leaves per plant of carrot at 50, 70 DAS and at harvest (Table-3). The maximum number of leaves per plant At 50, 70 DAS and at harvest was recorded 6.50, 11.77 and 13.00 respectively from treatment combination of O_2M_2 (Vermicompost, 10 t/ha + black polythene) while the minimum number of leaves per plant at 50, 70 DAS and at harvest were 3.73, 7.06 and 9.16, respectively from O_0M_0 (No manure + no mulch) (Appendix III).

4.3 Root length

A significant variation was observed on root length due to use of different level of manures (Table 4). The longest root length 14.74 cm was recorded from O_2 (Vermicompost (10 t/ha) treatment while the shortest root length 11.91 cm was observed from control plot (Appendix IV). It might be due to the fact that vermicompost may be responsible for creating favorable soil conditions and supplying

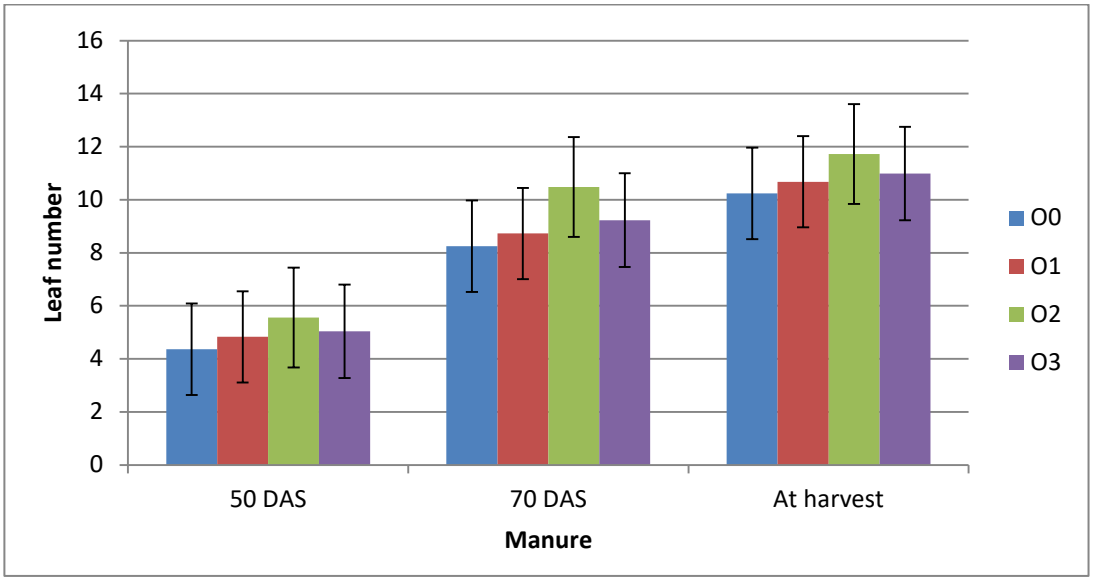


Figure 4: Effect of different manure on no. of leaves per plant at different days after sowing

Here, O_0 = No organic manure, O_1= Cowdung (20 t/ha), O_2 = Vermicompost (10 t/ha), O_3 = Cowdung (10 t/ha) + Vermicompost (5 t/ha)

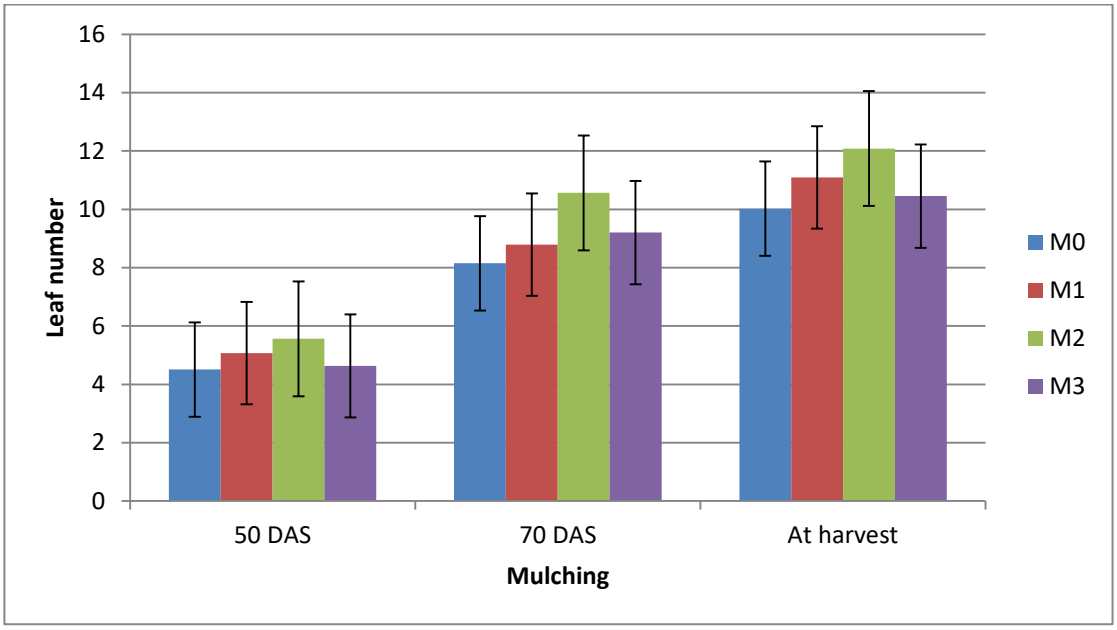


Figure 5: Effect of different mulches on no. of leaves per plant at different days after sowing

Here, M_0 = No mulch, M_1 = Water hyacinth, M_2 =Black polythene, M_3 = Wood ash

Table 3: Combined effect of manure and mulching on leaves number per plant at different days

Treatments	Leaves number		
	50 days	70 days	Harvest
O_0M_0	3.73f	7.06f	9.17d
O_0M_1	4.07ef	8.13d-f	10.40b-d
O_0M_2	5.03cd	9.27c-e	10.80b-d
O_0M_3	4.60de	8.53d-f	10.60b-d
O_1M_0	4.67c-e	7.80ef	9.27d
O_1M_1	5.00cd	8.47d-f	11.20b-d
O_1M_2	5.20b-d	10.20bc	12.00bc
O_1M_3	4.47d-f	8.47d-f	10.27cd
O_2M_0	5.13cd	9.53c-e	11.53bc
O_2M_1	6.00ab	9.93b-d	11.60bc
O_2M_2	6.50a	11.77a	13.00a
O_2M_3	4.67c-e	10.67ab	10.73b-d
O_3M_0	4.67c-e	8.20d-f	10.13cd
O_3M_1	5.20b-d	8.63d-f	11.14b-d
O_3M_2	5.50bc	10.95ab	12.50ab
O_3M_3	4.80c-e	9.13c-e	10.20cd
CV (%)	8.16	9.68	10.58
LSD (0.05)	0.83	0.85	0.38

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

Here, O_0 = No manure, O_1= Cowdung (20 t/ha), O_2 = Vermicompost (10 t/ha), O_3 = Cowdung (10 t/ha) + Vermicompost (5 t/ha), M_0 = No mulch, M_1 = Water hyacinth, M_2 =Black polythene, M_3 = Wood ash

the required plant nutrients for better growth and development, which help to the prolongation of maximum root length. This findings is an agreement with the result of Schuch *et al.* (1999), they reported that the root length of carrot varied with different amount of manure application.

Root length differed significantly due to the different mulch application (Table 5). Changing the mulches application beyond the black polythene affects this parameter. The maximum root length (15.21 cm) was recorded at treatment M_2 (Black polythene) and it was significantly different than other treatments. The minimum root length (11.98 cm) was found at M_0 (No mulch) (Appendix IV). The increase in root length due to different mulching was possibly black polythene mulch conserve soil moisture, keep down weeds, reduce soil erosion and promotes the growth of soil microorganisms, which makes it suitable for proper plant growth and development, ultimately leading to longer root formation. This result is in accordance with the findings of Rahman *et al*. (2018).

The combined effect of manures and mulches showed significant variation on root length of carrot (Table 6). The longest root 17.00 cm was observed from the treatment combination of O_2M_2 (Vermicompost, 10 t/ha + black polythene) and which was statistically similar (15.67 cm) to the treatment combination of O_3M_2 (Cowdung, 10 t/ha + vermicompost, 5 t/ha + black polythene). The shortest root length (10.50 cm) was recorded from control O_0M_0 (No manure + no mulch) treatment (Appendix IV).

4.4 Root diameter

Diameter of root was significantly influenced by the application of different level of manure (Table 4). The maximum diameter of root (4.12 cm) was recorded from O_2 (Vermicompost, 10 t/ha) treatment and it was significantly different than other manure treatments. On the other hand the minimum root diameter (3.14 cm) was observed from O_0 treatment (control) (Appendix IV). The experiment resulted that application of 10 t/ha vermicompost produced highest root diameter of carrot. The increase in individual root diameter might be due to vermicompost improved the physiological condition of the soil, which increase the water holding capacity and make available more nutrients for uptake by the crop.

Root diameter was also significantly varied due to the use of different mulching materials in carrot (Table 5).The highest root diameter (3.92 cm) was obtained at the mulches treatment M_2 (Black polythene) and it was statistically similar (3.75 cm) to M_1 (Water hyacinth). The lowest root diameter of root (3.15 cm) was obtained at the treatment of M_0 (No mulch). The lower root diameter obtained at the control mulches treatments might be due to retarded growth owing to limited moisture and nutrient availability. The result generally showed an increase in carrot root diameter when mulches application from control to water hyacinth and black polythene application.

A significant influence was found due to combined effect of manures and mulches materials on diameter of root (Table 6). The maximum diameter of root (4.50 cm) was observed from the treatment combination of O_2M_2 (Vermicompost, 10 t/ha + black polythene) and it was statistically similar (4.17 cm) to O_2M_1 (Vermicompost, 10 t/ha + water hyacinth). The minimum diameter of root (2.43 cm) was recorded from control O_0M_0 (No manure + no mulch) treatment (Appendix IV).

4.5 Fresh weight of leaves per plant

Remarkable difference was observed among the manures level as the fresh weight of leaves per plant (Table 7). Fresh weight of leaves per plant (72.78 g) was recorded maximum from the plants grown with O2 (Vermicompost, 10 t/ha) treatment and it was significantly different than other manure treatments. On the other hand, the minimum leaf weight per plant (47.58 g) was obtained in control plots (Appendix IV).

Different mulches showed significant variation on fresh weight of leaves per plant (Table 8). The highest leaf weight (69.85 g) was found from M2 (Black polythene) treatment which was significantly different and followed (65.83 g) by M1 (Water hyacinth) treatment, whereas the lowest leaf weight (47.79 g) was found from control (Appendix IV).

Table 4: Effect of different manure on root length and root diameter of Carrot

Manure	Root length (cm)	Root diameter (cm)
O_0	11.91 c	3.14 c
O_1	13.19 b	3.42 c
O_2	14.74 a	4.12 a
O_3	13.30 b	3.73 b
CV (%)	11.45	12.62
LSD (0.05)	0.86	0.29

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Here, O_0 = No manure, O_1= Cowdung (20 t/ha), O_2 = Vermicompost (10 t/ha), O_3 = Cowdung (10 t/ha) + Vermicompost (5 t/ha)

Table 5: Effect of different mulching on root length and root diameter of Carrot

Mulching	Root length (cm)	Root diameter (cm)
M_0(No mulch)	11.98 c	3.15 c
M_1(Water hyacinth)	12.98 b	3.75ab
M_2(Black polythene)	15.21 a	3.92 a
M_3(Wood ash)	13.57 b	3.59 b
CV (%)	11.45	12.62
LSD (0.05)	0.78	0.22

Means in a column having similar letter(s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.
Here, M_0= No mulch, M_1= Water hyacinth, M_2=Black polythene, M_3= Wood ash

Table 6: Combined effect of manure and mulching on root length and root diameter

Treatments	Root length (cm)	Root diameter (cm)
O_0M_0	10.5 h	2.43f
O_0M_1	12.13e-h	3.44c-e
O_0M_2	13.93cd	3.51cd
O_0M_3	11.07gh	3.16de
O_1M_0	11.86f-h	2.87ef
O_1M_1	13.00d-f	3.60b-d
O_1M_2	14.23b-d	3.65b-d
O_1M_3	13.67c-e	3.55cd
O_2M_0	12.93d-f	3.81bc
O_2M_1	13.74c-e	4.17ab
O_2M_2	17.00a	4.50a
O_2M_3	15.27bc	4.00bc
O_3M_0	12.60d-g	3.49cd
O_3M_1	13.07d-f	3.80bc
O_3M_2	15.67ab	4.00bc
O_3M_3	14.27b-d	3.65b-d
CV (%)	11.45	12.62
LSD (0.05)	1.72	0.20

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Here, O_0=No manure, O_1= Cowdung (20 t/ha), O_2 = (Vermicompost (10 t/ha), O_3 = Cowdung, (10 t/ha) + Vermicompost (5 t/ha), M_0 = No mulch, M_1 = Water hyacinth, M_2 =Black polythene, M_3 = Wood ash

Combined effect of manure and mulches on fresh weight of leaves per plant was also significant (Table 9). The maximum leaf weight per plant 82.53 g was observed from the treatment combination of O_2M_2 (Vermicompost 10 t/ha + black polythene)

treatment and the minimum weight per plant 35.73 g per plant was recorded from plants of control plot O_0M_0 (No organic manure + no mulch) treatment (Appendix IV).

4.6 Root weight per plant

A significant variation was observed on root weight per plant due to use of different manures (Table 7). The maximum root weight per plant 124.50 g was recorded from O_2 (Vermicompost, 10 t/ha) treatment which was statistically significant than other treatments. While the minimum root weight (47.58 g) was recorded from control plots (Appendix IV). Lang (1984) found that manures increased the yield of carrot (10%-20%) compared with control. Azarmi *et al.* (2008) reported that addition of vermicompost at the rate of 15 t/ha significantly increased growth and yield compared to control. Salminen *et al.* (2001) stated that root length, root diameter, root weight and quality root yield was increased when different amount of manures applied.

Different mulches materials showed significant variation for root weight per plant 0f carrot (Table 8). The highest root weight per plant (117.85 g) was found from M_2 (Black polythene) treatment which was statistically significant different from the other treatment. The lowest root weight per plant (92.23 g) was recorded from control treatment (Appendix IV). The increase in root weight application of different mulching treatment was possibly due to the availability of moisture and plant nutrients to the plant, which helped in rapid cell division and cell elongation and ultimately resulted in the production of thicker roots of carrot.

The combined effect of manures and mulch materials was found significant variation was observed on root weight per plant (Table 9). The maximum root weight per plant (145.33 g) was observed from treatment combination of O_2M_2 (Vermicompost, 10 t/ha + black polythene) treatment which was statistically significant different from other treatments and followed (122.53 g) by O_2M_1 (Vermicompost, 10 t/ha + water hyacinth). The minimum root weight per plant (66.00 g) was recorded from control plot O_0M_0 (No manure + no mulch) (Appendix IV).

4.7 Root yield per plot

A significant variation was observed on root weight per plot due to use of different levels of manure (Table 7). The maximum root weight per plot 3.11 kg was recorded from O_2 (Vermicompost, 10 t/ha) treatment which was statistically significant than other treatments. While the minimum root weight (2.13 kg) from control plots (Appendix IV).

Different mulch materials showed significant variation for root weight per plot of carrot (Table 8). The highest root weight per plot (2.95 kg) was found from M_2 (Black polythene) treatment which was statistically significant different from the other treatment.

The lowest root weight per plot (2.31kg) was recorded from control (Appendix IV). As per plot yield was the maximum in case of black polythene mulch. This might be due to the fact that ensuring better soil moisture and nutrient availability, black polythene also controlled weeds effectively. As a result highest yield per plot was obtained from this treatment. Mulching in carrot greatly influenced the yield and size of carrot (Benoit and Ceustermans, 1975).

The combined effect of organic manures and mulch materials was found significant variation was observed on root weight per plot (Table 9). The maximum root weight per plot (3.63 kg) was observed from treatment combination of O_2M_2 (Vermicompost, 10 t/ha + black polythene), which was statistically significant different from other treatments and followed (3.06 kg) by O_2M_1 (Vermicompost, 10 t/ha + water hyacinth). The minimum root weight per plot (1.65 kg) was recorded from control plot O_0M_0 (No manure + no mulch) (Appendix IV). From the above results, it was noted that vermicompost 10 t/ha with black polythene mulch combination possibly maintain higher moisture content in soil and increase the release of more plant nutrients from organic source which ultimately reflect much root formation of carrot. The available nutrient support proper vegetative growth.

Table 7: Effect of different manure on leaf weight and root weight of Carrot

Manure	Leaf weight per plant (g)	Root weight per plant (g)	Root weight per plot (kg)
O_0	47.58 d	85.83 c	2.13 d
O_1	54.50 c	96.67 b	2.42 c
O_2	72.78 a	124.50 a	3.11 a
O_3	64.33 b	116.41 b	2.81 b
CV (%)	11.66	12.43	10.27
LSD (0.05)	6.12	5.39	0.22

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.
Here, O_0= No manure, O_1= Cowdung (20 t/ha), O_2 = Vermicompost (10 t/ha), O_3 = Cowdung (10 t/ha) + Vermicompost (5 t/ha)

Table 8: Effect of different mulching on leaf weight and root weight of Carrot

Mulching	Leaf weight per plant (g)	Root weight per plant (g)	Root weight per plot (kg)
M_0 (No mulch)	47.79 d	92.23 d	2.31 c
M_1 (Water hyacinth)	65.83 b	109.39 b	2.71 b
M_2 (Black polythene)	69.85 a	117.85 a	2.95 a
M_3 (Wood ash)	55.71 c	103.93 c	2.59bc
CV (%)	11.66	12.43	10.27
LSD (0.05)	2.89	4.37	0.18

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.
Here, M_0= No mulch, M_1= Water hyacinth, M_2=Black polythene, M_3= Wood ash

Table 9: Combined effect of manure and mulching on leaf weight and root weight of Carrot

Treatments	Leaf weight per plant (g)	Root weight plant (g)	Root weight per plot (kg)
O_0M_0	35.73f	66.00f	1.65h
O_0M_1	54.80d-f	96.27de	2.32e-g
O_0M_2	55.60c-e	98.40c-e	2.46d-f
O_0M_3	44.19ef	82.67ef	2.07fgh
O_1M_0	37.80ef	76.67f	1.92gh
O_1M_1	66.00bc	102.27cd	2.56c-e
O_1M_2	68.07bc	106.40b-d	2.66c-e
O_1M_3	46.13d-f	101.33c-e	2.53d-f
O_2M_0	66.73bc	114.00b-d	2.85b-d
O_2M_1	74.53b	122.53b	3.06b
O_2M_2	82.53a	145.33a	3.63a
O_2M_3	67.33bc	116.13bc	2.90b-d
O_3M_0	50.93d-f	112.27 b-d	2.81b-d
O_3M_1	68.00bc	116.50 bc	2.91b-d
O_3M_2	73.20 b	121.27 b	3.03 bc
O_3M_3	65.20 b-d	115.60 bc	2.89b-d
CV (%)	11.66	12.43	10.27
LSD (0.05)	6.85	15.79	0.48

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Here, O_0= No manure, O_1= Cowdung (20 t/ha), O_2 = (Vermicompost (10 t/ha), O_3 = Cowdung (10 t/ha) + Vermicompost (5 t/ha), M_0= No mulch, M_1= Water hyacinth, M_2=Black polythene, M_3= Wood ash

4.8 Yield per ha

Per hectare yield of carrot was also significantly influenced by the application of different levels of manure (Table 10). The highest root yield (24.90 t/ha) recorded from O_2 (Vermicompost, 10 t/ha) treatment which was statistically significant different

from the other treatments and followed (22.29 t/ha) by O_3 (Cowdung, 10 t/ha + Vermicompost, 5 t/ha). The lowest root yield (17.00 t/ha) was obtained from control O_0 (No manure) treatment (Appendix V).

Significant variation in respect of yield per hectare was observed due to different mulch application (Table 11). The highest root yield (23.57 t/ha) was recorded from M_2 (Black polythene) treatment which was significantly different in statistically from other treatment, while the lowest (18.45 t/ha) was obtained from the control. When the mulches was changed from control to water hyacinth to black polythene, root yield of the crop was increased. Root yield was observed lowest (18.45 t/ha) from control plot (Appendix V).

The combined effect of manures and mulches was significantly varied on root yield (Table 12). However, the maximum root yield (29.07 t/ha) was obtained from the treatment combination of O_2M_2 (Vermicompost, 10 t/ha + black polythene) which was statistically significant different from the other treatments; where as the minimum yield (13.20 t/ha) was recorded from control plot O_0M_0 (No organic manure + no mulch) (Appendix V). Hasan *et al*. (2018) reported that combindly application of vermicompost (6 t/ha) and water hyacinth mulching gave the highest marketable (27.89 t/ha) and the gross yield (29.48 t/ha) of carrot.

4.9 Marketable yield per plot

Statistically significant difference in market yield per plot of carrot due to the application of different level of manures (Table 10).The marketable root yield (2.98 kg) recorded maximum from O_2 (Vermicompost, 10 t/ha) treatment which was statistically significant different from the other treatments and followed (2.54 Kg) by O_3 (Cowdung 10 t/ha + Vermicompost 5 t/ha) treatment. The minimum root yield (1.73 Kg) was obtained from control O_0 (No organic manure) treatment (Appendix V). Mulch materials varied significantly on the marketable root yield per plot (Table 11). The highest marketable yield per plot (2.74 kg) was recorded from M_2 (Black

polythene) treatment which was significantly different in statistically from other treatment, while the lowest (1.95 kg) was obtained from the control. When the mulches was changed from control to water hyacinth to black polythene, marketable yield of the crop was increased. Marketable yield per plot was observed lowest (1.95 kg) in the treatment control (Appendix V).

The combined effect of manures and mulches was significantly varied on Marketable yield per plot (Table 12). However, the maximum marketable root yield per plot (3.52 kg) was obtained from the treatment combination of O_2M_2 (Vermicompost, 10 t/ha + black polythene) treatment which was statistically significant different from the other treatments; whereas the minimum yield (1.29 kg) was recorded from control plot O_0M_0 (No manure + no mulch) (Appendix V).

4.10 Marketable yield

The results of the analysis of variance showed that marketable yield per plot of carrot was significantly ($P \leq 0.01$) influenced by the factor manure (Table 10). The marketable root yield (23.85 t/ha) recorded maximum from O_2 (Vermicompost, 10 t/ha) treatment which was statistically significant different from the other treatments and followed (20.39 t/ha) by O_3 (Cowdung 10 t/ha+ Vermicompost 5 t/ha). The minimum root yield (13.82 t/ha) was obtained from control O_0 (No manure) treatment (Appendix V).

Mulch materials highly and significantly ($P \leq 0.01$) affected marketable root yield per plot. The highest marketable yield per ha (21.95 t/ha) was recorded from M_2 (Black polythene) treatment which was significantly different in statistically from other treatment, while the lowest (15.63 t/ha) was obtained from the control (Table 11). When the mulches was changed from control to water hyacinth to black polythene, marketable yield of the crop was increased. Marketable yield per ha was observed lowest (15.63 t/ha) in the treatment control (Appendix V).

Table 10: Effect of different manures on yield of Carrot

Manure	Yield (t/ha)	marketable yield per plot (kg)	Marketable yield (t/ha)
O_0	17.0 d	1.73 d	13.82 d
O_1	19.33 c	2.12 c	16.92 c
O_2	24.90 a	2.98 a	23.85 a
O_3	22.29 b	2.54 b	20.39 b
CV (%)	11.56	13.87	10.37
LSD (0.05)	1.92	0.25	1.57

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Here, O_0= No manure, O_1= Cowdung (20 t/ha), O_2 = Vermicompost (10 t/ha), O_3 = Cowdung (10 t/ha) + Vermicompost(5 t/ha)

Table 11: Effect of different mulching on yield of Carrot

Mulching	Yield (t/ha)	marketable yield per plot (kg)	Marketable yield (t/ha)
M_0 (No mulch)	18.45 c	1.95 c	15.63 c
M_1 (Water hyacinth)	21.71 b	2.41 b	19.24 b
M_2 (Black polythene)	23.57 a	2.74 a	21.95 a
M_3 (Wood ash)	20.78bc	2.26 b	18.17 b
CV (%)	11.56	13.87	10.37
LSD (0.05)	1.13	0.21	1.31

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Here, M_0= No mulch, M_1= Water hyacinth, M_2=Black polythene, M_3= Wood ash

Table 12: Combined effect of organic manure and mulching on yield of Carrot

Combination	Yield (t/ha)	Marketable yield per plot (Kg)	Marketable yield (t/ha)
O_0M_0	13.20h	1.29i	10.39i
O_0M_1	18.59e-g	1.77gh	14.12gh
O_0M_2	19.68d-f	2.09e-g	16.68e-g
O_0M_3	16.53f-h	1.76gh	14.08gh
O_1M_0	15.33gh	1.68hi	13.40hi
O_1M_1	20.45c-e	2.39de	19.08de
O_1M_2	21.28c-e	2.49cd	19.96cd
O_1M_3	20.24d-f	1.91f-h	15.24f-h
O_2M_0	22.80b-d	2.60b-d	20.80b-d
O_2M_1	24.51b	2.92b	23.36b
O_2M_2	29.07a	3.52a	28.16a
O_2M_3	23.23b-d	2.89bc	23.08bc
O_3M_0	22.45b-d	2.24d-f	17.92d-f
O_3M_1	23.31b-d	2.55b-d	20.40b-d
O_3M_2	24.27bc	2.88bc	23.00bc
O_3M_3	23.12b-d	2.49cd	20.26b-d
CV (%)	11.56	13.87	10.37
LSD (0.05)	3.85	0.38	3.18

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.
Here, O_0= No manure, O_1= Cowdung (20 t/ha), O_2 = (Vermicompost (10 t/ha), O_3 = Cowdung (10 t/ha) + Vermicompost (5 t/ha), M_0= No mulch, M_1= Water hyacinth, M_2=Black polythene, M_3= Wood ash

The combined effect of manures and mulches was significantly varied on Marketable yield per ha (Table 12). However, the maximum Marketable root yield per ha (28.16 t) was obtained from the treatment combination of O_2M_2 (Vermicompost, 10 t/ha + black polythene) which was statistically significant different from the other treatments;

where as the minimum yield (10.39 t) was recorded from control plot O_0M_0 (No organic manure + no mulch) (Appendix V).

4.11Dry matter percentage of root

A significant variation was observed on dry weight of root per plant due to use of different manures (Table 13). The maximum dry matter of root per plant (16.06 %) was recorded from O_2 (Vermicompost, 10 t/ha) treatment while the minimum (12.16 %) from control plots (Appendix VI).

Regarding the effect of different mulches materials on root dry weight, it was significant effect. Root dry weight was markedly increased and achieved maximum (15.46 %) values in treatment of M_2 (Black polythene) treatment and it was statistically significant different and followed (13.87 %) by M_1 (Water hyacinth) treatment (Table 14). The increase in root dry weight as a result of mulches treatments may be for increasing root fresh weight. The lowest root dry weight (12.62 %) was observed in control (Appendix VI).

A significant effect of manures and mulches combination on root dry weight was found (Table 15). Manures and mulches combination caused significant increase in root dry weight. The highest values of root dry weight (17.78 % were recorded due to O_2M_2 (Vermicompost, 10 t/ha + black polythene) treatment and it was statistically significant different from other treatments and followed by O_2M_1 (Vermicompost, 10 t/ha + water hyacinth) treatment. On opposition to, the lowest ones (10.90 %) were proceeded from combination O_0M_0 (No manure + no mulch) (Appendix VI). This increase in root dry weight by changing the mulches items might have been resulted from increasing photosynthetic area per plant, which led to more photosynthesis production and therefore increasing dry matter accumulation with vermicompost and black polythene.

4.12Dry matter percentage of leaf

A significant variation was observed on dry matter of leaves due to use of different manures (Table 13). The maximum dry weight of leaves per plant (16.02 %) was recorded from O_2 (Vermicompost, 10 t/ha) treatment while the minimum (11.85 %) from control plots (Appendix IV).

Leaf dry weight was significantly affected by mulches materials treatments (Table 14). Mulches treatment M_2 (Black polythene) treatment performed maximum (15.38 %) average means of leaf dry weight. The lowest values of this trait (13.36 %) were recorded for the control treatment (Appendix VI).

Manures and mulches combination were significantly affected on leaf dry weight (Table 15). Maximum means of this character (17.78 %) obtained from O_2M_2 (Vermicompost, 10 t/ha + black polythene) treatment. The lowest values in this term (10.99 %) were produced from application O_0M_0 (No manure + no mulch) treatment (Appendix VI). The increase in leaf dry weight with the changed in mulches materials and organic manure combination may be attributed to the role of it in stimulatory leaf growth, increase in chlorophyll content and causing canopy regeneration and directs photosynthesis into top production rather than root storage**.**

4.13 Branched root percentage

A significant variation was observed on branched root percentage due to use of different manures (Table 13). The highest percentage of branched root (19.00 %) was observed from treatment O_0 (no manure) treatment which was followed (14.25 %) by M_3 (Wood ash) treatment. The lowest (7.00 %) was found in O_2 (Vermicompost, 10 t/ha) treatment (Appendix VI).

Significant differences in branched root percentage due to mulches materials were observed (Table 14). Mulches treatment M_0 (No mulch) showed higher branched root

Table 13: Effect of different manures on dry matter percentage of root and leaf, branched root of Carrot

Manure	Root dry matter (%)	Leaf dry matter (%)	Branched root (%)
O_0	12.16 d	11.85 d	19.00 a
O_1	12.86 c	13.42 c	14.25 b
O_2	16.06 a	16.02 a	7.00 d
O_3	13.97 b	15.38 b	11.00 c
CV (%)	11.42	9.62	8.54
LSD (0.05)	0.45	0.52	2.96

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

Here, O_0= No manure, O_1= Cowdung (20 t/ha), O_2 = Vermicompost (10 t/ha), O_3 = Cowdung (10 t/ha) + Vermicompost(5 t/ha)

Table 14: Effect of different mulching on dry matter percentage of root and leaf, branched root of Carrot

Mulching	Root dry matter (%)	Leaf dry matter (%)	Branched root (%)
M_0 (No mulch)	12.62 d	13.36 c	15.00 a
M_1 (Water hyacinth)	13.87 b	14.27 b	12.00 c
M_2 (Black polythene)	15.46 a	15.38 a	10.75 d
M_3 (Wood ash)	13.11 c	13.66 c	13.50 b
CV (%)	11.42	9.62	8.54
LSD (0.05)	0.41	0.49	1.26

Means in a column having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

Here, M_0= No mulch, M_1= Water hyacinth, M_2=Black polythene, M_3= Wood ash

Table 15: Combined effect of manure and mulching on dry matter percentage of root and leaf, branched root of Carrot

Treatment	Root dry weight (%)	Leaf dry weight (%)	branched root %
O_0M_0	10.90j	10.99j	22.00a
O_0M_1	12.80h	11.74i	20.00ab
O_0M_2	13.91ef	12.93h	18.00bc
O_0M_3	11.05j	11.76i	16.00b-d
O_1M_0	11.81i	12.81h	14.00c-e
O_1M_1	12.85gh	13.73g	12.00def
O_1M_2	14.34de	14.46f	15.00c-e
O_1M_3	12.45hi	12.71h	16.00b-d
O_2M_0	14.95cd	15.11d-f	10.00e-g
O_2M_1	16.12b	15.89bc	6.00gh
O_2M_2	17.78a	17.78a	4.00h
O_2M_3	15.42bc	15.29c-e	8.00f-h
O_3M_0	12.81gh	14.53f	14.00c-e
O_3M_1	13.73ef	15.75b-d	10.00e-g
O_3M_2	15.83b	16.38b	6.00gh
O_3M_3	13.53fg	14.88ef	14.00c-e
CV (%)	11.42	9.62	8.54
LSD (0.05)	0.71	0.65	3.92

Means in a column having similar letter are statistically similar and those having dissimilar letter differed significantly by LSD at 0.05 level of probability.
Here, O_0= No manure, O_1= Cowdung (20 t/ha), O_2 = Vermicompost (10 t/ha), O_3 = Cowdung (10 t/ha) + Vermicompost (5 t/ha), M_0= No mulch, M_1= Water hyacinth, M_2=Black polythene, M_3= Wood ash

percentage (15.00 %) The lowest branched root was observed by the treatment M_2 (Black polythene) (10.75 %) (Appendix VI).

The combined effect of manures and mulches showed significant differences among the treatment combination (Table 15). The maximum branched root (22.00%) was

observed in control plot O_0M_0 (No manure + no mulch). The minimum branched (4.00%) root was observed from treatment combination of O_2M_2 (Vermicompost, 10 t/ha + black polythene) treatment (Appendix VI).

4.14 Economic analysis

Economics is the major criteria to evaluate the best treatments which were economically sound and that can be accepted by farming community. The cost of cultivation, gross and net returns in addition to benefit cost ratio of different treatment combinations studied in the present investigation is presented in (Table 16 and Appendices VIII).

4.14.1 Cost of cultivation

The total expenditure was observed to range from Tk. 95,045 (O_0M_0) to 182,245/- (O_1M_3). Among all the inputs used in the present investigation, labor contributes more to the cost of cultivation (Table 16).

4.14.2 Gross returns

Gross returns for different treatment combinations in the present investigation ranged from Tk. 207,800/- (O_0M_0) to Tk. 563,200/- (O_2M_2). Among all the treatment combinations studied, O_2M_2 gave highest gross returns of Tk. 563,200/- followed by 467,200 (O_2M_1) (Table 16).

4.14.3 Net returns

Highest net returns per hectare of Tk. 446,355/- in carrot cultivation under different treatment combinations of organic manure and mulches studied was obtained with the O_2M_2 (Tk. 446,355/-) followed by O_2M_1 (TK. 359,075/-) whereas lowest net returns of Tk. 112,755/- was observed with O_0M_0 (Table 16).

4.14.4 Benefit cost ratio

Among all the treatment combinations studied in the present investigation, O_2M_2

resulted in highest benefit cost ratio of 4.82 followed by O_2M_3 (4.45). Further, lowest benefit cost ratio of 1.67 was obtained from O_1M_0 (Table 16).

Table 16: Effect of manure and mulches on economics of carrot

Treatments	Cost of cultivation (Tk./ha)	Yield (T/ha)	Gross returns (Tk./ha)	Net returns (Tk./ha)	Benefit cost ratio (BCR)
O_0M_0	95,045	10.39	207,800	112,755	2.19
O_0M_1	108,125	14.12	282,400	174,275	2.61
O_0M_2	116,845	16.68	333,600	216,755	2.86
O_0M_3	103,765	14.08	281,600	177,835	2.71
O_1M_0	160,445	13.40	268,000	107,555	1.67
O_1M_1	173,525	19.08	381,600	208,075	2.20
O_1M_2	182,245	19.96	399,200	216,955	2.19
O_1M_3	169,165	15.24	304,800	135,635	1.80
O_2M_0	95,045	20.80	416,000	320,955	4.38
O_2M_1	108,125	23.36	467,200	359,075	4.32
O_2M_2	116,845	28.16	563,200	446,355	4.82
O_2M_3	103,765	23.08	461,600	357,835	4.45
O_3M_0	95,045	17.92	358,400	263,355	3.77
O_3M_1	108,125	20.40	408,000	299,875	3.77
O_3M_2	116,845	23.00	460,000	343,155	3.94
O_3M_3	103,765	20.26	405,200	301,435	3.90

Here, O_0= No organic manure, M_0= No mulch
O_1= Cowdung (20 t/ha) M_1= Water hyacinth
O_2 = Vermicompost (10 t/ha) M_2=Black polythene
O_3 = Cowdung (10 t/ha) + Vermicompost (5 t/ha) M_3= Wood ash

Total cost of production was done in details according to the procedure of Krishitattik Fasaler Utpadan O unnayan (in Bengali), 1989 Alam *et al.*, pp 231-239.

Sale of marketable carrot @ TK. 20000/ t

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effects of manure and mulching on the growth and yield of carrot during November, 2017 to February, 2018. The experiment comprised of two different factors such as (i) four manure Viz. O_0 (no manure), O_1(Cowdung (20 t/ha), O_2 (Vermicompost (10 t/ha) and O_3 (Cowdung 10 t/ha + Vermicompost 5 t/ha) and (ii) four mulches materials viz, M_0 (No mulch), M_1 (Water hyacinth), M_2 (Black polythene) and M_3 (Wood ash), respectively. There was significant variation was recorded among the different organic manure and mulches in respect of all characters studied.

The tallest plant height (19.36 cm, 30.34 cm, 39.69 cm and 44.55 cm at 30, 30, 50, 70 DAS and at harvest respectively) was observed from manure treatment O_2 (Vermicompost). It was observed highest (18.89 cm, 33.81 cm, 41.01 cm and 44.81 cm) respectively from the mulches treatment of M_2 (black polythene). The plant height was observed highest (23.16 cm, 36.37 cm, 42.77 cm and 48.13 cm) from manure and mulches treatment combination of O_2M_2 (Vermicompost + black polythene). The maximum number of leaves per plant (5.58, 10.48 and 11.72 at 50, 70 DAS and at harvest respectively) was observed from manure treatment O_2 (Vermicompost) and 5.56, 10.55 and 12.08 at 50, 70 DAS and at harvest respectively from the mulches treatment M_2 (Black polythene). The maximum number of leaves per plant (6.50, 11.77 and 13.00) was observed from manures and mulches treatment combination of O_2M_2 (Vermicompost + black polythene). The maximum root length was 14.74 cm recorded from organic manure O_2 (Vermicompost), 15.21 cm from mulches treatment M_2 (Black polythene). The longest root 17.00 cm was observed from the organic

manures and mulches treatment combination of O_2M_2 (Vermicompost + black polythene).

The maximum diameter of root (4.12 cm) was recorded from O_2 (Vermicompost). The highest root diameter (3.92 cm) was obtained at the mulches treatment M_2 (Black polythene). The maximum diameter of root (4.50 cm) was observed from the treatment combination of O_2M_2 (Vermicompost + black polythene). The maximum fresh weight of leaves was 72.78 g and 69.85 g found to the plants were use manure O_2 (Vermicompost) and mulch M_2 (Black polythene) respectively. In the combination the maximum fresh weight of leaves per plant (82.53 g) was observed from the treatment O_2M_2 (Vermicompost + black polythene). The maximum root weight per plant 124.50 g and 117.85 g were recorded from manure O_2 (Vermicompost) and mulch M_2 (Black polythene), respectively. The maximum root weight per plant (145.33 g) was observed from treatment combination of O_2M_2 (Vermicompost, 10 t/ha + black polythene).

The root yield (24.90 t/ha) recorded maximum from O_2 (Vermicompost). The highest root yield (23.57 t/ha) was recorded from M_2 (Black polythene). The maximum root yield (29.07 t/ha) was obtained from the treatment combination of O_2M_2 (Vermicompost + black polythene).The maximum marketable root yield per plot was 2.98 kg from manure O_2 (Vermicompost) and 2.74 kg from mulch M_2 (Black polythene) treatment. In combination of manures and mulches it was 3.52 Kg from the treatment O_2M_2 (Vermicompost + black polythene). The marketable root yield (23.85 t/ha) recorded maximum from O_2 (Vermicompost) and 21.95 t/ha from M_2 (Black polythene) mulch. The maximum Marketable root yield per ha (28.16 ton) was obtained from the manure and mulches combination O_2M_2 (Vermicompost + black polythene).

The maximum dry matter of root per plant (16.06 %) was recorded from O_2 (Vermicompost). It was achieved maximum (15.46 %) values in treatment of mulches

M_2 (Black polythene). The highest values of root dry weight (17.78 % were recorded due to O_2M_2 (Vermicompost + black polythene). The maximum dry weight of leaves per plant (16.02 %) was recorded from O_2 (Vermicompost). Mulches treatment M_2 (Black polythene) performed maximum (15.38 %) average means of leaf dry weight. Maximum means of this character (17.78 %) obtained from O_2M_2 (Vermicompost, 10 t/ha + black polythene)**.** The minimum branched (7.00 %) was observed in O_2 (Vermicompost). The minimum branched (10.75 %) was observed in mulches M_2 (Black polythene). The minimum (4.00 %) branched was observed in the combined treatment of O_2M_2 (Vermicompost + black polythene).Incase of economic point of view, the highest gross return (Tk. 563200), net return (Tk. 446355) and BCR (4.82) were obtained from the treatment combination from O_2M_2 where the lowest gross return (Tk. 207800), net return (Tk.112755) were obtained from O_0M_0 and lowest BCR (1.67) from O_1M_0.

Conclusion:

On the basis of results of the present study, it may be concluded that yield of carrot is increased by the judicial application of organic manure and mulch.

1. The result revealed that the organic manure vermicompost (10 t/ha) gave the highest yield.
2. Mulching materials black polythene may be used for higher yield of carrot.
3. Application of Vermicompost (10 t/ha) with black polythene mulch is one of the most effective management practice to improve soil productivity.

Thus considering crop productivity, economic return and maintaining soil fertility, combined application of vermicompost (10 t/ha) with black polythene mulch may be recommended to farmers for profitable carrot production with affecting the soil health.

4. The combination O_2M_2 (4.82) resulted the highest benefit cost ratio followed by O_2M_3 (4.45).

Further trial of this research work in different location with another variety of carrot is needed to justify the result for common farmers.

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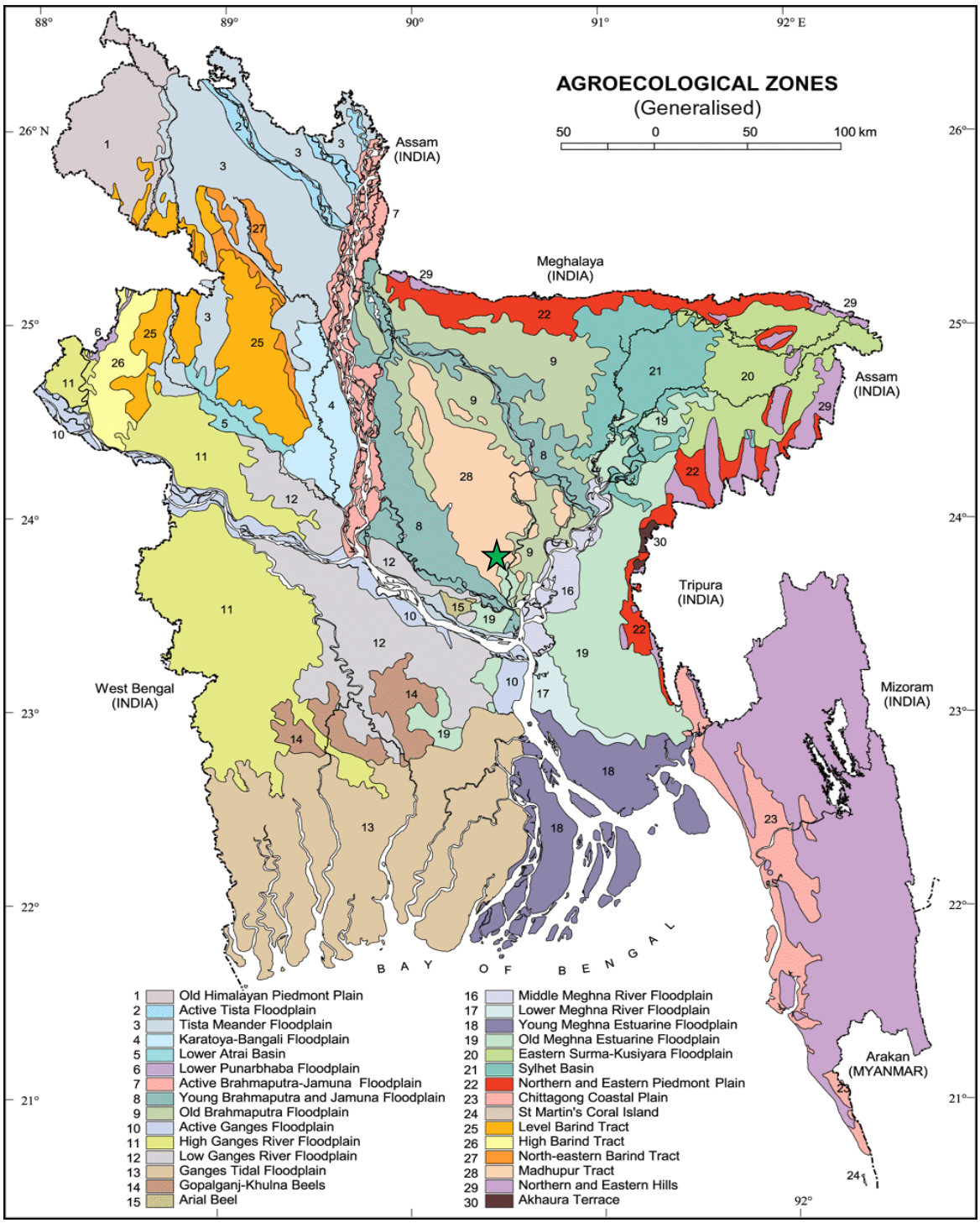
APPENDICES

Appendix I. Map showing the experimental site under the study



★ The experimental site under the study

Appendix II: Morphological, Physical and chemical characteristics of initial soil (0-15 cm depth) of the experimental site

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical composition of the soil

Soil separates	**%**
Sand	26
Silt	45
Clay	29
Texture class	Silty loam

C. Chemical composition of the soil

Sl. No.	**Soil characteristics**	**Analytical data**
1	Organic carbon (%)	0.45
2	Total N (%)	0.03
3	Total S (ppm)	225.00
4	Total P (ppm)	840.00
5	Available N (kg/ha)	54.00
6	Available P (ppm)	20.54
7	Exchangeable K (me/100 g soil)	0.10
8	Available S (ppm)	16.00
9	pH (1:2.5 soil to water)	5.6
10	CEC	11.23

Source: Soil Resource and Development Institute (SRDI), Farmgate, Dhaka

Appendix III. Analysis of variance for plant height and leaf number at different days of Carrot

Source of variation	Degrees of freedom (df)	Mean Square of						
		Plant height				Leaf number		
		30 DAS	50 DAS	70 DAS	At harvest	50 DAS	70 DAS	At harvest
Replication	2	3.021	0.787	8.902	1.208	0.458	1.003	2.554
Factor A (Organic)	3	46.481**	44.896**	4.714*	12.686**		8.215**	98.936**
Factor B (Mulching)	3	29.095*	49.280**	85.623**	78.063**	5.989*	5.517**	89.951**
A x B	9	22.282*	19.005*	55.516*	10.935**	4.353*	3.415*	48.768*
Error	30	7.458	6.046	17.932	1.917	1.452	1.136	15.443

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix IV. Analysis of variance of data on root length, Root diameter, leaf weight, Root weight per plant and Root weight per plot of Carrot

Source of variation	Degrees of freedom (df)	Mean Square of				
		Root length (cm)	Root diameter (cm)	Leaf weight (g)	Root weight per plant (g)	Root weight per plot (kg)
Replication	2	2.321	34.176	23.042	46.382	0.108
Factor A (Organic)	3	33.389**	124.404**	126.647**	132.332**	9.543**
Factor B (Mulching)	3	29.186*	111.871**	113.002**	125.010**	11.631**
A x B	9	20.602*	80.167*	59.758*	129.268**	7.807*
Error	30	6.867	26.971	19.452	38.018	2.064

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix V. Analysis of variance for yield of Carrot

Source of variation	Degrees of freedom (df)	Mean Square of		
		Yield (t/ha)	marketable yield (kg)	Marketable yield (t/ha)
Replication	2	20.701	5.472	249.51
Factor A (Organic)	3	194.121**	121.372**	1406.03**
Factor B (Mulching)	3	104.005**	125.430**	5201.43**
A x B	9	78.951*	61.426*	411.14*
Error	30	31.059	21.988	132.67

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix VI. Analysis of variance for dry matter percentage of root and leaf and branched root percentage of Carrot

Source of variation	Degrees of freedom (df)	Mean Square of		
		root dry matter (%)	leaf dry matter(%)	branch root %
Replication	2	5.533	66.809	0.353
Factor A (Organic)	3	57.377**	88.242**	7.767**
Factor B (Mulching)	3	46.576**	95.986**	12.098**
A x B	9	31.049*	67.771*	4.026*
Error	30	11.566	21.538	1.152

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix VII. Monthly average temperature, relative humidity and total rainfall and sunshine of the experimental site during the period from November, 2017 to February, 2018.

Month	Air temperature (°c)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (hr)
	Maximum	Minimum			
November, 2017	28.60	8.52	56.75	14.40	5.8
December, 2017	25.50	6.70	54.80	0	7.9
January, 2018	23.80	11.70	46.20	0	3.9
February, 2018	22.75	14.26	37.90	0	5.7

Source: Bangladesh Meteorological Department (Climate & Weather Division), Agargoan, Dhaka – 1212

Appendix VIII. Cost of production of carrot per he actor

A. Input cost (Tk./ha)

Treatments	Cultivation with labour	Seed cost	Pesticide	Intercultural operation	Mulching Cost (price and labour)	Seed sowing cost	Organic Matter			Harvesting cost	Sub Total (A)
							Cowdung	Vermicompost	Cowdung + Vermicompost		
O_0M_0	12,000	18,000	3,000	10,000	0	2,500	0			5,000	50,500
O_0M_1	12,000	18,000	3,000	10,000	12,000	2,500	0			5,000	62,500
O_0M_2	12,000	18,000	3,000	10,000	20,000	2,500	0			5,000	70,500
O_0M_3	12,000	18,000	3,000	10,000	8,000	2,500	0			5,000	58,500
O_1M_0	12,000	18,000	3,000	10,000	0	2,500	60,000			5,000	110,500
O_1M_1	12,000	18,000	3,000	10,000	12,000	2,500	60,000			5,000	122,500
O_1M_2	12,000	18,000	3,000	10,000	20,000	2,500	60,000			5,000	130,500
O_1M_3	12,000	18,000	3,000	10,000	8,000	2,500	60,000			5,000	118,500
O_2M_0	12,000	18,000	3,000	10,000	0	2,500		2,00,000		5,000	50,500
O_2M_1	12,000	18,000	3,000	10,000	12,000	2,500		2,00,000		5,000	62,500
O_2M_2	12,000	18,000	3,000	10,000	20,000	2,500		2,00,000		5,000	70,500
O_2M_3	12,000	18,000	3,000	10,000	8,000	2,500		2,00,000		5,000	58,500
O_3M_0	12,000	18,000	3,000	10,000	0	2,500			1,30,000	5,000	50,500
O_3M_1	12,000	18,000	3,000	10,000	12,000	2,500			1,30,000	5,000	62,500
O_3M_2	12,000	18,000	3,000	10,000	20,000	2,500			1,30,000	5,000	70,500
O_3M_3	12,000	18,000	3,000	10,000	8,000	2,500			1,30,000	5,000	58,500

O_0= No organic manure
O_1= Cowdung (20 ton/ha)
O_2 = Vermicompost (10 ton/ha)
O_3 = Cowdung (10 ton/ha) + Vermicompost (5 ton/ha)

M_0= No mulch
M_1= Water hyacinth
M_2=Black polythene
M_3= Wood ash

B.Overhead cost (Tk./ha)

Treatments	Overhead cost (Tk./ha)				Sub total (A)	Total cost of production (A + B)	Yield (Ton/ha)			
	Cost of leased land for 6 months (8% value of land tk-10,00000)	Miscellaneous cost (Tk-5% of the input cost)	Interest on running capital for 6 months (8% of cost per year)	Sub total (B)				Gross Return (Tk./ha)	Net Return (Tk./ha)	BCR
O_0M_0	40,000	2525	2,020	44,545	50,500	95,045	10.39	207800	112,755	2.19
O_0M_1	40,000	3125	2,500	45,625	62,500	108,125	14.12	282400	174,275	2.61
O_0M_2	40,000	3525	2,820	46,345	70,500	116,845	16.68	333600	216,755	2.86
O_0M_3	40,000	2925	2,340	45,265	58,500	103,765	14.08	281600	177,835	2.71
O_1M_0	40,000	5525	4,420	49,945	110,500	160,445	13.40	268000	107,555	1.67
O_1M_1	40,000	6125	4,900	51,025	122,500	173,525	19.08	381600	208,075	2.20
O_1M_2	40,000	6525	5,220	51,745	130,500	182,245	19.96	399200	216,955	2.19
O_1M_3	40,000	5925	4,740	50,665	118,500	169,165	15.24	304800	135,635	1.80
O_2M_0	40,000	2525	2,020	44,545	50,500	95,045	20.80	416000	320,955	4.38
O_2M_1	40,000	3125	2,500	45,625	62,500	108,125	23.36	467200	359,075	4.32
O_2M_2	40,000	3525	2,820	46,345	70,500	116,845	28.16	563200	446,355	4.82
O_2M_3	40,000	2925	2,340	45,265	58,500	103,765	23.08	461600	357,835	4.45
O_3M_0	40,000	2525	2,020	44,545	50,500	95,045	17.92	358400	263,355	3.77
O_3M_1	40,000	3125	2,500	45,625	62,500	108,125	20.40	408000	299,875	3.77
O_3M_2	40,000	3525	2,820	46,345	70,500	116,845	23.00	460000	343,155	3.94
O_3M_3	40,000	2925	2,340	45,265	58,500	103,765	20.26	405200	301,435	3.90