EFFECT OF ORGANIC MANURE AND SPACING ON THE GROWTH AND YIELD OF CARROT (*Daucus carota* L.)

BY

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CERTIFICATE

*This is to certify that the thesis entitled, "**EFFECT OF ORGANIC MANURE AND SPACING ON THE GROWTH AND YIELD OF CARROT (Daucus carota L.)**" submitted to the Department of Horticulture and Postharvest Technology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by **BIDHAN KUMAR PAUL, Registration No.: 01020** under my supervision and my 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 duly been acknowledged.

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ABSTRACT

An experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of organic manure and spacing on the growth and yield of carrot during November 2007 to February 2008. The experiment comprised of two factors such as (i) four organic manure Viz. T_0 (control), T_1 (Cowdung), T_2 (Poultry manure), T_3 (Vermicompost) and (ii) three spacings viz. S_1 (25 cm ×10 cm), S_2 (25 cm × 15 cm) and S_3 (25 cm × 20 cm) respectively. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In case of organic manure, the highest yield (33.36 t/ha) was recorded from T_1 and the lowest yield (23.72 t/ha) was from T_0. In case of spacing, the highest yield (32.75 t/ha) was obtained from S_2 and the lowest yield (24.64 t/ha) was from S_3. For combined effect, the maximum yield (35.98 t/ha) was observed from the treatment combination of S_2T_1 and the minimum yield (18.78 t/ha) was from S_3T_0. It may be concluded that cowdung with 25 cm × 15 cm spacing can be used to obtain higher growth and yield of carrot.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
g	=	gram
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Non significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
t	=	Ton

Chapter 1

Introduction

CHAPTER I

INTRODUCTION

Carrot (*Daucus carota* L.) is a herbaceous biennial plant belongs to the genus *Daucus,* species *carota* L. and the member of Apiaceae family (Peirce, 1976).Carrot is mainly a temperate crop grown during spring through autumn in temperate countries and during winter in tropical and subtropical countries of the world (Bose and Som, 1990). Carrot grows successfully in Bangladesh during Rabi season when temperature ranges from 11.17 ^{0}C to 28.9 ^{0}C (Alim, 1974) and the best time is from mid November to early December for its cultivation to get satisfactory yield (Rashid, 1993).

Carrot contains high amount of carotene (10 mg/100g), thiamin (0.04 mg/100g), riboflavin (0.05mg/100g) and also serves as a source of carbohydrate, protein, fat, minerals, vitamin-C and calories (Yawalker, 1985). Blindness in children for the severe Vitamin-A deficiency is a problem of public health in some countries, particularly in the rice dependent countries of Asia (Woolfe, 1988). So, carrot (rich in Vitamin-A) may contribute a lot of Vitamin-A to overcome this situation in Bangladesh.

The popularity of carrot is increasing day by day in Bangladesh especially among the urban people because of its high nutritive value and possible diversified use in making different palatable foods. Carrot can be eaten either row or by making soups and curries and grated roots are used as salad. The area under carrot cultivation was 899 thousand hectares with total production of 193740 thousand tones in the world (FAO, 2000). In Bangladesh the production statistics of carrot is not available. Rashid (1993) mentioned an average yield of carrot 25 tonnes per hectare. The production is relatively low compared to other carrot producing countries, Switzerland, Denmark, Sweden, UK, Australia and Israel, where the average per hectare yield are reported to be 40.88 - 42.67, 51.88, 54.88, 56.70 and 64.20 tonnes respectively (FAO, 2000).

Organic manure improves soil structure as well as increases its water holding capacity. Moreover, it facilitates aeration in soil. Recently organic farming is appreciated by vegetable consumers as it enhances quality of the produce. Inorganic cultivation leaves residual effect in crops which is believed to cause hazard to public health and environment.

Plant spacing is one of the important factors for the increased production of carrot. Pavlek, (1977); Lipari (1975) and McCollum *et al.* (1986) reported that there is a positive correlation between the number of plants and yield of carrot. But many workers reported that different plant densities of spacing have different effect for the marketable yield of carrot (Dragland, 1978; Nogueira *et al.* 1982).

Considering its importance the study was done for the following objectives-

i) to find out appropriate organic manure which give the best yield

ii) to estimate the proper spacing for growth and yield

iii) to study the interaction effect of organic manure and spacing on growth and yield

Chapter 2

Review of literature

CHAPTER II

REVIEW OF LITERATURE

2.1 Effect of organic manure on the growth and yield of carrot

Optimum organic 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.

Akand (2003) conducted an experiment with mulching and organic manure trial on carrot in BAU, Bangladesh and observed that black polythene mulch and organic manure (cowdung) significantly resulted the highest yield of carrot of his experiment.

Mesquita *et al.* (2002) conducted an experiment on a clayey yellow Red Oxisol to evaluate the residual effect of the application of phosphorus and urban waste compost of the previous two years on the root production of carrot cv. Brasilia in Brazil. Carrot plants were harvested *90* days after planting. After the harvest a linear and quadratic effect for phosphorus and urban waste compost ($P<0.01$) was observed. The linear interaction P X quadratic urban compost was highly significant. The maximum root production was 26.5 t/ha corresponding to 18.5 t/ha of P_20_5 and 53.2 t/ha of urban waste compost.

Maity *et al.* (2001) worked on growth and Sporulation of *Alternaria radicina* under various carbon and nitrogen sources and found that carrot black rot pathogen *Alternaria radicina* grew best on a liquid medium containing xylose and potassium nitrate as the carbon and nitrogen sources, respectively.

Starch, sucrose and dextrose also supported mycelial growth. Ammonium salts as in organic nitrogen sources were poorly utilized. Among the organic - nitrogen sources, casein hydrolysate produced good growth, followed by glycine. Maximum vegetative growth was observed in medium containing a carbon nitrogen ratio of 16:1.

Oliveira *et al.* (2001) studied the effect of earthworm compost and mineral fertilizer on root production in carrot and found that the different levels (0, *20*, *25* and 30 t/ha) of earthworm compost, in the presence or absence of mineral fertilizers, on the production (cv. *Brasilia Nova Selocoa)* roots was e-valuated in a field experiment conducted in Areia (Praibaj), Brazil during July–October 1997. Earthworm compost at *25* t/ha produced the highest total (70.1 t/ha) and marketable (31.1 t/ha) yields and the lowest non-marketable yield of roots (39.0 t/ha). The production of Extra-A and Extra grade roots increased linearly as earthworm compost rates increased. Production of Extra-A and Extra grade roots increased by approximately 0.6 and 0.16 t/ha for each of ton of earthworm compost 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 9.4 t/ha respectively, compared to its absence.

Salminen *et al.* (2001) showed the effect of plant growth in carrot with the application of digested poultry slaughterhouse waste as nitrogen source, gave the higher yield.

The Horticulture Farm, Bangladesh Agricultural University, Mymensingh, Rahman (2000) carried out an experiment and found that plant height of TPS seedlings was significantly influenced by the application of cowdung. The plant height (75.28 cm) at 100 days was obtained from the highest dose of cowdung (100 ton/ha.)

In Brazil, Schuch *et al.* (1999) worked on the effect of organic manure (chicken and quail) on yield and quality of carrot cv. Nantes Forto, Flakkese, Fuyumaki, Nantes Superior and Harumaki Kinko in 1993 and 1995. In 1995, cv. Nantes superior and Harumaki Kinko were replaced by 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, Nantes For to produced 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.

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

Sediyama *et al.* (1998) carried out an experiment to assess the plant nutritional 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 *(pennisetum purpureum)* and coffee straw and crushed sugarcane with four replications, from 3 May to 23 August 1994 in Ponte Nova county, Minas Gerais State, Brazil. Generally, both a greater plant height and aerial part yield were obtained from treatments with organic compounds and dry swine manure. The organic 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 produced form 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 for human diets.

Roe (1998) carried out an experiment by using compost, obtained from dairy manure and municipal solid waste to find out the beneficial effects on broccoli. He found beneficial effects on growth, yield and nutrient component compost application in the broccoli production.

Vieira *et al.* (1998) studied on a clayey Dusky Red Latosol in Dourados, Brazil, to evaluate the response of *Arracacia xanthorrhiza* to P fertilizer application at 4.3, 25.8, 43.0, 60.2 or 81.7 kg/ha as triple supper phosphate as well as the response to application of poultry house litter at 1, 6, 10, 14 or 19 : ia. Treatments were defined by the plane puebla III experimental matrix, resulting in the following P (kg/ha) and poultry house litter (t/ha) combination: 4.3 x 6; 25.8 x 1; 25.6 x 6; 25.8 x 14; 43.0 x10; 60.2 x6; 60.2 x s 60.2 x 19 and 81.7 x 14. Each plot was 3.5 m^2 with 10 plants grouped in double rows with 0.50m between plants, 0.60 m between paired rows and 80m between double rows. During the vegetative cycle, plant height was measured every 15 days. Harvesting was carried out 9 month after planting. Plant height presented little variation due to treatment and maximum heights were between 31cm (4.3kg P/ha + 6 t litter/ha) and 37cm (60.2kg P/ha +19 t litter /ha), 234 and 260 days after planting respectively. Dry manure production of marketable root was independent of poultry house litter level, at increased linearly with P dose ranging from 0.42 t/ha (4.3kg P/ha) to 1.3 t/ha (81.7kg/ha). Marketable root yield increased linearly with P and poultry house litter rates, averaging 10 t/ha.

Nielsen *et al.* (1998) conducted to test the essential of various organic wastes as soil amendments in horticultural production, in British Clumbia, 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 biosolids, biowastes and peat. Yield of both chard 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 biosolids and biowastes have the essential to 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 by broadcasting or placement or at the 3 to 4 leaf stage by placement. Placement involved application in rows 7-10 cm deep in the middle of every second inter-row of plants. Ammonium sulfate was applied at a rate calculated to achieve a soil N content of 75 mg/dm^3. On all sites carrot yield harvested from placement treatments were significantly higher than that from broadcast treatments. Irrespective of fertilizer application method, the lowest contents of nitrates were detected in roots cultivated in heavy soil containing 1.8% organic manure.

Zarate *et al.* (1997) conducted in Brazil to evaluate rates and methods of application of poultry manure on lettuce. The soil was supplied with 0, 7 or 14 t/ha semi-rotted poultry manure incorporated into the soil 0, 7 or 14 t/ha semi-rotted poultry manure applied to the soil surface. They found in the absence of incorporated manure, surface application of manure/ha 14 t gave significantly higher yield (17.8 t fresh manure per ha) than other nutrients.

When 7 t/ha was incorporated, the rate of surface application had no significant effect on yields (13.3-17 t/ha), whereas when 14 t/ha was incorporated, surface application of 7 t/ha manure gave the significantly highest yields (20 t/ha fresh matter).

Geweda *et al.* (1995) carried in a pot trial, lettuce (cultivars Syrens and Debata) and carrot (cultivars Karo F_1 and Kama F_1) seedlings were grown 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 experimental conditions, no external symptoms of the Pb toxicity were observed but differences in the mineral and organic composition of lettuce leaves and carrot roots retarding Pb-contamination was found, particularly in the soil with no organic manure.

Datta and Chakrabarty (1995) conducted a field experiment in 1991-93 at Sriniketan, West Bengal with 0, 50 and 100 kg/ha each of N, P_20_5 and K_20 and manure with 5 t/ha rice 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 riposted 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 weight 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.

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

Almazov and Kholuyako (1990) worked with the application of organic manures and mineral fertilizers in productivity of a vegetable crop in 1982-86 and found that the effects of application of the NPK rate for each crop and/or 2 peat (organic manures) rates on yields and quality of 4 vegetable crops. Peat (organic manures) gave the highest yields in 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 in cabbage.

Bohec (1990) studied the use of urban compost and sewage sludge compost for vegetable crops in 1980-86. Various vegetable crops were grown in rotation on land with annual application of composted FYM, composted urban waste or composted sewage sludge. In 1981, the highest total yield of celery and yield trimmed to 40 cm. were given by compost Hydromer or by composted FYM while other composts gave lower yields. In 1982, the yield of leeks was similar in all treatments except the control without added organic manureand composted household waste from Auray. Yields of celery in 1986 were the highest with FYM than that of any other treatments. Lettuce and celery showed accumulation of Cd while carrot and celery leaves accumulation Pb. In all treatments, including the control, soil Cu and Cd increased from 1980 to 1986.

Kundous 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 sowing 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 (oc) 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 yields of the first three crops but not the fourth crop. Concentration of N, P and 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.

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

2.2 Effect of spacing on the growth and yield of carrot

Amjad and Anjum (2001) had set up an experiment on the effect of root size, plant spacing and umbel order on the quality of carrot seed in University of Agriculture, Faisalabad-38040, Pakistan. They observed that the 1000-seed weight, seed moisture content, plant height, root length and fresh and dry weights of seedlings harvested 10 days after germination were not significantly affected by the root size. Plant spacing had significant effects on 1000-seed weight, root length and fresh weight of seedlings. Wider spacing (45 cm) proved better compared with close spacing. However, seed moisture content, seed germination, plant height and dry weight of seedlings after 10 days of germination had no significant response to plant spacing.

Taivalmaa and Talvitie (1997) studied in a field experiments on the effects of ridging, sowing rate and sowing system on the yield and visible quality of carrots (cv. Fontana BZ) in W. Finland in 1990-92. The highest yields were recorded for carrots sown in double rows on a narrow ridge. The effect of sowing system on mean root weight differed depending on the ridging regime. The mean weight of roots was higher for carrots cultivated on broad ridges than in other systems. Sowing rate had the most significant effect on mean root weight. For industrial purposes it is recommended that carrots be cultivated on broad ridges in double rows at low sowing rates with irrigation. The optimal cultivation technique for carrots destined for the fresh vegetable market would be narrow ridges sown in double rows at high sowing rates. The ridging system, sowing rate and row spacing did not appear to affect the external quality of roots.

Wiebe (1987) grew carrots at densities ranging from 350 to 1200 plants/m^2. He found that a density of 400-500 plant/m^2 was optimum for early harvest but 600-700 plants/m^2 gave higher yields of marketable roots at late harvest.

Dragland (1986) carried out an experiment in Norway on carrot sown in May. He thinned out seedlings to give densities of 45, 70 or 90 plants/m^2. He found that at the first harvest on 1 September, the highest salable yield (29 ton/ha) was achieved with a density of 70 plants/m^2 and at 2nd harvest on 10 October, the highest salable yield (42 ton/ha) was achieved with a density of 90 plants/m^2.

Mccollum *et al.* (1986) conducted an experiment in USA to evaluate the response to densities of 39, 59 or 79 plants/m^2. They found that marketable and total yields increased linearly with increased plant density from 24 to 85 plants/m^2. Mean length and diameter of marketable roots were decreased linearly with increased plant density.

Rashid *et al.* (1986) carried out an experiment and reported that the roots of carrot continued to increase in size until harvested 135 days after sowing. They suggested that for getting higher total yield and early yield, the crop should be sown as early as possible in the Rabi season. They also found that in case of cultivar Nantes, harvesting of roots as baby carrots is possible 75 days after sowing.

Snoek (1984) worked on the relationship between plant density and yield in Netherlands. He found that the optimum density was about 500 plants/m^2.

Farazi (1983) conducted an experiment on the effect of plant spacing on the yield of carrot under Bangladesh condition. He found that the closest spacing (18 cm x 8 cm) produced significantly higher yield over wider spacing.

Hoque and Bhuyan (1983) conducted and experiment with five different varieties of carrot namely, Nantes superior, Scarlet Nantes, Danvers 126, Chantenay red cored 5 and Imperator 58 at BARI, Joydebpur, during the winter of 1981-1982 with a view to find out the optimum time of harvest for maximum yield of any particular variety. Among the varieties, Danvers 126 gave the highest yield (59.2 t/ha) after 126 of sowing. They further noted that carrot should be harvested within 110 to 125 days of sowing for obtaining the highest yield of good quality roots.

Noguera *et al.* (1982) conducted an experiment in Brazil to find out the effect of plant spacing on yields of carrot (*Daucus carota var. sativa* L.) cv. Kuroda

Nacional. They thinned carrots to spacing of 20 cm x 5 cm, 20 cm x 8 cm, 20 cm x 10 cm and 20 x 15 cm which produced total yields of 14333.3 kg/ha, 12539.7 kg/ha, 11920.6 kg/ha and 12079.4 kg/ha respectively. Average root weight was increased from 55.53 kg/plot to 128.43 kg/plot as spacing was increased but it was significantly higher at the greatest spacing.

Salter *et al.* (1979) found in an investigation that root yield of carrot was affected by harvesting time. They obtained the highest absolute yield from the latest harvest, while the highest yield of canning roots (20-30 mm diameter) was obtained from the earlier harvests.

Mack (1979) Reported after an investigation that total root yields as well as roots of 25 mm and 38 mm in diameter were increased in carrot cv. Red cored and Chantenay as row spacing was reduced from 60 cm to 15 cm under New Zealand condition. Difference within row spacing did not have a significant impact on total yield but affected yield of various size grades. In general the root length was decreased as the plant population increased.

Salter *et al.* (1979) in UK reported that total root yield was not significantly affected by plant arrangement on plant density in most cases. However, the yield of canning size roots (20-30 mm diameter) was influenced by plant density. With the lowest density treatments, the highest yield of canning roots was obtained form the earliest harvest. Mean root weight was significantly affected by density.

Dragland (1978) conducted an experiment of the yield and quality of carrots at different plant densities in Norway. He noticed that in general both the total and the marketable yields increased with increasing plant density. Root size was decreased with increasing plant density but the number of splitted of branched roots was not significantly affected by the plant spacing.

Kepka *et al.* (1978) in a small scale field experiment found that total as well as marketable yield of carrots rose with decreasing inter-row spacing from 45 cm to 10 cm and intra-row spacing from 6 cm to 2 cm. A population of 111 of 222 plants/m^2 produced the highest and most uniform yield.

Fritz and Habben (1977) sowed the seeds of four carrot cvs. in green house condition under German Federal Republic conditions where the root were harvested 71, 99 of 127 days later. Seeds of eight cvs. were sown in the open condition and roots were harvested 96, 132, 173 or 208 days later. They suggested that carrot should be harvested at proper stage of maturity; otherwise it will become fluffy and unfit for consumption. Moreover, the percent of root splitting, firmness, the contents of dry matter, carotene and sucrose are increased during the growth of carrots, whereas the contents of glucose and quotient are decreased. The contents of total sugars remained almost constant from the beginning of the harvesting period but increased at low temperatures in late autumn.

Pavlek (1977) studied three years trial with 15 carrot cultivars to investigate the effects of plant density on yields under Yugoslavia condition. He found a positive correlation between the number of plants and yield per hectare.

Bussell (1976) worked with spacing on baby carrots sown on three different dates from mid September to mid-December under New Zealand conditions. He reported that the optimum population at harvest was about 13000 plants/m^2. Root length decreased as the plant population increased. Again Bussell (1978) arranged another experiment on the production of baby carrot and showed the same result.

Lucchesi *et al.* (1976) studied with the radish cv. Early Scarlet Globe. The plants were spaced within the row at 4 and 8 cm with 5 cm, 10 cm, 15 cm and 20 cm between rows. They obtained the highest commercial yield (375 g/0.5 m^2) from plants spaced at 15 cm x 8 cm.

Bussell (1975) studied the effect of plant densities on the yield of small (13 to 18 mm diameter, 7.5 to 11.5 cm long) finger carrots ranging from 533 to 2500 seeds per square meter in two experiments. He obtained the highest yield from the highest densities used in both the experiments.

Lipari (1975) worked with three plant densities (50, 75 and 100 plants per square meter) and two rows spacing (20 cm and 40 cm) of carrot and found a significant correlation between the yield of marketable roots and plant density. He observed that yield was increased by the higher density of plants in the row, the number of root increased but single weight of marketable root decreased.

Bussell and Dalenger (1972) worked on carrot cvs. planted in October in New Zealand and harvesting was done at weekly interval beginning 10 weeks from planting time. The roots were assessed for color determined as mg carotene/100 g dry matter. Eleven cvs. were appeared unsuitable for baby carrots (i.e. 7.5-12.5 cm long and 2.50/5-7.5/10.0 cm diameter) production for reasons of low yield of poor color. The remaining 10 cvs. together with Manchester Table were grown in further sown in mid-January and harvested in late March and April. Yields were lower than in the first trial but the cvs. s754, Grenadier, Amsterdam Finger, Amsterdam Elson, Amsterdam Forcing, Tiny Tot, B52 and continental were considered to be suitable in New Zealand.

Frohlich *et al.* (1971) conducted an experiment and reported that total and marketable yields of late carrot were increased as a result of reduction in row spacing from 27 cm to 25 cm. Increasing plant density enhanced the marketable yield more than the total yield.

Jedlickova *et al.* (1971) planted carrot seeds of Nantes variety at the distance of 3.5 and 7 cm apart within rows and of 22.5 cm, 30.0 cm and 37.5 cm apart between rows. The highest yields were obtained from the spacing of 3 cm x 22.5 cm or 3 cm x 30.0 cm.

Bleasdale *et al.* (1961) reported that employing a 17.78 cm in row-row spacing with about 112 plants per square meter increased the mark table yield of carrot.

Ward (1959) conducted an experiment for two years with Top Weight variety of carrot. He grew the carrots with several spacing, starting form 2.54 cm to 17.78 cm within the rows. Spacing at 7.62 cm gave the highest number of large carrots. Spacing at 5.08 cm had the greatest yield of medium number and medium graded carrots.

Goodman (1953) found from an investigation that wide spacing showed a depressing effect on yield with the increased percent of pitted and course roots.

Wagner and Benes (1955) from one of their experiments reported that a spacing of 25 cm x 5 cm had produced the highest yield of seven carrot varieties. In another experiment they noticed that a spacing of 30 cm x 5 cm was the best. They concluded that the highest yield and the best quality were associated with the greatest distance between the rows and the smallest distance within the row.

Warne (1952) made an investigation and reported that the optimum plant density for carrot was between 60 and 100 plants per square meter. The general conclusion from this trial was that visual inspection of a root crop could lead to an unnecessary fear of overcrowding; about 10% of the crop must in practice be too small if the crop as a whole was to give its maximum yield

Nilsson and Hintze (1952) conducted trials with 8 varieties and strains of carrot at 7 localities in Sweden from 1948 to 1950. Each consisted of 4 or 8 blocks randomized in a split plot design. Heavier yields obtained in 5 cm spacing than 10 cm; in two Southern localities where unthinned plots were compared with 5 cm spacing, the former gave the higher yield.

Chapter 3

Materials and methods

CHAPTER III

MATERIALS AND METHODS

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

3.1 Experimental site

The experiment was conducted at the Central Farm of the Sher-e-Bangla Agricultural University, Dhaka during November 2007 to April 2008. Laboratory works were done both at Horticulture Laboratory and Soil Science Laboratory in Sher-e-Bangla Agricultural University, Dhaka-1207.

3.2 Climate

The experimental area is situated in sub-tropical climatic zone as characterized by heavy rainfall during the month of April to September and scanty rainfall during the rest period of the year (Anonymous, 1960). Information regarding monthly maximum and minimum temperature (^0C), rainfall (cm) and relative humidity (%) were recorded from the Weather Yard Station, Agargaon, Dhaka during the study period.

3.3 Soil

The experiment area was belonged to the Modhupur Tract and AEZ 28 (FAO, 1971). The soil was sandy loam with a pH value 6.6. The nutrient status of the soil was determined in SRDI, Khamarbari, Dhaka and is presented in (Appendix ii).

3.4 Experimental materials

"New Caroda" variety of carrot was used for the experiment. The seeds of this variety were collected from "Hamid Seed Store", Siddique Bazar, Dhaka.

3.5 Experimental Treatments

The experiment was conducted to study the effect of four levels of organic manure and three levels of spacing. Vermicompost collected from Dr. Md. Nurul Islam, Department of Soil Science, Sher-e-Bangla Agricultural University Different levels of two factors were as follows:

Factor A: Different types of Organic Manure

T_0= Control (No manure)

T_1= Cowdung

T_2= Poultry manure

T_3= Vermicompost

Factor B: Different types of Spacing

S_1= 25 cm × 10 cm

S_2= 25 cm × 15 cm

S_3= 25 cm × 20 cm

Two factors consist of twelve (4 × 3 =12) treatments combination. These were as follows:

Treatment Combination	Description	
	Spacing	Organic manure
S_1T_0	25 cm × 10 cm	Control (No manure)
$S_2 T_0$	25 cm × 15 cm	Control (No manure)
S_3T_0	25 cm × 20 cm	Control (No manure)
S_1T_1	25 cm × 10 cm	Cowdung
S_2T_1	25 cm × 15 cm	Cowdung
S_3T_1	25 cm × 20 cm	Cowdung
$T_2 S_1$	25 cm × 10 cm	Poultry manure
$T_2 S_2$	25 cm × 15 cm	Poultry manure
$T_2 S_3$	25 cm × 20 cm	Poultry manure
$T_3 S_1$	25 cm × 10 cm	Vermicompost
$T_3 S_2$	25 cm × 15 cm	Vermicompost
$T_3 S_3$	25 cm × 20 cm	Vermicompost

T_0= Control (No manure)

T_1= Cowdung

T_2= Poultry manure

T_3= Vermicompost

S_1= 25 cm × 10 cm (Spacing)

S_2= 25 cm × 15 cm (Spacing)

S_3 = 25 cm × 20 cm (Spacing)

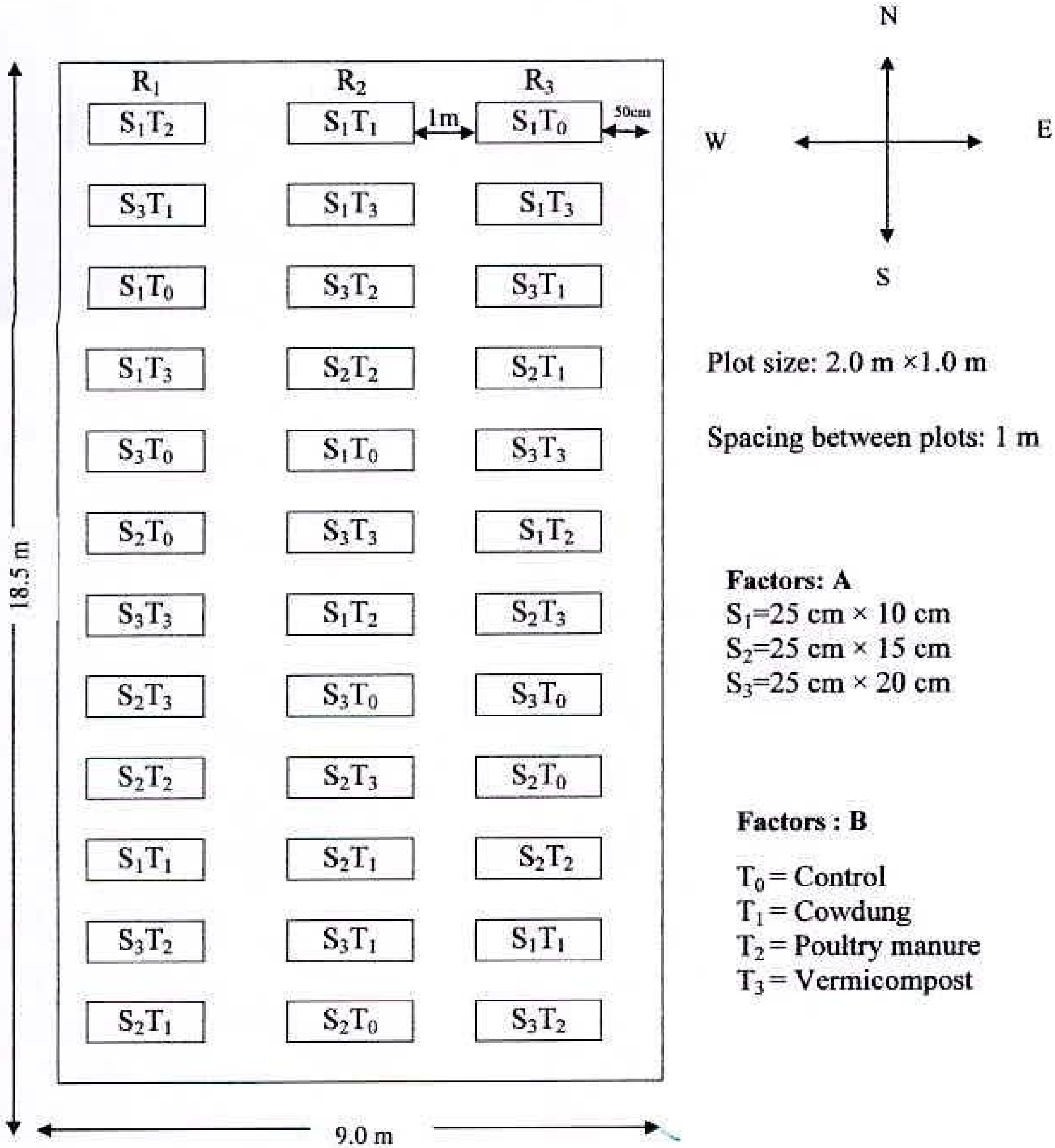

Figure 1. Field layout of the experimental area

3.6 Design of the experiment

The two factors experiment was laid out in a Randomized Complete Block Design with three replications. The whole experimental area was 18.5 m × 9.0m, which was divided into three blocks. Each block was again divided into 12 plots and hence there were 36 (12×3) unit plots. The treatments were assigned randomly in each block separately. The size of unit plot was 2.0m ×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 for two hours to dry. The seeds were treated with Vitavex-200 @ 3g/100g seed.

3.8 Seed Rate and Seed Sowing

Seeds were used at the rate of 3 Kg/ha as mentioned by Rashid (1993), consequently 55 g of seeds were used for the experimental area. Four shallow furrows with 1.5 cm depth were made in each plot respectively. Seeds were sown on different organic manure and different spacing as per treatments. Before seed sowing, Savin 85 WP @ 2 kg/ha was applied to each plot for precautionary measures against ants and worms infestation to the seed and seedlings.

3.9 Land preparation

The selected land for the experiment was first opened on 05 November, 2007 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 vigorous tilth. Deep ploughing and good tilth was necessary for getting better yield of the crop (Ahmad, 1969b). 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 85 WP @ 2 kg/ha to protect the young plant from the attack of mole cricket, cutworm and ants. Irrigation channels were made around each block.

3.10 Manure and Fertilizers

The amount of different types of organic manures were applied in this experiment were given below :

Manures	**Dose (t/ha)**	**Dose (kg/plot)**	**Available amount of nutrient (kg/ha)**		
			N	**P_2O_5**	**K_2O**
Cowdung	35.00	7.00	250.00	175.00	280.00
Poultry manure	20.00	4.00	240.00	220.00	140.00
Vermicompost	35.00	7.00	560.00	176.40	210.00

*plot size : 2 m^2

Source : Principles and Practices of Agronomy

The total amount of cowdung, vermicompost and poultry manure were applied during land preparation. (Vermicompost contains % of N, P_2O_5 & K_2O respectively 1.6, 0.504 & 0.60)

3.11 Intercultural Operation

Emergence of seedlings started about six days after sowing. Different amount of plants per plot were found due to different spacing. Different plant spacing in different plot was adjusted by thinning at two stages like 15 and 30 days after sowing.

i. Thinning

Seedlings were thinned out two times. First thinning was done after 15 days of sowing keeping two seedlings in each site at requisite distance as per treatment. The second thinning was done after 30 days of sowing keeping only one seedling in each hole.

ii. 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 before application of second dose fertilizer.

iii. Irrigation

The field was irrigated five times during the whole period of plant growth. Just after sowing light watering was done with fine watering can. Surface rust was broken after each irrigation. The second, third, fourth and fifth watering were done at 20, 35, 55 and 75 days after sowing of seeds respectively.

iv. Insects and diseases Management

Precautionary measures against Fusarium rot were taken by spraying Dithane M-45 @ 2 g /litre water. The crop was infested by cutworms (*Agrotis ypsilon)* 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%.

3.12 Collection of data

i. Plant height (cm)

Length of the largest leaves was considered as the foliage length. It was measured by using a meter scale and recorded in centimeter (cm). Ten plants in each plot were used to measure foliage length per plant.

ii. Number of leaves per plant

Number of leaves was counted 15 days interval after 40 days of sowing and continued to harvest. Ten plants in each plot were used to count number of leaves per plant.

iii) Fresh foliage weight per plant (g)

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).

iv) Foliage dry matter per plant (%)

Leaves were detached from the root and kept in an oven at 70-80^{0}C for 72 hours. After drying, the leaves were kept in a desiccator containing blue silica gel. Fifteen minutes later the samples were weighed by using electric balance and recorded in gram (g).

v) Root length per plant (cm)

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

vi) Root diameter per plant (cm)

Ten selected plants were used to determine root diameter. Root diameter was measured at the time of harvesting from the middle portion with slide calipers and recorded in centimeter (cm).

vii) Root fresh weight per plant (g)

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

viii) Root dry matter per plant (g)

Ten selected carrot root were used to determine root dry weight. Immediate after harvest roots were weighed initially, then chopped and kept it in an oven at 70-80^{0}C for 48 hours in order to get constant weight. (AOAC, 1965). The dry weight of root was measured by electric balance and was considered as dry weight and recorded in gram (g).

$$\text{Percentage of dry matter} = \frac{\text{Fresh weight of root (g)}}{\text{Dry weight of root (g)}} \times 100$$

ix) Cracking root (%)

The percentage of cracking roots was estimated by using the following formula-

$$\text{Percentage of cracking root} = \frac{\text{No.of cracked root}}{\text{Total no. of root}} \times 100$$

x) Branched root (%)

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

$$\text{\% of branched root} = \frac{\text{Percentage of branched root}}{\text{Total no. of root}} \times 100$$

xi) Gross yield of roots per plot (kg)

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

$$\text{Gross yield (kg/plot)} = \frac{\text{Area of single plot (mxm) x Average yield per plant (g) x 10000}}{\text{Spacing (cmxcm)x1000}}$$

xii) Gross yield of roots per hectare (t)

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

$$\text{Gross yield (t/ha)} = \frac{\text{Area (ha) x Average yield per plant (g) x 10000}}{\text{Spacing (cmxcm) x 1000 x 1000}}$$

xiii) Marketable yield per plot (kg)

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

Marketable yield = Gross yield − Non marketable yield (No. of cracked root and branched root)

vix) Marketable yield per hectare (t)

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

3.13 Harvesting

Final harvest was done when most of the roots of carrot showed the sign of maturity i.e. after 80 days of sowing.

3.14 Economic Analysis

Cost and return analysis in details was done according to the procedure of Alam et al. (1989)

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.

Chapter 4

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Plant height (cm)

The plant height was recorded at different stages of growth i.e. 45, 60, 75 and 90 days after sowing (DAS). The plant height was not varied significantly due to the variation of spacing. The tallest (25.17 cm) plant was observed from the spacing of S_1 (25 cm x 10 cm) while the shortest (23.16 cm) from the spacing of S_3 (25 cm x 20 cm) at 45 DAS. At 60 DAS, The tallest (37.05 cm) plant was observed from the spacing of S_1 (25 cm x 10 cm) while the shortest (34.67 cm) from the spacing of S_3 (25 cm x 20 cm). At 75 DAS, The tallest (45.93 cm) plant was observed from the spacing of S_1 (25 cm x 10 cm) while the shortest (41.36 cm) from the spacing of S_3 (25 cm x 20 cm). At 90 DAS, The tallest (50.27 cm) plant was observed from the spacing of S_1 (25 cm x 10 cm) while the shortest (46.61 cm) from the spacing of S_3 (25 cm x 20 cm) (Fig. 2). The plant height was decreased with increasing in spacing. The increased plant height at closer spacing was due to more competition for air and light. This is in agreement with the results of Rashid (1998) and Amjad and Anjum (2001), they obtained taller plants from closer spacing. But this is contradictory with the findings of Badaruddin and Haque (1997), Khushk *et al.* (1990) and Kumer *et al.* (1998) they found taller plant height at the wider spacing.

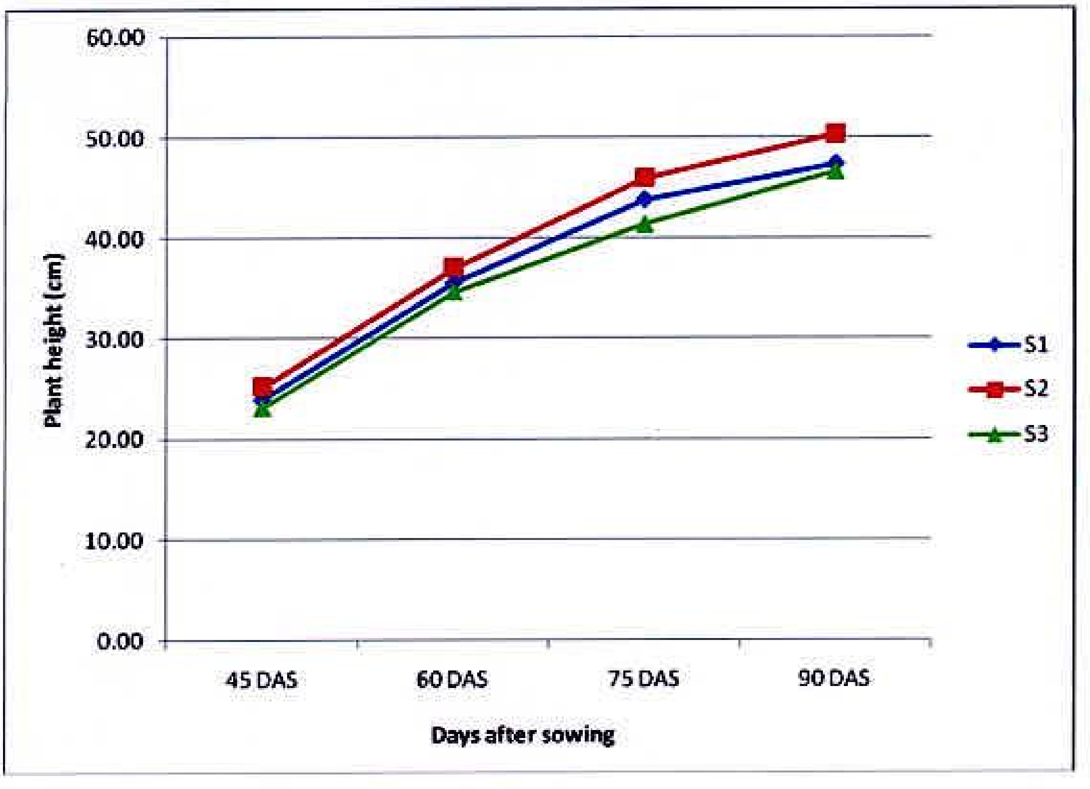

Figure 2. Effect of spacing on plant height (cm) of carrot

Here,

S_1= 25 cm × 10 cm

S_2= 25 cm × 15 cm

S_3= 25 cm × 20 cm

The plant height was recorded at different stages of growth i.e. 45, 60, 75 and 90 days after sowing (DAS). The plant height was not varied significantly due to the variation of the application of different organic matter (Appendix IV). The tallest (27.31 cm) plant was observed from cowdung treatment (T_1) while the shortest (18.71 cm) from the control treatment (T_0) at 45 DAS. At 60 DAS, The tallest (39.09 cm) plant was observed from cowdung treatment (T_1) while the shortest (30.26 cm) from the control treatment (T_0). At 75 DAS, The tallest (46.64 cm) plant was observed from cowdung treatment (T_1) while the shortest (38.604 cm) from the control treatment. At 90 DAS, The tallest (51.01 cm) plant was observed from cowdung treatment (T_1) while the shortest (44.60 cm) from the control treatment (T_0) (Fig. 3). The plant height was at peak at 90 DAS. In general, plants height increased gradually in the early stages of sowing of the plant development. Rashid and Shakur (1986) also reported similar results in plant height variation over the period of crop growth.

The plant height was recorded at different stages of growth i.e. 45, 60, 75 and 90 days after sowing (DAS). A significant interaction was found between application of different organic matter and spacing on plant height (Appendix IV). The tallest (28.12 cm) plant was observed from treatment combination of S_1T_1 (spacing 25 cm × 10 cm with cowdung) while the shortest (17.46 cm) from treatment combination of S_3T_0 (spacing 25 cm × 20 cm) at 45 DAS. At 60 DAS, The tallest (39.54 cm) plant was observed from treatment combination of S_1T_1 (spacing 25 cm × 10 cm with cowdung), while the shortest (28.60 cm) from the treatment combination of S_3T_0 (spacing 25 cm × 20 cm).

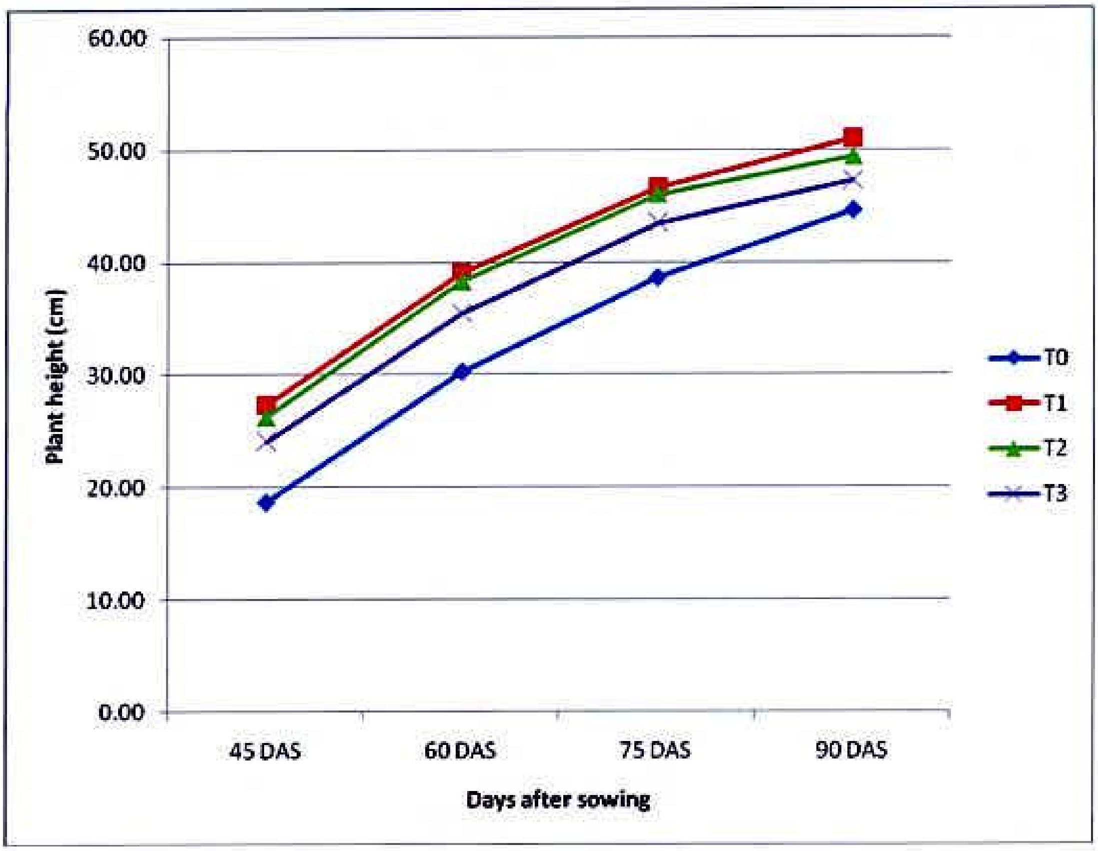

Figure 3. Effect of organic matter on plant height (cm) of carrot

Here,

T_0 = control (no manure)

T_1 = cowdung

T_2 = poultry manure

T_3 = Vermicompost

At 75 DAS, The tallest (51.17 cm) plant was observed from treatment combination of S_1T_1 (spacing 25 cm × 10 cm with cowdung), while the shortest (35.50 cm) from the treatment combination of S_3T_0 (spacing 25 cm × 20 cm). At 90 DAS, The tallest (52.87 cm) plant was observed from treatment combination of S_1T_1 (spacing 25 cm × 10 cm with cowdung), while the shortest (43.11 cm) from the treatment combination of S_3T_0 (spacing 25 cm × 20 cm) (Table 1).

Table 1. Combined effect of organic manure and spacing on plant height of carrot

Treatment	Plant height			
	45 DAS	60 DAS	75 DAS	90 DAS
S_1T_0	19.83bcd	31.70bcd	39.82bc	47.13abcd
S_1T_1	28.12a	39.54a	51.17a	52.87a
S_1T_2	27.37a	39.41a	46.53ab	51.90ab
S_1T_3	25.36abc	37.55ab	46.20ab	49.17abcd
S_2T_0	18.85cd	30.46cd	40.49bc	43.56cd
S_2T_1	27.60a	39.15a	46.23ab	49.43abcd
S_2T_2	27.37a	38.98a	46.55ab	50.27abc
S_2T_3	21.91abcd	33.71abcd	41.82bc	46.47abcd
S_3T_0	17.46d	28.60d	35.50c	43.11d
S_3T_1	23.85abcd	36.13abc	40.68bc	45.87bcd
S_3T_2	26.44ab	38.89a	46.84ab	50.87ab
S_3T_3	24.90abc	35.06abcd	42.42bc	46.17abcd
$LSD_{(0.05)}$	6.395	6.021	6.487	6.027
Level of significance	*	*	*	*
CV (%)	15.68	9.94	8.77	7.40

* = significant at 0.05 level

Here,

T_0 = Control (no manure)

T_1 = Cowdung

T_2 = Poultry manure

T_3 = Vermicompost

S_1 = 25cm × 10 cm

S_2 = 25cm × 15 cm

S_3 = 25cm × 20 cm

4.2 Number of leaves per plant

The number of leaves per plant was recorded at different stages of growth i.e. 45, 60, 75 and 90 days after sowing (DAS). The number of leaves per plant was not varied significantly due to the variation of spacing (Appendix IV). The maximum number of leaves per plant (8.43) was observed from the spacing of S_3 (25 cm x 20 cm) while the minimum number of leaves per plant (8.12) from the spacing of S_1 (25 cm x 10 cm) at 45 DAS. At 60 DAS, The maximum number of leaves per plant (11.08) was observed from the spacing of S_3 (25 cm x 20 cm) while the minimum number of leaves per plant (10.43) from the spacing of S_1 (25 cm x 10 cm). At 75 DAS, The maximum number of leaves per plant (12.13) was observed from the spacing of S_3 (25 cm x 20 cm) while the minimum number of leaves per plant (11.39) from the spacing of S_1 (25 cm x 10 cm). At 90 DAS, The maximum number of leaves per plant (12.34) was observed from the spacing of S_3 (25 cm x 20 cm) while the minimum number of leaves per plant (11.83) from the spacing of S_1 (25 cm x 10 cm) (Fig. 4). As the spacing was increased number of leaves was found to be increased. This might have been due to the absorption of more nutrients, getting more sunlight on larger leaf area and better aeration influenced by the gradual increase in the spacing. This result is agrees well with the finding of Kumar *et al.* (1998) and Rashid (1998). They found increased number of leaves per plant at wider spacing.

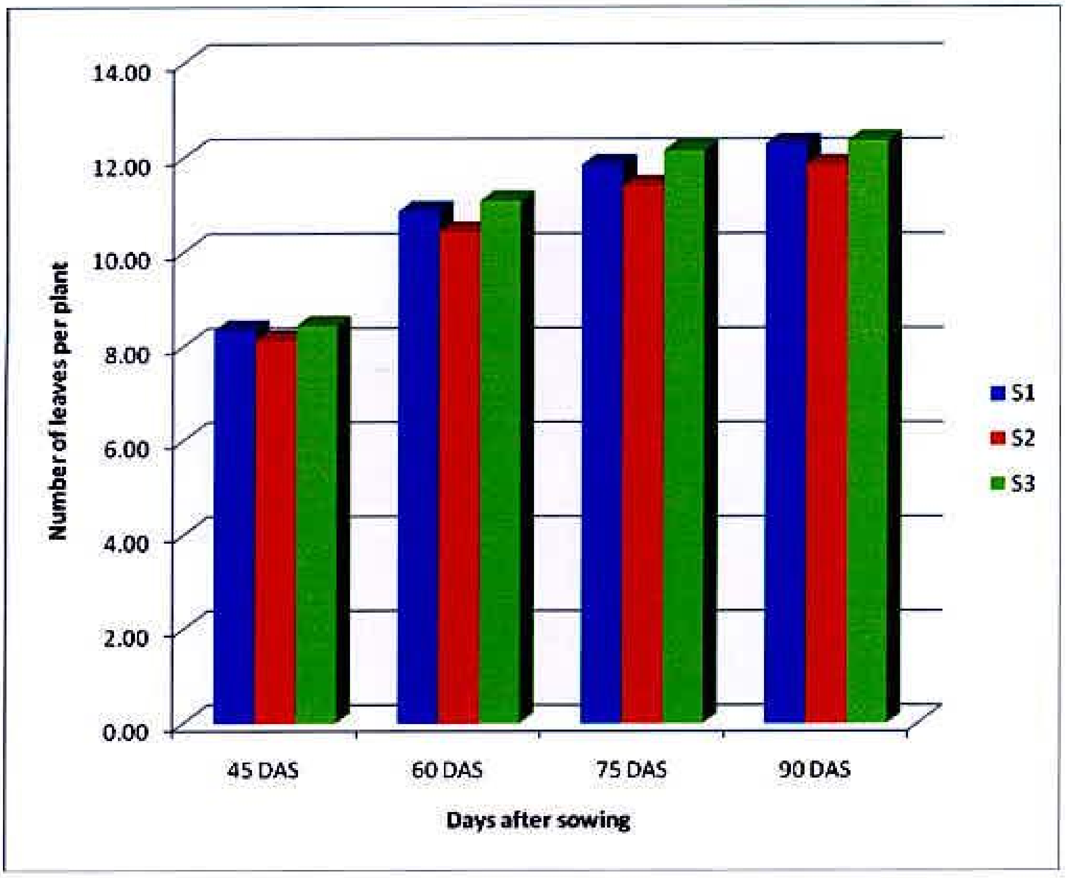

Figure 4. Effect of spacing on number of leaves of carrot

Here,

S_1= 25cm × 10 cm

S_2= 25cm × 15 cm

S_3= 25cm × 20 cm

The number of leaves per plant was recorded at different stages of growth i.e. 45, 60, 75 and 90 days after sowing (DAS). The number of leaves per plant was not varied significantly due to the variation of the application of different organic matter (Appendix IV). The maximum number of leaves per plant (8.82) was observed from cowdung treatment (T_1) while the minimum (7.21) from the control treatment (T_0) at 45 DAS. At 60 DAS, The maximum number of leaves per plant (11.63) was observed from cowdung treatment (T_1) while the minimum (9.39) from the control treatment (T_0). At 75 DAS, maximum number of leaves per plant (12.80) was observed from cowdung treatment (T_1) while the minimum (10.48) from the control treatment. At 90 DAS, The maximum number of leaves per plant (12.81) plant was observed from cowdung treatment (T_1) while the minimum (11.28) from the control treatment (T_0) (Fig. 5).

The number of leaves per plant was recorded at different stages of growth i.e. 45, 60, 75 and 90 days after sowing (DAS). A significant interaction was found between application of different organic matter and spacing on number of leaves per plant (Appendix IV). The maximum number of leaves per plant (9.30) was observed from treatment combination of S_3T_1 (spacing 25 cm × 20 cm with cowdung) while the minimum (6.87) from treatment combination of S_1T_0 (spacing 25 cm × 10 cm) at 45 DAS. At 60 DAS, The maximum number of leaves per plant (12.30) was observed from treatment combination of S_3T_1 (spacing 25 cm × 20 cm with cowdung), while the minimum (9.27) from the treatment combination of S_1T_0 (spacing 25 cm × 10 cm). At 75 DAS, maximum number of leaves per plant (14.00) plant was observed from treatment

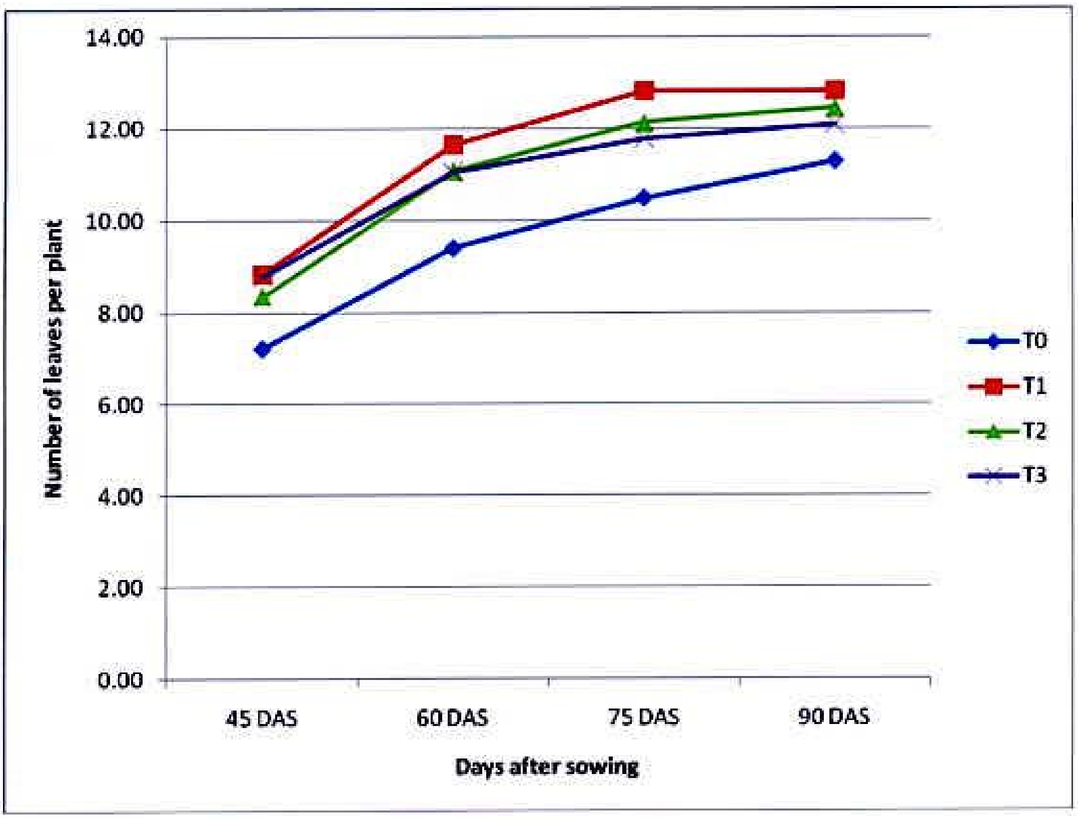

Figure 5. Effect of organic matter on number of leaves of carrot

T_0 = control (no manure)

T_1 = cowdung

T_2 = poultry manure

T_3 = Vermicompost

combination of S_3T_1 (spacing 25 cm × 20 cm with cowdung), while the minimum (10.30) from the treatment combination of S_1T_0 (spacing 25 cm × 10 cm). At 90 DAS, The maximum number of leaves per plant (13.40) plant was observed from treatment combination of S_1T_1 (spacing 25 cm × 10 cm with cowdung), while the minimum (11.07) from the treatment combination of S_3T_0 (spacing 25 cm × 20 cm) (Table 2).

4.3 Fresh weight of leaves per plant (g)

Significant variation was found in respect of fresh weight of leaves per plant by different spacing (Appendix IV). The fresh weight of leaves per plant varied from 92.38 g to 74.65 g (Table 3). The maximum weight (92.38 g) was found to the plants were grown at the spacing of S_3, while the minimum (74.65g) in S_1. The fresh weight of leaves per plant was gradually decreased from the plants grown from spacing.

A signification variation was observed on fresh weight of leaves per plant due to use of different organic manures (Appendix IV). The maximum fresh weight of leaves per plant was 100.55 g recorded from T_1 (cowdung) treatment, while the minimum (59.83 g) from the control at final harvest of the crop (Table 4).

A significant interaction was found between organic manures and spacing on fresh weight of leaves per plant (Appendix IV). The maximum fresh weight of leaves per plant (107.89 g) was observed from the treatment of S_3T_1 followed by others. The minimum fresh weight of leaves per plant (58.92 g) was recorded from the treatment of S_1T_0 (Table 5).

Table 2. Combined effect of organic manure and spacing on number of leaves per plant of carrot

Treatment	Number of leaves per plant			
	45 DAS	60 DAS	75 DAS	90 DAS
S_1T_0	6.87b	9.27b	10.30d	11.07b
S_1T_1	8.50ab	10.37ab	11.60bcd	11.63ab
S_1T_2	8.27ab	10.40ab	11.03cd	11.63ab
S_1T_3	9.17ab	11.67ab	12.63abc	12.87ab
S_2T_0	7.40ab	9.40b	10.40d	11.20b
S_2T_1	8.57ab	11.17ab	12.23a-d	12.83ab
S_2T_2	7.97ab	12.20a	13.37ab	13.40a
S_2T_3	8.43ab	10.63ab	11.33bcd	11.80ab
S_3T_0	7.37ab	9.50b	10.73cd	11.57ab
S_3T_1	9.30a	12.30a	14.00a	13.40a
S_3T_2	8.90ab	11.67ab	12.50abc	12.83ab
S_3T_3	8.73ab	10.83ab	11.30bcd	11.57ab
$LSD_{(0.05)}$	2.055	2.118	1.830	1.825
Level of significance	*	*	*	*
CV (%)	14.64	11.60	9.17	8.87

*significant at 5% level

Here,

S_1 = 25cm × 10 cm

S_2 = 25cm × 15 cm

S_3 = 25cm × 20 cm

T_0 = Control (no manure)

T_1 = Cowdung

T_2 = Poultry manure

T_3 = Vermicompost

4.4 Leaves dry matter per plant (%)

Spacing had not significantly effect on dry matter content of leaves per plant (Appendix IV). The S_3 (25 cm×20 cm) treatment gave the maximum dry matter (16.32%) of leaves, which was statistically similar to the treatment S_2 (25 cm×15 cm) and the minimum (15.73%) dry matter content of leaves per plant was found in treatment S_1 (25 cm×10 cm) (Table 3).

Organic manure had significant effect on dry matter content of leaves per plant (Appendix IV). The highest dry matter (18.36%) was recorded in plants fertilized with cowdung followed by litter (16.15%). The lowest dry matter (13.45%) was recorded from the control treatment (Table 4).

Table 3. Effect of spacing on growth of carrot

Treatment	Fresh leaves weight per plant (g)	Leaves dry matter per plant (%)	Root length (cm)	Diameter of root (cm)
S_1	74.65b	15.73	16.67	10.50
S_2	86.98a	15.79	17.28	10.98
S_3	92.38a	16.32	16.80	10.58
$LSD_{(0.05)}$	10.47	2.946	3.738	2.436
Level of significance	*	NS	NS	NS
CV (%)	3.52	5.26	6.79	6.49

Table 4. Effect of organic manure on growth of carrot

Treatment	Fresh leaves weight per plant (g)	Leaves dry matter per plant (%)	Root length (cm)	Diameter of root (cm)
T_0	59.83c	13.45c	15.50b	9.30b
T_1	100.55a	18.36a	18.31a	11.83a
T_2	90.28b	16.15b	16.72ab	10.76ab
T_3	88.01b	15.84b	17.13ab	10.86ab
LSD (0.05)	7.741	2.179	2.765	1.802
Level of significance	*	*	*	*
CV (%)	3.52	5.26	6.79	6.49

*= Significant at 0.05 level of probability

NS = Non significant at 0.05 level of probability

Here,

T_0 = Control (no manure)

T_1 = Cowdung

T_2 = Poultry manure

T_3 = Vermicompost

S_1= 25cm × 10 cm

S_2= 25cm × 15 cm

S_3= 25cm × 20 cm

Table 5. Combined effect of organic manure and spacing on growth of carrot

Treatment	Fresh leaves weight per plant (g)	Leaves dry matter per plant (%)	Root length (cm)	Diameter of root (cm)
S_1T_0	58.92f	12.97d	15.35bc	9.65d
S_1T_1	87.83c	17.60ab	17.42ab	11.10bc
S_1T_2	78.74d	16.62bc	16.57bc	10.72bcd
S_1T_3	73.10e	15.73c	17.33ab	10.87bcd
S_2T_0	60.24f	13.42d	15.94bc	9.92cd
S_2T_1	105.93a	18.50a	18.77a	12.63a
S_2T_2	91.64c	15.57c	17.17abc	10.56bcd
S_2T_3	90.10c	15.68c	17.25abc	10.81bcd
S_3T_0	60.33f	13.96d	15.20c	8.33e
S_3T_1	107.89a	18.98a	18.7a	11.76ab
S_3T_2	100.46b	16.26bc	16.43bc	11.00bc
S_3T_3	100.83b	16.09bc	16.82abc	10.91bcd
LSD (0.05)	5.044	1.420	1.802	1.174
Level of significance	*	*	*	*
CV (%)	3.52	5.26	6.79	6.49

* = Significant at 0.05 level of probability

Here,

S_1= 25cm × 10 cm

S_2= 25cm × 15 cm

S_3= 25cm × 20 cm

T_0 = Control (no manure)

T_1 = Cowdung

T_2 = Poultry manure

T_3 = Vermicompost

The combined effect of organic manure and spacing was statistically significant on dry matter content of leaves per plant (Appendix IV). The maximum (18.98%) dry matter content of leaves per plant was found in the treatment S_3T_1 which was statistically similar to that of S_2T_1 and the minimum (12.97%) was in the treatment S_1T_0 which is statistically significant to that of S_1T_0 and S_3T_0 (Table 5)

4.5 Root length (cm)

There was not significant difference among the spacing of carrot production in respect of root length (Appendix IV). The longest root (17.28 cm) was recorded from the plants grown at the spacing of S_2, and the shortest root (16.67 cm) was recorded from the plants grown at the spacing of 25 cm ×10 cm (S_1) (Table 3).

The length of carrot root was found to be statistically significant due to the affect of different organic manure (Appendix IV). The longest root (18.31 cm) was obtained from the application of cowdung (T_1) and the shortest (15.50 cm) was from control (T_0) treatment (Table 4).

A significant interaction was found between organic manure and spacing on root length of carrot (Appendix IV). The longest root (18.77 cm) was recorded from the treatment S_2T_1, which was statistically similar to that of S_3T_1. The shortest root (15.20 cm) was found from the treatment S_3T_0 (Table 5).

4.6 Diameter of root (cm)

There was not significant difference among the different spacings of carrot production in respect of diameter of root (Appendix IV). The maximum root diameter (10.98 cm) was found from the plants sown at the spacing of S_2, while the minimum root diameter (10.50 cm) at the spacing of S_1 (Table 3). The findings agreed with Mecollum *et al.* (1986).

Diameter of carrot root was significantly influenced by the application of organic manure (Appendix IV). The highest diameter of root (11.83 cm) was obtained from cowdung (T_1). The lowest diameter of root (9.30 cm) was observed in crops of control (T_0) treatment (Table 4). The findings agreed with Akand (2003).

The interaction effect of organic manure and spacing statistically influenced the root diameter of carrot (Table 6). The highest root diameter (12.63 cm) was observed from the treatment combination of S_2T_1 where plants were grown at the spacing of 25 cm×15 cm and the application of cowdung (T_1). The lowest (9.65) diameter of root was obtained from t S_1T_0 treatment (Table 5).

4.7 Fresh weight of root per plant (g)

Different spacing for carrot production was found to have not significant effect on Fresh weight of root per plant (Appendix IV). The maximum Fresh weight of root per plant (132.17g) was obtained from the plants grown at the spacing of 25 cm ×

15 cm (S_2). The minimum fresh root weight (126.61g) was obtained from the plants grown at the spacing of 25 cm × 10 cm (S_1) (Table 6).

The fresh weight of root per plant significantly differed with organic manure treatments (Appendix IV). The maximum fresh weight of root (142.74 g) was recorded from cowdung followed by litter (136.00 g) treatment (Table 7). However, the control treatment gave the lowest fresh weight of root (103.80 g).

The interaction effect of organic manure and spacing was statistically significant in respect of fresh weight of root (Table 8). The maximum fresh weight of root (145.43 g) was recorded from the plants grown at the spacing of 25 cm × 15 cm and the application of cowdung i.e. combined treatment S_2T_1 while the minimum (96.27 g) at the spacing of 25 cm×20 cm and control treatment i.e. combined treatment S_3 T_0. The highest weight of fresh root was statistically differed from other treatment combinations

Table 6. Effect of spacing on yield of carrot

Treatment	Fresh wt. of root per plant	Dry wt. of root per plant	cracking root per plant	Branched root per plant	Gross yield of roots per plot	Gross yield of roots per hectare	Marketable yield per plot	Maretable yield per hectare
S_1	127.74	15.43	3.63	4.90	6.79a	34.23ab	6.22a	31.13a
S_2	132.17	16.76	3.78	6.69	7.17a	35.75a	6.55a	32.75a
S_3	126.61	16.08	4.14	6.63	5.52b	27.60b	4.93b	24.64b
LSD (0.05)	12.67	3.349	3.018	4.812	1.142	7.471	1.024	4.927
Level of significance	NS	NS	NS	NS	*	*	*	*
CV (%)	4.80	5.91	11.90	12.50	5.44	6.54	4.93	4.75

* = Significant at 0.05 level of probability

NS = Non significant at 0.05 level of probability

Table 7. Effect of organic manure on yield of carrot

Treatment	Fresh wt. of root per plant	Dry wt. of root per plant	cracking root per plant	Branched root per plant	Gross yield of roots per plot	Gross yield of roots per hectare	Marketable yield per plot	Marketable yield per hectare
T_0	103.80c	13.82b	2.26b	6.49	5.20b	25.99b	4.75b	23.72b
T_1	142.74a	18.67a	4.80a	5.09	7.37a	37.10a	6.64a	33.36a
T_2	136.00ab	16.27ab	4.24ab	6.57	6.84a	33.73a	6.23a	31.08a
T_3	132.82b	15.59b	4.10ab	6.14	6.57a	33.28a	5.97a	29.87a
LSD (0.05)	9.375	2.477	2.232	3.559	0.919	5.526	0.7576	3.644
Level of significance	*	*	*	NS	*	*	*	*
CV (%)	4.80	5.91	11.90	12.50	5.44	6.54	4.93	4.75

* = Significant at 0.05 level of probability

Table 8. Combined effect of organic manure and spacing on yield of carrot

Treatment	Fresh wt. of root per plant	Dry wt. of root per plant	cracking root per plant	Branched root per plant	Gross yield of roots per plot	Gross yield of roots per hectare	Marketable yield per plot	Marketable yield per hectare
S_1T_0	105.40d	12.97g	2.33bc	5.42bcd	5.39f	26.97f	4.97e	24.85e
S_1T_1	137.87bc	18.17ab	3.58abc	3.75d	7.65a	39.00ab	6.98a	35.30a
S_1T_2	135.68bc	15.73cdf	4.83a	4.58cd	7.26ab	36.63a-d	6.74a	33.40a
S_1T_3	132.00bc	14.84def	3.80ab	5.83a-d	6.86bc	34.30cd	6.19b	30.97b
S_2T_0	109.74d	14.60efg	2.12c	6.71abc	6.07de	30.33ef	5.51cd	27.53cd
S_2T_1	145.43a	19.00a	3.99a	5.69a-d	7.90a	39.53a	7.19a	35.98a
S_2T_2	138.45b	16.81bc	4.62a	8.30a	7.40ab	35.33bcd	6.76a	33.80a
S_2T_3	135.07bc	16.61bcd	4.38a	6.07a-d	7.32ab	37.80abc	6.74a	33.70a
S_3T_0	96.27e	13.88fg	2.34bc	7.33ab	4.13g	20.67g	3.76f	18.78f
S_3T_1	144.92a	18.86a	5.16a	5.84a-d	6.55cd	32.77de	5.76bc	28.80bc
S_3T_2	133.86bc	16.28cde	4.94a	6.83abc	5.84ef	29.23ef	5.21de	26.03de
S_3T_3	131.39c	15.31c-f	4.11a	6.50abc	5.54ef	27.73f	4.99e	24.93e
LSD (0.05)	6.109	1.614	1.455	2.319	0.5987	3.601	0.4937	2.375
Level of significance	*	*	*	*	*	*	*	*
CV (%)	4.80	5.91	11.90	12.50	5.44	6.54	4.93	4.75

* = Significant at 0.05 level of probability

4.8 Dry weight of root per plant (%)

The effect of spacing significantly influenced in respect of dry weight of root (Table 8). The maximum (16.76%) dry weight of root was found at the spacing of 25 cm x 15 cm (S_2) and the minimum (15.43%) was found at the spacing of 25 cm x 10 cm (S_1). The result was agreed by Amjad and Anjum (2001).

The dry matter of root also varied significantly with the application of different organic manures (Appendix IV). The dry matter of roots was recorded to be the highest (18.67%) in plants raised with cowdung followed the litter (16.27%) (Table 7). The lowest dry matter of root (13.82%) was obtained from control treatment.

Combination of organic manures and spacing significantly influenced the dry weight of root (Table 8). The maximum dry weight of root (19.00%) was obtained on cowdung (T_1) at the spacing of 25 cm x 15 cm (S_2) i.e. The combined treatment of S_2T_1 gave the highest result and the minimum dry weight of root (12.97%) was observed on control treatment (T_0) at the spacing of 25 cm x 10 cm (S_1) i.e. combined treatment of S_1T_0 gave the lowest result. The highest dry weight of root represented by S_2T_1 was statistically similar with S_3T_1. The lowest dry weight of root represented by S_2T_0 was statistically similar with S_3T_0 and S_1T_0.

4.9. Percentage of cracking root

The mean value of cracking percentage with the treatment of three spacing not varied significantly (appendix IV). The maximum percentage (4.14%) of cracking root was observed in the treatment of S_3 (25 cm × 20 cm) while the minimum (3.63%) in S_2 (25 cm×10 cm) (table 6).

Organic manure had significant effect on the cracking percentage of roots. The highest percentage of root cracking (4.80 %) was observed from the treatment of cowdung application which was followed by litter (4.24%) treatment. The lowest (2.26%) percentage of root cracking was found in the control treatment (Table 7).

The combined effect of the application of organic manure and spacing was highly significant among the treatment mean. The maximum cracking percentage of root (5.16%) was observed from the treatment of S_3T_1. The minimum (2.12%) cracking percentage of root was observed from the treatment of S_1T_0 (Table 8). The result showed that the early and dense sowing influenced positively on growth of plant. All the process of consumption of nutrient, air, water and light to become a competitive situation under less spacing comparatively than wider spacing.

4.10 Branched root percentage

The branched root per plant with the treatment of three spacing not varied significantly (appendix IV). The maximum branched root per plant (6.69) was observed in the treatment of S_2 (25 cm × 15 cm) while the minimum (4.90) in S_1 (25 cm×10 cm) (table 6).

Organic manure had significant effect on the branched root per plant. The highest branched root per plant (6.57) was observed from the treatment of litter (T_2) application treatment. The lowest (5.09) branched root per plant was found in the control treatment (Table 7).

The combined effect of the application of organic manure and spacing was significantly varied on branched root per plant. The maximum branched root per plant (8.30) was observed from the treatment of S_2T_2. The minimum (3.75) branched root per plant of root was observed from the treatment of S_1T_1 (Table 8).

4.11 Gross yield of roots per plot and hectare

Significant variation was found in respect of yield by spacing (Fig. 9). The maximum yield (35.77 ton/ha and 7.17 kg/plot) was found from the treatment of S_2 (25 cm x 15 cm) while the minimum (27.60 ton/ha and 5.52 kg/plot) gross yield was found from the treatment of S_3 (25 cm x 20 cm). The highest yield was found under the spacing of S_2 (25 cm x 15 cm) due to be set up more number of plants than other two spacing in the same size of plot. The result was agreed with Bussell (1975). He obtained the highest yield from the highest densities used in the experiments.

Statistically significant variation due to different organic manure was found in gross yield of roots per plot and hectare (Table 3). The maximum gross yield (37.10

ton/ha and 7.37 kg/plot) was obtained from the application of cowdung (T_1), which was statistically similar with T_2 and T_3 treatment. The minimum gross yield (25.99 ton/ha and 5.20 kg/ha) was obtained from control treatment.

The combined effect of the application organic manure and spacing was significantly varied on gross yield of root. However, the maximum (39.53 ton/ha and 7.90 kg/plot) and the minimum yield (20.67 ton/ha and 4.13 kg/plot) were obtained from the treatment combination of S_2T_1 and S_3T_0, respectively.

4.12. Marketable yield per plot and hectare

Significant variation was found in respect of marketable yield per plot and hectare by different spacing (Fig. 6). The maximum marketable yield per plot and hectare (32.75 ton/ha and 6.55 kg/plot, respectively) was found from the treatment of S_2 (25 cm x 15 cm) while the minimum (24.64 ton/ha and 4.93 kg/plot, respectively) marketable yield per plot and hectare was found from the treatment of S_3 (25 cm x 20 cm). The highest marketable yield was observed under the treatment S_2 due to the highest amount of seedlings to be set up than other treatments. This result was agreed with Frohlich *et al.* (1971). He reported that increasing plant density enhanced the marketable yield.

Statistically significant variation due to organic manure was found in gross yield of roots per plot and hectare (Table 3 and Fig 7). The maximum marketable yield (33.36 ton/ha and 6.64 kg/plot) was obtained from the application of cowdung (T_1), which was statistically similar with T_2 and T_3 treatment. The minimum gross yield (23.72 ton/ha and 4.75 kg/ha) was obtained from control treatment.

The combined effect of the application organic manure and spacing was significantly varied on marketable yield per plot and hectare. The maximum marketable yield per plot and hectare (35.98 ton/ha and 7.19 kg/plot) was obtained from the treatment combination of $S_2T_1$and the minimum marketable yield per plot and hectare (18.78 ton/ha and 3.76 kg/plot) was obtained from the treatment combination of S_3T_0.

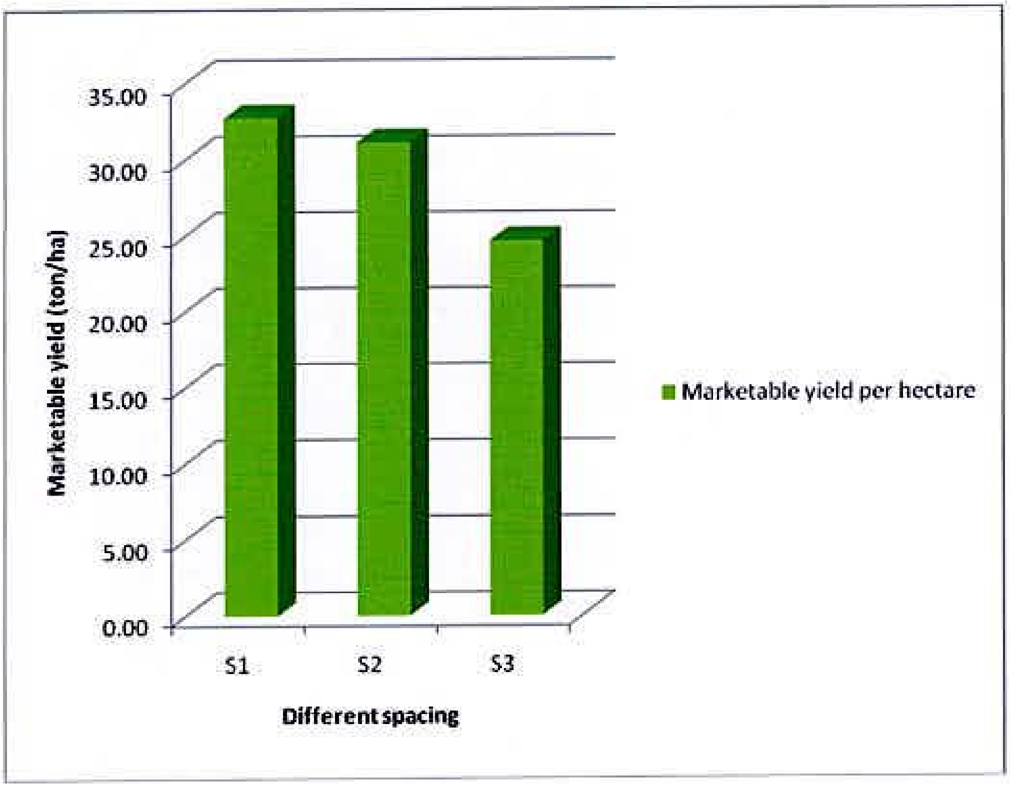

Figure 6. Effect of spacing on marketable yield of carrot

Here,

S_1= 25cm × 10 cm

S_2= 25cm × 15 cm

S_3= 25cm × 20 cm

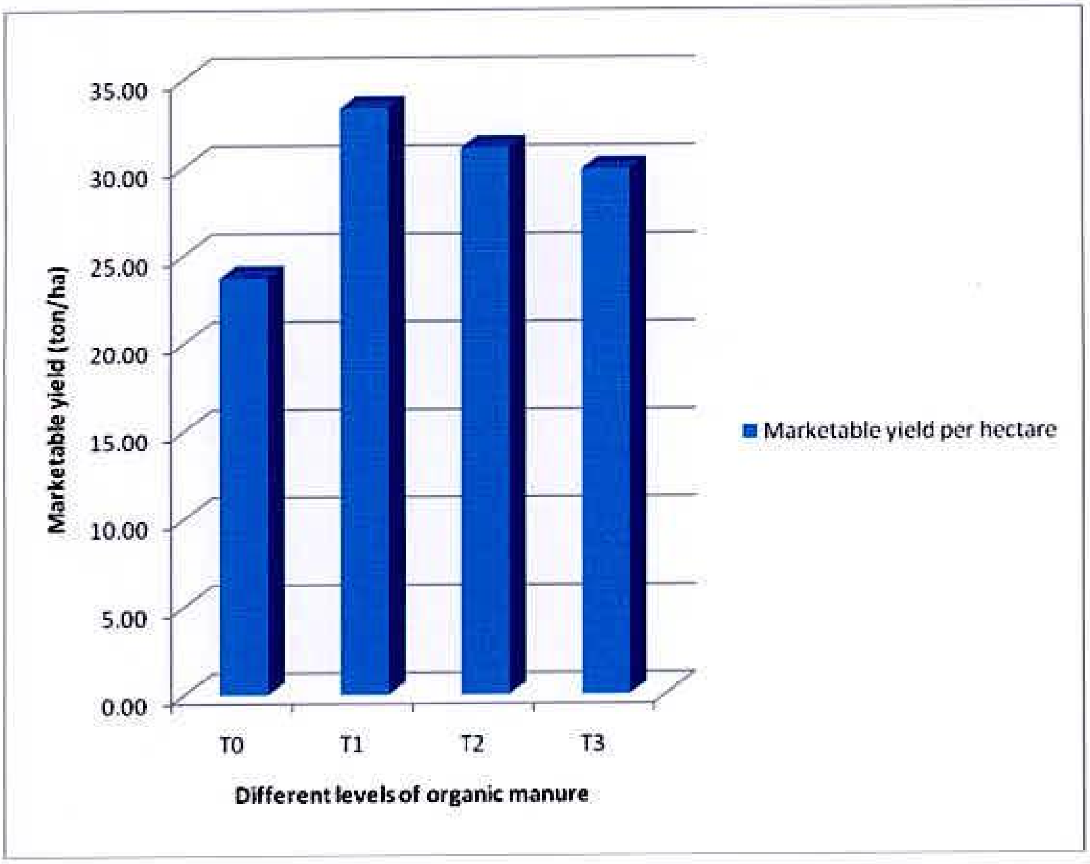

Figure 7. Effect of organic manure on marketable yield of carrot

Here,

T_0 = control (no manure)

T_1 = cowdung

T_2 = poultry manure

T_3 = Vermicompost

Chapter 5

Summary and conclusion

CHAPTER V

SUMMARY AND CONCLUSION:

An experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of organic manure and spacing on the growth and yield of carrot during November 2007 to Fubruary 2008. The experiment comprised of two different factors such as (i) four organic manure Viz. T_0 (Control, no manure), T_1 (Cowdung), T_2 (Poultry manure), T_3 (Vermicompost) and (ii) three spacings viz. S_1 (25 cm ×10 cm), S_2 (25 cm × 15 cm) and S_3 (25 cm × 20 cm) respectively.

The tallest (25.17, 37.05, 45.93 and 50.27 cm at 45, 60, 75 and 90 DAS, respectively) plant was observed from the spacing of S_1. The tallest (27.31, 39.09, 46.64 and 51.01 cm at 45, 60, 75 and 90 DAS, respectively) plant was observed from cowdung treatment (T_1). The tallest (28.12, 39.54, 51.17 and 52.87 cm) plant was observed from treatment combination of S_1T_1.

The maximum number of leaves per plant (8.43, 11.08, 12.13 and 12.34 at 45, 60, 75 and 90 DAS, respectively) was observed from the spacing of S_3 (25 cm x 20 cm). The maximum number of leaves per plant (8.82, 11.63, 12.80 and 12.81 34 at 45, 60, 75 and 90 DAS, respectively) was observed from cowdung treatment. The maximum number of leaves per plant (9.30, 12.30, 14.00 and 13.40 at 45, 60, 75 and 90 DAS, respectively) was observed from treatment combination of S_3T_1.

The maximum fresh weight of leaves (92.38 g) was found to the plants were grown at the spacing of S_3. The maximum fresh weight of leaves per plant was 100.55 g recorded from T_1 treatment. The maximum fresh weight of leaves per plant (107.89 g) was observed from the treatment of S_3T_1.

The S_3 (25 cm × 20 cm) treatment gave the maximum dry matter (16.32%) of leaves. The highest dry matter (18.36%) was recorded in plants fertilized with cowdung. The maximum (18.98%) dry matter content of leaves per plant was found in the treatment S_3T_1.

The maximum length and diameter of root were recorded from the plants grown at the spacing of S_2. The maximum length and diameter of root were obtained from the application of cowdung. The maximum length and diameter root were recorded from the treatment S_2T_1.

The maximum fresh weight and dry weight of root per plant were obtained from the plants grown at the spacing of S_2. The maximum fresh weight and dry weight of root was recorded from cowdung. The maximum fresh and dry weight of root was recorded from the plants grown at the spacing of 25 cm × 15 cm and the application of cowdung i.e. combined treatment S_2T_1.

The maximum percentage (4.14%) of cracking root was observed in the treatment of S_3. The highest percentage of root cracking (4.80 %) was observed from the treatment of cowdung. The maximum cracking percentage of root (5.16%) was observed from the treatment of S_3T_1.

The maximum branched root per plant (6.69) was observed in the treatment of S_2 (25 cm × 15 cm). The highest branched root per plant (6.57) was observed from the treatment of litter (T_2) application treatment. The maximum branched root per plant (8.30) was observed from the treatment of S_1T_2.

The maximum yield (35.77 ton/ha and 7.17 kg/plot) was found from the treatment of S_2. The maximum gross yield (37.10 ton/ha and 7.37 kg/plot) was obtained from the application of cowdung. However, the maximum (39.53 ton/ha and 7.90 kg/plot) was obtained from the treatment combination of S_2T_1.

The maximum marketable yield per plot and hectare (32.75 ton/ha and 6.55 kg/plot,) was found the treatment of S_2. The maximum marketable yield (33.36 ton/ha and 6.64 kg/plot) was obtained from the application of cowdung. The maximum marketable yield (35.98 ton/ha and 7.19 kg/plot) was obtained the treatment combination of S_2T_1. So, it may be concluded that cowdung with 25cm × 15cm spacing can be used to obtain higher growth and yield of carrot.

Conclusion : Considering the present experiment, further studies in the following areas may be suggested :

1. For local compliance extra research is needed in diverse agro ecological zones.

2. Different levels of organic manure combination may also practices.

3. With the applying more organic manure and spacing yield was increased. But cowdung was more effective.

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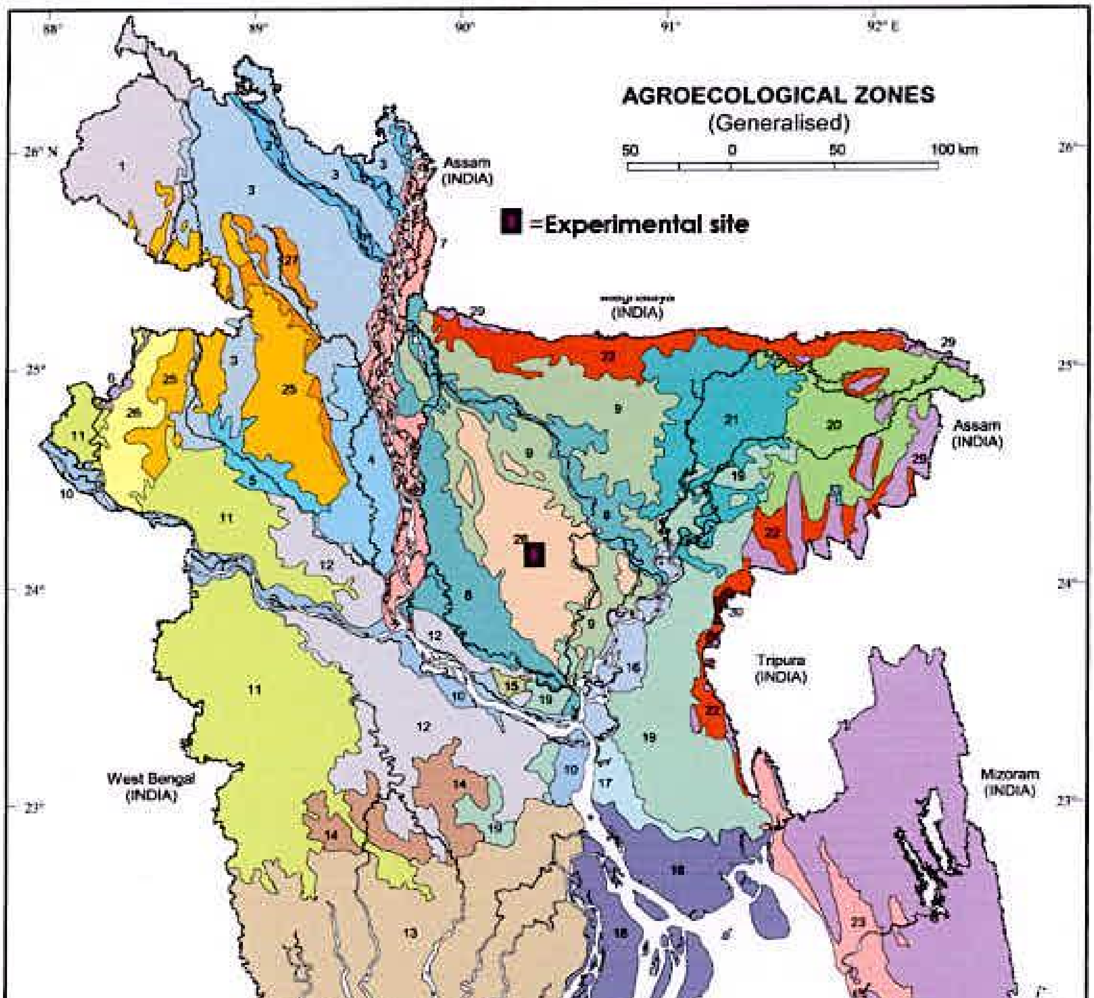
Appendices

Appendices

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Results of Physical and chemical properties of soil of the experimental plot

Physical properties

Constituents	Amount (%)
Sand,	32.45
Silt,	61.35
Clay,	6.10
Textural class	Sandy loam

Chemical analysis

Soil properties	Amount
Soil pH	5.6
Organic carbon (%)	1.32
Total nitrogen (%)	0.075
Available P (ppm)	19.5
Exchangeable K (%)	0.2

Appendix III. Monthly Average Air Temperature, Total Rainfall, Relative Humidity and Sunshine Hours of the experimental site during the period from September 2007 to March 2008

Year	Month	Average Air temperature (^{0}C)			Total rainfall (mm)	Average RH (%)	Total Sun shine hours
		Maximum	Minimum	Mean			
2007	November	29.7	20.1	24.9	5	65	192.20
	December	26.9	15.8	21.35	0	68	217.03
2008	January	24.6	12.5	18.7	0	66	171.01
	February	27.1	15.8	21.05	09	66	168.60

Source: Dhaka Metrological Centre (Climate Division)

Appendix IV. Analysis of variance of different characters of carrot

Source of variation	Degree of freedom	Plant height				Number of leaves			
		45 DAS	60 DAS	75 DAS	90 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Replication	2	6.345	2.658	15.972	0.701	4.088	0.373	1.034	0.636
Factor A	2	12.266	17.294	62.742	45.059	0.297	1.308	3.341	0.916
Factor B	3	132.142	143.462	120.174	69.251	5.064	8.446	25.616	3.85
AB	6	5.974*	4.014*	19.626*	5.513*	0.506*	1.452*	16.366*	1.763*
Error	22	14.265	12.642	14.678	12.667	1.473	1.564	25.686	1.161

*= Significant at 0.05 level of probability

NS = Non significant at 0.05 level of probability

Appendix IV. Contd.

Source of variation	Degree of freedom	Fresh foliage weight per plant	Foliage dry matter per plant	Root length	Diameter of root	Fresh wt. of root per plant	Dry wt. of root per plant
Replication	2	6.686	0.96	0.36	0.649	13.087	0.371
Factor A	2	990.806*	1.262^{NS}	1.255 ^{NS}	0.796 ^{NS}	103.764^{NS}	5.314^{NS}
Factor B	3	2735.392*	36.348*	12.1*	9.822*	2661.346*	36.377*
AB	6	107.44*	0.647*	0.556*	1.1*	39.789*	0.237*
Error	22	8.874	0.703	1.319	0.481	13.016	0.909

Appendix IV. Contd.

Source of variation	Degree of freedom	cracking root per plant	Branched root per plant	Gross yield of roots / plot	Gross yield of roots hectare	Marketable yield per plot	Marketable yield per hectare
Replication	2	1.035	0.733	0.176	2.401	0.088	2.833
Factor A	2	0.808NS	12.451^{NS}	8.996*	225.277 *	17.641*	221.325*
Factor B	3	10.909*	4.166 ^{NS}	7.691*	197.034 *	18.008*	152.744*
AB	6	0.529*	1.784*	0.071*	4.868*	0.351*	1.285*
Error	22	0.783	1.876	0.125	4.522	1.863	1.967

* = Significant at 0.05 level of probability

NS = Non significant at 0.05 level of probability