GROWTH AND YIELD OF CARROT AS INFLUENCED BY POTASSIUM AND PLANT PER HILL

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BY

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CERTIFICATE

This is to certify that the thesis entitled, *"Growth and yield of Carrot as influenced by potassium and plant per hill"* **submitted to the Dept of Horticulture & Postharvest Technology Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment 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** *Farida Eshaque Papree* **Registration No.00994 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 by her.

Dated: 30.06.2008

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Dedicated to
My
Beloved
Parents

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The Author

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ABSTRACT

The experiment was carried out to study the effect of different levels of potassium and number of plant per hill on growth and yield of carrot at the Horticultural Farm, Shcr-e-Bangla Agricultural University, Dhaka during the period of November 2006 to March 2007. The experiment consisted of two factors. Factor A- four levels of potassium viz. $K_{()}$ = Control, K| = 180 Kg, K_2 = 200 Kg, K^ = 220 Kg $K_2$0/ha respectively. Factor B-Number of plant per hill viz P| = 1 plant per hill, P_2 = 2 plants per hill, = 3 plants per hill. The experiment was laid out with randomized complete block design (RCBD). Incasc of potassium highest yield (25.23 t/ha) was obtained from $K_2$and lowest (18.25 t/ha) from k_0. Incase of number of plant per hill the highest yield (22.32 t/ha) was found from P* and lowest (19.27 t/ha) from P|. For combined effect of K_2P? produced the highest (26.24 t/ha) yield and the lowest yield (13.81 t/ha) obtained from K_0P| Considering the above findings, application of 200 kg $k_2$0/ha with three plants per hill appeared to be suitable for cultivation of carrot.

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ABBREVIATIONS AND ACRONYMS

ABBREVIATIONS	FULL NAME
AEZ	=Agro- ecological Zone
SRDI	=Soil Resources Development Institute
cv	= Cultivar
DAS	=Days After Sowing
BARI	^Bangladesh Agricultural Research Institute
et al.	- and others
Kg	=Kilogram
g/1	=Gram per liter
RCBD	= Randomized Complete Block Design
RH	= Relative Humidity
SAU	= Sher-e-Bangla Agricultural University
FAO	=Food and Agriculture Organization
t/ha	=Tone per hectare
TSP	=Triple Super Phosphate
UK	^United Kingdom
Viz.	=Namely
%	=Percentage
&	=And
@	=At the rate

Chapter 1

INTRODUCTION

Carrot *(Daucus carota* L.), is one of the most popular vegetable crops in the world and the member crop of Apiaceous family (previously Umbclliferae). It is considered to be a native of Mediterranean region (Pierce, 1987). It is well distributed throughout the temperate, tropical and subtropical parts of the world (Bose and Som, 1*990)* and extensively cultivated in Europe, Asia, North Africa and North and South America (Thompson and Kelly, 1957). Carrot grows successfully in Bangladesh during Rabi season and mid November to early December is the best time for its cultivation to get satisfactory yield .Rashid (1993).

Vegetables are one of the most important components of human food which provides proteins, carbohydrates, fats, vitamins and minerals Per capita vegetable production in Bangladesh is much less than its requirement. Carrot contains higher amount of carotene (l0mg/l00g), thiamin (0.04mg/100g) , riboflavin (0.05mg/100g) and also serves as a source of carbohydrate , protein , fat , minerals , vitamin - C and calories (Yawalkcr,1985). Sugar and volatile terpenoids are the two major components of carrot flavor; glucose, fructose and sucrose which make up more than 95% of the free sugars and 40% to 60% of the stored carbohydrates in the carrot root. The ratio of sucrose to reducing sugar increases with root maturity but decreases following harvest and during cold storage

(Freman and Simon, 1983). Blindness in children for the serve 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 raw or by making halua, a preparation of sweets in Bangladesh. Carrot root is also used as vegetable for preparing soups and curries and grated roots are used as salad. But large-scale production of carrot is yet to be started to meet up its demand. In Bangladesh, the production Statistics of carrot is not available and even not included in the BBS report before the year 2000.

The area under carrot cultivation was 992 thousand hectares with total production of 21,020 thousand metric tones in the world (FAO, 2002). In Bangladesh, the production statistics of carrot is not available. In 2005, Bangladesh produces 6,350 MT carrots in cultivating 2,090 acre. (BBS, 2005) Rashid (1999) mentioned an average yield of 25 tones per hectare of carrot. This 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 tones respectively (FAO, 2002).

Carrot production can be increased in two ways, either by extending the area under cultivation or by increasing the yield per hectare with the increase in population. Land area for vegetable production is not increasing as per requirement due to limitation of land. So, it is only possible to increase the production of carrot through increasing the yield per unit area.

The growth and yield of carrot largely depends on the soil, climatic conditions and different production practices. Proper cultivation method could be made for sustainable carrot production. Growers generally allow to grow single carrot plant per hill. Planting more than one plant per hill can increase the production of a number of root crops such as tapioca and sweet potato (Mandal *et al.*, 1973; Siddique and Rabbani, 1987). Planting of two plants per hill has been shown to give higher yield of carrot (Tarafdar, 1999).

Carrot cultivation requires ample supply of plant nutrients. Use of potassium fertilizer is essential for its growth and root development .All root crops respond to liberal applications of potassium. Potassium helps in the root development and essential for photosynthesis and for starch formation and its translocation from upward to downward. It is also necessary for quality of carrot (Dyachenko and Kurumli, 1978). Among the yield promoting factors, application of proper doses of potassium is of great importance.

However, excessive or under dose of potassium can effect the growth and yield of the crop. Only an optimum dose of potassium is necessary to produce maximum yield of good quality carrot. Muriate of potash, (MP) is widely used as the source of potassium because of its maximum availability of potassium from and cheaper than any potassium fertilizer.

Considering the above circumstances, the present study has been undertaken with the following objectives :

1. To determine the optimum use of potassium for ensuring the growth and higher yield of carrot
2. To find out the number of plants per hill in order to get maximum growth and yield of carrot.
3. To find out the suitable combination of level of potassium and plant per hill for attaining desirable yield of carrot.

Chapter 2

REVIEW OF LITERATURE

Carrot *{Daucus carota* L.) is an important carotene rich root vegetables of the world as well as Bangladesh and specially form the nutritional point of view; carrot draws much attention to the researchers throughout the world to develop its production technology. Carrots known to be a heavy absorber of moisture, which should be ensure through proper soil moisture management such as mulching and irrigation. Use of potassium fertilizer and mulching arc to important factors for maximum yield of a crop. Like many other root and tuber crops, the growth and yield of carrot are largely influenced by these two factors. A number of factors like emergence, soil moisture and temperature, plant growth and yields of the crop are closely related with these factors.Optimum dose of potassium and proper mulch materials arc necessary to ensure the highest economic return of the crop. Although many research works have been done on various cultural aspects of carrot in different countries, unfortunately literature regarding studies on potassium level mulching materials under Bangladesh conditions is scanty. For this reason, available literature on carrot and other root crops related to present research work arc reviewed in this chapter.

2.1 Effects of number of plants per hill on growth and yield of carrot

There is no work on the effect of plants per hill on the growth and yield of carrot. As a root crop carrot is close to sweet potato. Therefore, reports related to sweet potatoes are reviewed here.

Haider (2001) conducted an experiment on the effect of plant spacing, number of plant(s) per hill and mulching on the growth and yield of carrot under Bangladesh (BAU) condition. She found that two or three plants per hill produced significantly higher yield than one plant per hill.
Following a similar experiment Tarafder (1999) found that two, three or four plants per hill produced significantly higher yield than one plant per hill.

Sidddique and Rabbani (1987) studied the effects of length of cuttings, part of vine inserted into the soil at planting and number of vines planted per hill on the yield of sweet potato. They observed that the number of tuberous roots per hill and yield were increased when two vine cuttings were planted per hill.

Saladaga and Rodolfo (1987) stated that generally no significant differences in agronomic characters and yield components of sweet potato were observed using either the traditional method or the recommended practice planting. Varying the number of cuttings per hill significantly influenced only the fresh vine weight of Kaimay BNAS-51 and Summer Big Yellow sweet potato verities. Plants that developed from one cutting per hill produced heavier herbage than other treatments. Root yield was likewise not markedly affected by the number of cuttings per hill although the varieties significantly differed in this parameter. Among the varieties Kaimay obtained the highest value in yield and nearly all yield components.

Dragland (1986) carried out an experiment in Norway seeding of the carrot cv. Nantes Duke sown in may were thinned out to give densities of 45 , 70 or 90 plants/ m^2 in beds of 2, 3, 4 or 5 rows between path ways (wheel tracks) 150 cm apart, Centre to centre and 28 cm wide . At the first harvest on l^{sl} September the highest salable yield (29t/ha) was achieved with a density of 70

9 . .

plants per m distributed in 4 rows. At harvest on 10 October, a density of 90 plants per m^2.in 4 or 5 rows gave the highest yield (42 t/ha).

Mandal *et al.* (1973) conducted an experiment at Trivandrum in India used non branched (H-165) and branched (H-97) types of tapioca *(Manihot esculcnta)* to study the effect of plant density, fertility level and shoot number on tuber yield and quality of tapioca hybrids and found that two plants per hill gave a better yield than that of one plant per hill. They recommended spacing of 75 cm 75 ID , with two plants per hill and 90 cm 90 cm with one plant per hill for types H-165 and H-97, respectively.

From an experiment on sweet potato , Siddique and Rabbani (1987) worked on the effect of length of vine cuttings ,part of vine inserted into soil at planting and number vines planted per hill on the yield of sweet potato. They observed that the number of tuberous roots per hill and yield were increased when two vine cuttings were planted plant per hill.

2.2 Effect of potassium on the growth and yield of carrot

Carrot responds well to manures and fertilizers. Both organic and chemical fertilizers arc applied.

Zdravkovic *et al.* (2007) conducted an experiment in different types of fertilization on some carrot cultivars were applied., the cultivars were fertilized in three ways: (1) using manure at 50 t/ha; (2) NPK (15: 15: 15) at 670 kg/ha; and (3) calcium ammonium nitrate (CAN) at 670 kg/ha. There were significant differences depending upon the manner of fertilizer application. The average yield achieved by fertilizer application was significant (the highest yield was with manure fertilizer). There were significant differences among the cultivars (from Amsterdam early 27.06 t/ha until Flakcr 57.52 t/ha) and years. There were also significant differences in the cultivar and year correlation.

Pekarskas and Bartaseviciene (2007) an experiment was conducted in Lithuania, during 2001-04, to determine the effect of different potassium fertilizer forms on ecologically cultivated carrot yield and quality. Treatment with potassium magnesia and potassium sulfate increased the total harvest of carrots while the marketable harvest of carrot also increased regardless of the potassium fertilizer form. Potassium fertilizer forms did not have substantial influence on the marketable harvest of carrots. Potassium magnesia increased the content of carotene in carrots significantly compared with potassium chloride fertilizer application.

Anjaiah and Padmaja (2006) field experiment was conducted on a light- textured Alfisol in Rajendranagar, Hyderabad, Andhra Pradesh, India to evaluate the effects of potassium (0, 40, 80 and 100 kg K< sub>2</ sub>0/ha) and FYM (0, 5, 10 and 15 t/ha) on the root yield and quality (total carotenes, total soluble solids and total sugars) of carrot. Root yield and quality parameters increased with increasing levels of both potassium and FYM. Potassium at 120 kg/ha and FYM at 15 t/ha recorded the best yield and quality, but potassium at 80 kg/ha and FYM at 15 t/ha was the most cost-effective.

Portz *et al.* (2006) conducted the level and accumulation of nutrients in Peruvian carrot under 3 levels of N (0, 150 and 300 kg/ha), P (0, 80 and 160 kg/ha) and K (0, 80 and 160 kg/ha) were studied in Nova Friburgo, Rio de Janeiro, Brazil. The nutrient contents of leaves, cons and roots had no significant correlation with commercial root production. Greater nutrient accumulation in leaves, corms and roots was observed between 150 and 210 DAT [days after transplanting], at 210 DAT, and at 300 DAT, respectively. The fertilizer treatments had significant effects on the nutrient content, but had no significant effects on commercial root production.

Hochmuth *et al.* (2006) conducted Potassium (K) is required for successful carrot *(Daucus carota)* production on sandy soils of the southeastern United States,. Soil test methods for K in carrot production have not been rigorously validated. Excessive fertilization sometimes is practiced by carrot growers to compensate for potential losses of K from leaching and because some growers believe that high rates of fertilization may improve vegetable quality.

Hochmuth *et al.* (2006) conducted Potassium (K) is required for successful carrot *(Daucus carota)* production on sandy soils US, Soil test methods for K in carrot production have not been rigorously validated. Excessive fertilization sometimes is practiced by carrot growers to compensate for potential losses of K from leaching and because some growers believe that high rates of fertilization may improve vegetable quality. Carrots were grown in three plantings during the winter of 1994-95 in Gainesville, Fla., to test the effects of K fertilization on carrot yield and quality on a sandy soil testing medium (38 ppm) in Mehlich-1 soil-test K. Large-size carrot yield was increased linearly with K fertilization. Yields of U.S. No. 1 grade carrots and total marketable carrots were not affected by K fertilization. K fertilizer was not required on this soil even though the University of Florida Cooperative Extension Service recommendation was for 84 lb/acre K. Neither soluble sugar nor carotenoid concentrations in carrot roots were affected by K fertilization. The current K recommendation for carrots grown on sandy soils testing 38 ppm Mehlich-1 K could be reduced and still maintain maximum carrot yield and root quality..

Selvi *et al.* (2005) a field study was conducted in India to investigate the effects of different N, P and K levels on carrot cv. Zino performance. Different combinations of N, P and K at 100, 135 and 170 kg/ha were used. Full rates of P and K, and half rate of N were applied at sowing. The remaining N was applied at 30 days after sowing. The highest yield (21.21 t/ha) was obtained under N: P:K rate of 135:135:170, followed by 20.25 and 20.21 t/ha obtained from treatments with 170:100:170 and 17:135:170 kg/ha, respectively. A rate of 170:170:170 kg/ha did not significantly increase the yield, which was low at 18.67 t/ha. Total N content was in the range 1.62-1.98%. N at 135 kg/ha resulted in high total N values (1.90-1.98%), while N at 170 kg/ha resulted in higher total N values (1.80-1.86%).

Anjaiah *et al.* (2005) An experiment was conducted in India, to study the response of carrot to different levels of potassium (K) and farmyard manure (FYM) to determine the optimum levels of K and FYM which enhance nutrient uptake and root yield.. The root yield was highest at 17.59 t/ha, followed by K 12.19 t/ha. There was significant increase in root yield (13.0 t/ha) with FYM application up to. The available K increased with increasing K levels at all crop growth stages, but the interaction effect of K and FYM was not significant.

Zalewska (2005) a pot experiment was carried out to study the effect of various Ca, Mg, K and FI saturations of soil CEC on the yield and mineral composition of carrot. A decrease in Mg saturation of CEC to the level approximately 5.7% and a simultaneous increase in the saturation of K to the level 13.5% resulted in a significant decrease in carrot yield. A decrease in K saturation of CEC below 5% also caused significant decrease in the yield of carrot roots. An increase in K saturation of CEC from 2.3 to 13.5% and a simultaneous decrease in Mg saturation from 13.3 to 5.7% caused an increase in the concentration and uptake of potassium and a decrease in the uptake and content of magnesium in carrot roots and leaves. The result was that the value of K: (Ca + Mg) ratio in carrot roots increased from 0.96 to 2.68 mol.

Selvi *et al* (2005) a field study was conducted on Ultic Tropudalf in Tamil Nadu, India to investigate the effects of different N, P and K levels on carrot cv. Zino performance. Different combinations of N, P and K at 100, 135 and 170 kg/ha were used. Full rates of P and K, and half rate of N were applied at sowing. The remaining N was applied at 30 days after sowing. The highest yield (21.21 t/ha) was obtained under N: P: K rate of 135: 135: 170, followed by 20.25 and 20.21 t/ha obtained from treatments with 170:100:170 and 17:135:170 kg/ha, respectively. A rate of 170:170:170 kg/ha did not significantly increase the yield, which was low at 18.67 t/ha. Total N content was in the range 1.62-1.98%. N at 135 kg/ha resulted in high total N values (1.90-1.98%), while N at 170 kg/ha resulted in higher total N values (1.80- 1.86%).

Uddin *et al.* (2004) In the present study, a 2-year field experiment was conducted at the Regional Agricultural Research Station, BARI, Hathazari, Bangladesh in the year 2000-01 and 2001-02 on the fertilizer requirement of carrot, as influenced by different levels of NPKS and cowdung. Six combinations of NPKS (N: P: K: S at 120:45:120:30, 120:40:90:30, 90:30:60:20 and 60:15:30:10 kg/ha) and cow dung (0 and 5 t/ha) were used in this investigation. Different combinations of NPKS and cowdung showed significant influence on the yield of carrot. The combination of fertilizer 120- 45-120-30 kg ha-1 of NPKS and 5 t ha-1 cowdung produced the highest root yield of 27.22 t ha-1 which was 303% higher over control treatment. The highest marginal rate of return (7633%) also obtained from the same treatment.

Kancheva *et al.* (2004) carrots cv. Nantski were supplied with 0, 8. 16 and 24 kg N, P and K/ha in a field experiment conductcd in Bulgaria. Results arc presented on the optimum combinations of fertilizers that will give high carrot yield and quality for processing and direct consumption..

Sady *et al.* (2004) During 1999-2001, investigations concerning the effects of N, P, K, Ca and Mg fertilizer application on the bioaccumulation of cadmium in carrot roots grown on two different soils were carried out. The level of nitrate accumulation in carrot roots depended more on the soil (organic matter contcnt) and on the climate conditions than on the fertilizer application factors. Bioaccumulation of cadmium in carrot roots depended both on the soil properties and on the applied fertilizers. Accumulation of cadmium by the plants was significantly limited in the case of calcium and magnesium nutrition, while increase in this compound was observed when NPK as well as the individual application of these nutrients were used. The higher cadmium content within the root tissue was observed in the treatment with higher cadmium level in the soil.

Kader (2004) results are presented of experiments conducted in Budapest, Hungary, to study the effects of N, P and K fertilizers (alone and in combinations) on the development, weed infestation and yield of carrot cv. Vorosorias and on the mineral composition of the foliage and roots..

Malhi *et al.* (2004) for producers in the Parkland zone of Canadian prairies, timothy

(Phleum pratense) hay provides another opportunity for crop diversification and there is potential for an increase in the production area. The objective of this study was to determine the influence of nitrogen (N) (0 to 200 kg N ha-1), phosphorus (P) (0 to 87.5 kg P ha-1), potassium (K) (0 to 62.5 kg K ha-1), and sulfur (S) (0 to 40 kg S ha-1) fertilizer application rates on forage dry matter yield (DMY) and quality of timothy (cv. Drummond) grown for hay under dry land conditions. Forage quality measurements included percentage of leaf, stem and head, head length, protein content (PC), neutral detergent fiber content (NDF), and acid detergent fiber content (ADI'). The field experiments were conducted at Buchanan, Saltcoats, Carrot River, and Star City in the Parkland zone of Saskatchewan, Canada. The fertilizer sources were ammonium nitrate for N, triple superphosphate for P, muriate of potash for K, and potassium sulfate for S. The fertilizers were surface-broadcast annually in mid to late April. The application of N at the three sites (Buchanan, Saltcoats, and Star City) markedly increased DMY, usually increased the percentage of leaf and head, head length and PC, reduced the percentage of stem and had no consistent effect on NDF and ADF. The DMY increased moderately with P and K application at Carrot River, and with S application at Star City. The percentage of leaf, stem and head, head length, PC, NDF, and ADF showed no response to P, K, or S fertilizer applications. In summary, the application of N at Buchanan and Saltcoats, P and K at Carrot River, and N and S at Star City were considered essential for optimum forage yield and quality of timothy..

Akhilesh-Sharma *et al.* (2003) a field experiment was conducted to study the effects of integrated use of farmyard manure, and N, P and K fertilizers on the yield and root yield of carrot (*D. carota* cv. Nantes). Three levels of N, P and K (50, 100 and 150% of the recommended rates of 50:40:35 kg N: P_2O_5: K_20/ha) and 3 levels of farmyard manure (0, 10 and 20 t/ha) were evaluated in split-plot design with 3 replications. The application of 10 t farmyard manure/ha resulted in a significant increase in root yield and other characters over the control in both years. The application of 100% NPK was superior over the other fertilizer combinations in terms of root yield, whereas 100 and 150% of the recommended rate were equally effective and significantly better than the 50% level with regard to the other characters. The interaction between farmyard manure and NPK fertilizers was also significant. The highest net return (155 000 rupees/ha) and a benefit cost ratio of

4.37 were obtained with 10 t farmyard manure/ha + 100% of the recommended NPK rate. The application of 10 t farmyard manure/ha reduced the required N, P205 and K20 rates by 25, 20 and 15 kg/ha, respectively..

Feller *et al.* (2003) new data are presented from on-farm nutrient measurements during 1999-2001 in spring onions, bunching carrots, Japanese radish, dill, lambs' lettuce, rocket salad, celcriac and celery. The average removal of nutrients by harvesting are tabulated for N, P, K and Mg. Nitrogen demand and the Nmin target value in kg/ha arc compared with data published in 2001. Data are within a 10% variation range, however Japanese radish and celery had higher demands due to strong vegetative growth. The highest N demand was found in celery (270 kg N/ha), followed by Japanese radish (245 kg N/lia), spring onion (160 kg N/ha), bunching carrot (145 kg N/ha), dill (110 kg N/ha), rocket salad (100 kg N/ha) and lambs' lettuce (38 kg N/ha). For rocket salad, nitrogen uptake curves modeled and measured arc presented for different sowing dates. The model underestimated the uptake by 40% for June-sown plants.

Salo *et al.* (2002) fustigations was compared to broadcast application of solid NPK fertilizer with cabbage (cv. Gastello), carrot (cv. Panther) and onion (cv. Sturon). In the broadcast application, P and K were given as a single application in spring and N was spiit according to the existing recommendations. In the fustigation applications, nutrients were given according to the expected nutrient uptake rate based on previous Finnish experiments. Growth and nutrient uptake were monitored by monthly samplings. In 1998, growing season was extremely rainy, and N leaching from conventional broadcast application was expected. However, leaching seemed to have no impact in the sandy experimental soil, as broadcast application resulted in good growth of cabbage and onion. In 1999, natural rainfall was low, and irrigation was applied according to tensiometer measurements. Treatments did not affect carrot and onion growth, but cabbage growth and nutrient uptake were still decreased by fustigation towards the middle of the growing period. At harvest, cabbage yields and nutrient uptakes were similar between the treatments. Cabbage yields averaged to over 90 t/ha in both years. At harvest, total nutrient uptakes were 213-243 kg N/ha, 36-40 kg P/ha and 302-345 kg K/ha. Carrot yielded according to the samplings close to 90 t/ha and nutrient uptake in roots and leaves was 180-190 kg N/ha, 23-30 kg P/ha and 325-444 kg

K/ha. Onion yielded 40-50 t/ha, with uptakes of 117-166 kg N/ha, 18-28 kg P/ha and 117-136 kg K/ha. Fcrtigation did not increase nutrient use efficiency in these experimental conditions. Soil was not prone to leaching and adequate moisture in rooting layer created good conditions for nutrient uptake throughout the season in all treatments

Lyngdoh (2001) an experiment was conducted to evaluate the response of carrot cv. Early nantes to varying levels of N, P and K in the agro ecological conditions in Meghalaya, India. The different of N, P and K rates did not have any strong influence on the vegetative growth of the plant. Root length increased significantly with the N levels in a dose-dependent manner, while the effect of P was significant but differed between years. The moderate level of K resulted in the longest root. No significant difference in root diameter was observed due to variation in nutrient application. The highest N level and moderate K level produced the greatest yield. 'fhcrc were strong positive correlations between the levels of N and K and root weight and yield per plot. K played a key role in increasing the root TSS value. Results suggest that a fertilizer rate of N: P: K at 80:50:80 kg/ha may be applied to increase carrot yield with quality roots under the agro climatic conditions of Meghalaya.

Subrahmanyam *et al.* (2000) field experiments were conducted to determine the effect of foliar feeding with 0.1 and 0.5% water-soluble fertilizers (Multi-K, PF 19-19-19 + micro elements (ME), PF 19-09-19+2 Mgo + ME and PF 17-10- 27 + ME) on carrot *(Daucus carota),* aubergines *(Solatium melongena*) and cabbage *(Brassica oleracea* cv. Capitat) in Bangalore, Karnataka, India, during 1998-99. Five sprays at 10-day intervals were administered with the first foliar spray applied 30 days after transplanting and 40 days after sowing. All the crops responded well to all the fertilizers. All the treatments increased yields substantially compared to the control although yield improvement varied marginally among the fertilizers applied. On average, Multi-K (13-00-46) alone increased yield by 25, 24.8 and 25.9% in brinjal, cabbage and carrot, respectively. The highest and lowest additional yields were 12.5 and 0.5 t/ha, respectively, with 1.0% Multi-K and PF 17-10-27 + ME, in cabbage and brinjal, respectively. An increase in cabbage yield was observed when the spray concentration was increased from 0.5 to 1.0% for both Multi-K and PF 19-19-19 + ME. However, carrot yield decreased with increased spray concentration of both Multi -K and PF 19-19-19 + ME. Both cabbage and carrot yields increased when the concentration of PF 19-09-19 + 2 MgO + ME was increased. A decrease in the yields of all 3 crops was observed with the increase in concentration of PF 17-10-27 + ME.

Lyngdoh (2001) conducted an experiment to evaluate the response of carrot cv. Early Nantes to varying levels of N, P and K in the agro ecological conditions in Meghalaya , India. The different of N, P and K rates did not have any strong influence on the vegetative growth of the plant. Root length increased significantly with the N levels in a dose-dependent manner, while the effect of P was significant but differed between years. The moderate level of K resulted in the longest root. No significant difference in root diameter was observed due to variation in nutrient application. The highest N level and moderate K level produced the greatest yield. There were strong positive correlations between the levels of N and K and root weight and yield per plot. K played a key role in increasing the root TSS value. Results suggest that a fertilizer rate of N:P:K at 80:50:80 kg/ha may be applied to increase carrot yield with quality roots under the agro climatic conditions of Meghalaya..

Salo *et al.* (1999) data on soil analyses, fertilizer use and yields were collected from carrot and pea producers converting to integrated production in 1997, to identify changes in fertilizer practice and effects on yield. On carrot fields, the average total N rate was 80 kg/ha, which was unaffected by soil organic matter content and by the preceding crop. Corresponding P rates averaged 35 kg/ha and K rates 131 kg/ha. The P rate was reduced when soil P analyses were high, but K rate was not adjusted for soil K. The resulting changes in N, P and K rates had no influence on the carrot yield, which averaged 49 t/ha (close to the national average). On pea fields, the average N rate was 42 kg/ha, with rates reduced where soil organic matter content was high. P rates averaged 16 kg/ha and K rates 52 kg/ha. There was no evidence that these fertilizer rates were adjusted for soil P or K content. Changes in N, P and K fertilizer practice again had no influence on the yield, which averaged 5.4 t/ha. The data showed that as a rule, farmers followed fertilizer recommendations. Nitrogen rates were adjusted according to the estimated yield, but results of soil analyses were often not used in fertilization planning. Yield data showed that the existing fertilizer recommendations are sufficient to achieve average yields in Finland, and that the recommended rates could be reduced even further.

Flick *et al.* (1998) results of a field trial with carrot cv. Panther, grown on sandy loam, to determine the effects of applying 24 kg P/ha and 83 kg K/ha and biocompost treatments (autumn, autumn + spring, spring, control) on glucose and sucrose contents and sensory quality are briefly discussed and tabulated..

Lazar *et al.* (1997) an experiment was conducted in Romania, during 1995-97 on carrot cultivars Nantes and Chantenay to study the effect of sowing date and fertilizer application on the yield and quality of carrot roots. The treatments comprised: late-March and early-June sowing; 110 kg KC1 + 150 kg NH_4N0_3/ha; and 150 kg KN03 + 100 kg NIl_4N0_3/ha. Late-March sown Chantenay gave the best yield. However, Nantes, particularly those sown in early-June, showed higher quality than Chantenay. The application of $KN0_3$ increased the yield and quality of carrot roots..

Singh (1996) the effects of N (50, 100 or 150 kg/ha) and K (20, 40, 60 or 80 kg/ha) on carrot (cv. Pusa Kesar) seed yield were investigated in the field during winter seasons of 1992-93 and 1993-94. Plant height, number of umbels/plants and seed yield increased with increasing rates of N. Maximum plant height (mean of 148.95 cm), number of umbels/plant (46.27) and seed yield (9.84 q/ha) were recorded following application of 150 kg N/ha. The number of umbels/plant and seed yield also increased with increasing rates of K; the highest seed yield (mean of 9.35 q/ha) was observed at the highest rate of K.

Sharangi and Paria (1996) conducted a field trial on a sandy loam soil during the winter seasons of 1992-93.Carrot received N fertilizer at 0, 50, 70 or 80 kg/ha combination with K fertilizer at 0, 40, 50 or 60 kg/ha. Application of 80 kg/ha N/ha + 50 kg K/ha Produced the longest, widest and heaviest roots.

Konopinski (1995) carried out field trials near Lublin, Poland, with carrot cv. Perfection. The plants received N:P:K at 150:150:300 kg/ha (control) or Super Fertilisant of French manufacture containing 11% organic matter, 14% Ca, 3.5% Mg, 4% P205, 2.5% S03 plus all essential microelements. Super
Fertilizer was applied at 50 or 100 kg/ha. Using the 100 kg/ha rate gave the best yield increase in carrot viz., 70 and 30% over the control, respectively. Crop

quality was also best in this variant.

Sharangi and Paria (1995) carried out an experiment where carrots (cv. *Pusa Kesar*) were grown in the winter seasons of 1992 and 1993 on a sandy loam soil with N fertilizer at 0, 50, 70 or 80 kg/ha and K at 0, 40, 50 or 60 kg K_20/ha. P was applied at 60 kg/ha. The crop was harvested 120 days after sowing. Shoot growth, root diameter and root TSS, carotene and total sugar contents increased with increasing rate of N. Root yield was also highest with the highest N rate (22.08 t/ha). With K application, most parameters increased with up to 50 kg/ha, then remained steady or declined with 60 kg/ha, although yield increased further with 60 kg/ha (19.66 t/ha). An interactive effect between N and K was found for plant height, root length, root diameter and root sugar content.

Kadi *et al.* (1994) carried out a trial at the Bajo Seco experimental station in Venezuela with carrot cv. Super Flakkee. Seeds were sown on 22 Feb. on an Orthoxic Tropudults Ultisol soil to which 0-200 kg P_20_5, 0-300 kg K_20 and 0- 40 t poultry manure/ha had been applied. Thinning was carried out on 15-18 April so that the distance between plants was 3, 6, 9, 12 or 15 cm. The highest yield at harvest (95.6 t/ha) was obtained with 150 kg P205 + 225 kg K_20 + 10 t poultry manure/ha and a distance of 12 cm between plants, but the results were not statistically significant.

Roa (1994) conducted a field experiment on red sandy loam soil, the effects of K at 0, 50, 100, 150, and 200 kg K_20/ha as KC1 or K_2S0_4 on growth, yield and quality of carrot. Mean root weight and yield were highest at 50 kg K_20/ha. Carotene content was increased by K application.

Balooch *et al.* (1993) carried out a field trial during 1988-89.Tandojam carrots were grown from seed in seedbed to which 75 and 100 kg P_20_5 and 75,100 or 125 kg K_20/ha had been applied. All plots also received 100 kg N in 3 split application during seed beds preparation. They observed that root yield was highest at the highest NPK rate. This was due to increased root size and weight.

Abo-Sedera and Eid (1992) stated in a field trial during the winter season of 1989/90 and 1990/91.Carrot cv. Red Cored Chantenay plants on a clay loam soil was supplied with N and K_20 at 30 and 24, 45 and 48, or 60 and 72 kg/feddan respectively in 2 equal applications, 4 and 8 weeks after sowing.Overall, the best results, in terms of vegetative growth, yield and quality, were obtained with 60 kg N + 72 kg K_2O/feddan.

Pill *et al* (1991) incorporation of 15 g of 9:19.8:12.5 N:P:K fertilizer/liter of fluid drilling gel increased shoot fresh weight compared with untreated, primed or hydrated seeds under greenhouse conditions. When these same treatments were applied under field conditions, 15 g of 9:19.8:12.5 N: P: K fertilizer/liter of gel increased economic root fresh weight but the seed treatments had little effect.

Grigorov (1990) on medium or heavy loamy soils in the region between the rivers Volga and Don, the soil moisture content during germination to start of root development should be maintained at not less than 80-85% and thereafter at 70%. For this, 15 irrigation applications (4400 m3 water/ha) were required in dry years and 8 applications (2500 m3/ha) in wet years. By observing these irrigation regimes and applying N: P_2O_5: K_2O at 60:130:20 kg/ha a 40-50 t/ha yield of ecologically clean produce could be expected

Tremblay-Parent (1989) a survey of carrot and onion production by various growers on Quebec histosols south of Montreal in 1986 and 1987 showed that NPK fertilization in 1987 was not correlated with yield in that year, but that there was a correlation between yield in 1987 and NPK application in 1986 for carrots only. This indicates that the residual effects of previous crops are important in carrot production, and that fertilization strategy should take the crop rotation into account.

Sarker (1989) conducted an experiment with different levels of nitrogen, phosphorus and potassium on yield and components of carrot and reported that the highest yield of 31.99 t/ha of carrot was obtained from the plants fertilized with the highest dose of nitrogen (120kg N/ha).The highest yield of 34.27 t/ha was recorded when nitrogen and potash each at 120 kg/ha were applied. Application of nitrogen significantly affected the root length and individual root weight. K had significant effect on root diameter and fresh weight and had no significant effect on root length.

In a two-year trial livers (1988) found that the shoots reached their maximum weight 3 months after sowing, whereas roots grew considerably more during both the 3rd and 4th month. The roots and shoot DM were positively correlated and the yield was also increased by the application of K and N.

Michalik (1987) carried out the response of the cv. Nantes to 13 different fertilizer forms applied at various rates. Nitrogen as ammonium nitrate or urea had no significant effect on dry matter. Potassium as chloride or sulphate from had no effect on dry matter.

Bruckner (1986) conducted an experiment over 3 years and reported that increasing the N supply (0-200 kg N/ha) produced a relatively small increases in yields .N at 100 kg/ha gave the best yield without increasing the $N0_3$ content of carrots. Cultivers Flakkcer RZ and Flakkeer Karaf had a high uptake of K_2O (242.8-326.6 kg/ha) and a low uptake of P_20_5 (62.3-64.4 KG/HA), Ca(39.1-58.0 kg/ha) and Mg (19.0-26.98 kg/ha).

Jacobson *et al.* (1986) reported that the effect of fertilizers was studied in a field trial involving NPK at 16-5-12 or 14-4-17 with N at 60,120,180 and 240 kg/ha. Yield was not significantly affected, but the incidence of cavity spot was least at the lowest rate of N and at all rates of N was less with the formulation containing the lower level of K.

Maurya and Goswami (1985) carried out an experiment with the cv. Nantes, N: P_20_5: K_20 were applied at 40-60:18-32:75-125 kg/ha. The highest yield of 25 .08 t/ha and good root quality were obtained with the 60:32:125 kg/ha rate. Only 7.28 t/ha was obtained from the non-fcrtilized plot.

Krarup *et al.* (1984) conducted an experiment where chantenay carrot were fertilized with K_20 (0,100 or200 units/ha).There were no difference in total yield with the medium and high K20 levels.K20 contents regard from 0.67 to

0. 83%in roots and from 0.54 to 0.76%in leaves .Nutrient extraction by the whole plant (calculated on the basis of yields and contents)varicd in accordance with the level of application; from 63.35 to 94.33 kg/ha for K20.Leaf and root K20 contents and the level of K20 extraction were lower than expected, probably due to the characteristics of the soil, which was deficient in K.

Farazi (1983) while conducting an experiment on spacing and application of fertilizer concluded that the highest yield of carrot (45.4 t/ha) was obtained from the crop fertilized with the highest of N (112 kg N/ha) ,and potash had no significant effect on the yield of carrot .Both nitrogen and potash had significant effect of diameter of root, but little effect on the length of root .The weight of leaves per plant was increased with the increasing level of nitrogen ,and potash had no considerable effect on the weight of leaves per plant.

Polach (1982) conducted a 4-year fertilizer trial with the carrot cv. Nantes, grown on a soil with adequate phosphorus and medium to low potassium contents. Nitrogen at 0-180 kg/ha and potash at 0-196 kg/ha were applied in 12 different treatments. Basal nitrogen application at 60 kg/ha and basal potash at 151.2kg/ha gave the best yield and quality of carrot.

Szwonek (1980) found that root yield was depressed by high K-rates especially on plants on which K was applied twice. The highest root yield was obtained from plants containing 5% potassium in the based leaves during the early stages of growth.

Inal *et al.* (1998) .an experiment was conducted to evaluate the effects of various nitrate/chloride ($N0_3$/C1) ratios on growth, nitrate accumulation, and mineral absorption in carrot plants in a controlled environment. The experiment included two Cl sources (KC1 and $CaCl_2$) In KC1 treatments, Na absorption decreased. It was concluded that combining N and Cl in fertilizer applications can enhance the production of better quality carrots and at the same time decrease the N fertilizer input.

Singh and Singh (1996) conducted the effects of N (50, 100 or 150 kg/ha) and K (20, 40, 60 or 80 kg/ha) on carrot (cv. Pusa Kcsar) seed yield were investigated in the field during winter seasons of 1992-93 and 1993-94. Plant height, number of umbels/plants and seed yield increased with increasing rates of N. Maximum plant height (mean of 148.95 cm), number of umbels/plant (46.27) and seed yield (9.84 q/ha) were recorded following application of 150 kg N/ha. The number of umbels/plant and seed yield also increased with increasing rates of K; the highest seed yield (mean of 9.35 q/ha) was observed at the highest rate of K.

Hassan *et at.* (1992) conducted in,carrot cv. Red Cored Chantenay seeds were sown (at a rate of 2 kg seeds/feddan) in 70-cm-wide beds on a silty clay soil either broadcast over the whole bed or in 2 or 3 drills. N, P and K were applied (split between 1 month after planting and 3 weeks later) at (1) 20, 24 and 24 kg/feddan, respectively, (2) 40, 36 and 48 kg/feddan, respectively, or (3) 60, 48and 72 kg/feddan, respectively. Controls were not fertilized. Plants were harvested in Jan. Sowing in 3 drills/bed resulted in greater plant height, leaf weight/plant, average root weight, root length, total plant FW and yield than 2 drills/bed or broadcast sowing. Average root weight, root length, total plant FW and yield increased with increasing fertilizer application rates up to 40 kg N + 36 kg P_20_5 + 49 kg K_20/leddan. The highest and lowest yields were obtained with fertilizer rate (2) + 3 drills/bed (32.7 t/feddan) and no fertilizer + broadcast sowing (19.7 t/feddan), resp. [1 feddan 0.42 haj.

Considering the available review of literature and the findings of the researsers showed that the present study was undertaken with a view to investigate the effect of Potassium and plant per hill on growth and yield of carrot under the condition of SAU, Sher-e-Bangla Nagar, Dhaka.

Chapter-3

MATERIALS AND METHODS

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

3.1 Location of the experiment field

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during November 2006 to March 2007. The location of the experimental site was at 23°75' N latitude and 90°34' E longitude with an elevation of 8.2 meter from sea level (Anon., 1989).

3.2 Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month from May to September and scattered rainfall during the rest of the year. Information regarding average monthly, soil temperature as recorded by Bangladesh Meteorological Department (climate division) Agargoan, Dhaka, during the period of study have been presented in Appendix I.

3.3 Soil of the experimental field

Soil of the study site was salty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with PM 5.8-6.5, ECE-25.28 (Haider *et al.*, 1991). The analytical data of the soil sample collected from the experimental area were determined in the soil Resource Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.4 Planting materials

The seeds of carrot cv. New Kuroda (a Japanese verity) were used in the experiment. The seeds of Snow Brand Co. Ltd., Tokyo, Japan were collected from Nadim Seed Store, Siddique Bazar, Dhaka.

3.5 Treatments of the experiment

The experiment was a two factorial designed to study the effect of different level of potassium and number of plants per hill on the growth and yield of carrot. The experiment consisted of the following treatments:

Factor A:

It comprised 4 levels of potassium

I. K_0 = O kg K_20 (control)

II. K| = 180 kg K_20 per hectare

III. K_2= 200 kg K_20 per hectare

IV. K_3 = 220 kg K_20 per hectare

Factor B:

I. P| = 1 Plant per Hill

II. P_2 =2 Plants per Hill

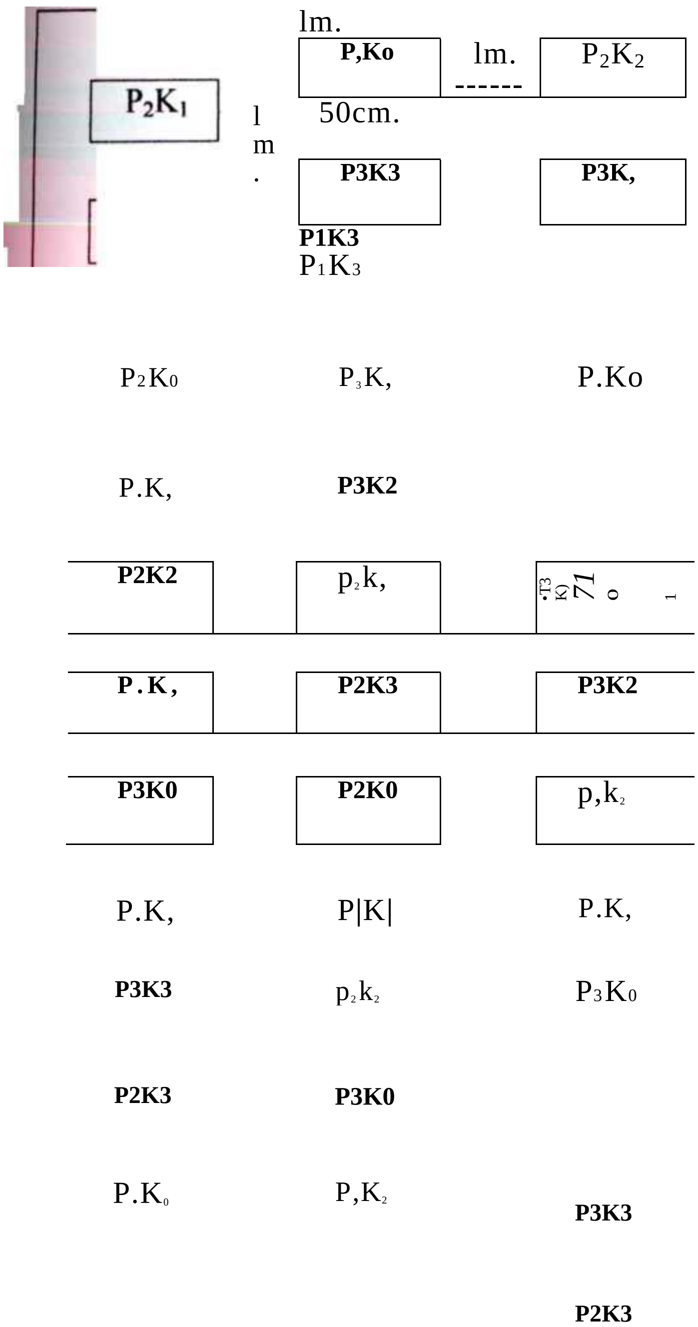
III. P_3 =3 Plants per Hill.

There were 12 (4 x 3) treatments combination such as K_0P|, K_0P_2, K_0P_3, K|P|, k,p_2, K,P_3, K_2Pi, K_2P_2, K_2P_3 K_3P_1, K_3P_2, k_3p_3

3.6 Experimental design and layout

The experiment was conducted in Randomized Complete Block Design (RCBD) having two factors with three replications. The total area of the experimental plot was 165.75 m^2 (19.5m X 8.5m) which was divided into three equal blocks and each block was divided into 12 unit plots. The size of each plot was 1.5m xl.O m. Thus, there were 36 (12 x 3) unit plots altogether in the experiment. The distance between blocks were 1.0 m and 0.5 m wide drain was made between the plot, to facilities different intercultural operations.

The complete layout of the experimental plot has been shown in figure 1.



Plot size : 1.5m xl in Spacing : 25 cm x 15 cm Spacing between plot: 50 cm Spacing between replication : 1 m

Factors : A

Ko : Control treatment

K_1 : 180 kg K_2O/ ha

K_2: 200 kg K_2O/ha

K_3: 220 kg K_2O/ha

Factors : B

Pi : 1 Plant Per hill.

P_2 : 2 Plants Per hill.

P_3 : 3 Plants Per hill.

Fig 1: Field layout of the two factors experiment in the Randomized complete Block Design (RCBD)

3.7.1 Land preparation

3.7 Cultivation procedure

The soil was well prepared and good tilth was ensured for commercial crop production. The land of the experimental field was ploughed with a power tiller. Later on the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was ready.

3.7.2. Application of manure and fertilizers

The following doses of manures and fertilizers recommended by Rashid, (1999) were applied to the experimental plots to grow the crop as below:

Manures/Fertilizers	Dose/ha	Dose/plot *
Well decomposed cow dung	10 tons	1.50 Kg
Urea	150 Kg	22.50 gm
Triple Super Phosphate (TSP)	125 Kg	18.75 gm
Potassium	As per treatment	

.2 *Unit plot size was 1.5 m x 1 .Om=1.5m^2

Potassium was applied at the rate of 180, 200, 220 Kg K_20 per hectare in the form of muriate of potash as different treatments. The entire amount of cow dung was applied at the time of initial land preparation and the total amount of urea and TSP was applied during the final land preparation. Potassium (K_20) as per treatment schedule was top-dressed at 30 days after sowing the seeds.

3.8 Seed soaking

Before sowing, the seed were soaked in water for 24 hours and then wrapped with a piece of thin cloth prior to planting. Then the moistened seeds were spread over polythene sheet for two hours to dry out the surface water, this operation was to facilitate for quick germination of seeds.

3.9 Sowing of seeds

The soaked seeds @ 3 Kg/ha (Rikabdar, 2000) were sown on 30 November, 2006. Shallow furrows with 1.5 cm depth were made at a distance of 15cm along the rows spaced at a distance of 25 cm. There were 40 holes in each unit plots and four to ten seeds were placed in each hole and immediately after sowing covered with loose soil.

3.10 Intercultural operations

3.10.1 Thinning

Emergence of seedlings started after 6 days from the date of sowing. Seedlings were thinned out two times. First thinning was done after 20 days of sowing (DAS), leaving four seedling in each hill .The second thinning was done after 10 days from first thinning, keeping one, two & three healthy seedling in each hill as per requirement.

3.10.2. Weeding

Weeding was done as and necessary to keep the crop free from weeds, for better soil aeration and to break the crust and to achieve good quality of carrot roots. Generally weeding was done four times.

3.10.3 Irrigation

The field was irrigated five times during the whole period of plant growth.Just after sowing light watering was done with fine watering cane at first time. Surface crust 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.

3.11 Plant protection

3.11.1 Insect pest

The crop was infested with cut warm *(Agrostis ipsilon)*, mole cricket, field cricket during the early stage of growth of seedlings. These insects were controlled by spraying Dursban 20 EC at the contrition of 0.2% at 15 days interval for three times starting from 20 days after sowing.

3.11.2 Diseases

At early growth stage some of the plants affected by foot root disease which was controlled by Ridomil MZ 72 WP at the rate of 2.5 g/L of water.

3.12 Harvesting

The crop was harvested on 15 March, 2007 after 105 days from seed sowing when the foliage turned pale yellow (Bose and Som, 1990). Rikabdar (2000) suggested that carrots should be harvested in Bangladesh within 90-105 days after sowing for maximum yield and quality. The crop was harvested plot wise carefully by hand. The soil and fibrous roots and hearing to the roots were cleaned with cloth. Ten plants were selected at random and uprooted very caretuliy from each unit plot at the time of harvest and mean data on the following parameters were recorded.

3.13 Parameters assessed

Growth stage

1. Plant height (cm)
2. Number of leaves per plant

Maturity stage

1. Length of root per plant (cm)
2. Diameter of root per plant (cm)
3. Fresh weight of leaves per plant
4. Fresh weight of root per plant
5. Dry matter content of roots (%)
6. Dry matter content of leaves (%)
7. Cracked roots per plot
8. Rotten roots per plot
9. Branched roots per plot
10. Total yield of roots per plot (Kg)
11. Total yield of roots per hectare (tone)
12. Marketable yield of roots per plot (Kg)
13. Marketable yield of roots per hectare (tone)

3.14 Collection of data

Ten plants per plot were sampled in the middle rows and marked by bamboo stick for collection of per plant data while the crop of whole plot was harvested to record per plant data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random sampling to avoid the border effect.

3.14.1 Plant height

In order to measure the plant height, a centimeter (cm) by a meter scale at 45,60,75 and 90 days after sowing (DAS) from the point of the attachment of the leaves to the root (ground level) up to the tip of the longest leaf.

3.14.2 Number of leaves per plant

Number of leaves per plant of 10 sampled hills were counted at 45, 60, 75 and 90 DAS. All the leaves of the plants were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from the counting.

3.14.3 Length of root per plant (g)

The average length of the root was recorder in cm by a meter scale from the point of attachment of the leaves (proximal end) to the last point of the root (distal end) in each treatment combination.

3.14.4 Diameter of root per plant (cm)

The average diameter of the root was measured at the thickest portion of the root at harvest with the help of a slide caliper.

3.14.5 Fresh weight of leaves per plant (100 gm)

Leaves were detached by a sharp knife and 100 gm fresh weight was recorded in gram (g).

3.14.6 Fresh weight of root per plant (100 gm)

Under ground modified roots were detached by knife from the attachment of leaves and after the cleaning the soil and thin roots, the l00gm fresh weight was taken in gram (g) by a triple beam balance.

3.14.7 Dry matter content of roots (%)

Immediately after harvest, roots were cleaned thoroughly by washing with water and air dried. Then from several roots, a sample of 100g was taken and cut into small pieces were sun dried for 3 days and then oven dried for 72 hours at 70°-80°c temperature. After oven drying, the samples were weighted by an electrical balance and dry matter content was calculated by using the following formula—

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

3.14.8 Dry matter content of leaves (%)

Fresh leaves of l00g as per treatment sample were weighted and cut into small pieces. After sun drying for 3 days the samples were oven dried at 72 hours. Then the samples were weighted by an electrical balance and the weight of dry leaves were calculated by using the following formula—

$$\%\text{Dry matter of leaves} = \frac{\text{Constant dry weight of leaves (g)}}{\text{Fresh weight of leaves (g)}} * 100$$

3.14.9 Cracked roots per plot

At the time of harvest, the number of cracked roots were counted. Cracked root percentage was calculated by using the following formula—

$$\text{racked root (\%)} = \frac{\text{Number of cracked roots}}{\text{Number of total roots}} * 100$$

3.14.10 Rotten roots per plot

At, harvest the number of rotten roots were counted and the result was calculated on percentage basis as per the following formula

$$\text{Rotten roots (\%)} = \frac{\text{Number of rotten roots}}{\text{Number of total roots}} * 100$$

3.14.11 Branched roots per plot

At the time of harvest, the number of branched roots were counted and branching percentage of roots per plot was calculated by the following formula--

$$\text{Branched roots (\%)} = \frac{\text{Number of branched roots}}{\text{Number of total roots}} \times 100$$

3.14.12 Total yield of roots per plot (kg)

After removal of cracked roots, branched root and rotten root, the fresh weight of roots per plot was taken and recorded in kilogram (kg).

3.14.13 Total yield of roots per hectare (tone)

The yield of roots per hectare was computed from the per plot yield and was recorded in tones.

3.14.14 Marketable yield of roots per plot (kg)

The marketable yield of roots per plot was consisted of only good quality roots other than branched, racked and rotten roots. The marketable roots were weighted and expressed in kg.

Marketable yield = Gross yield - Non marketable yield of cracked, branched and rotten roots

3.14.15 Marketable yield of roots per hectare (tone)

The marketable yield per hectare was computed from the per plot marketable yield data and was recorded in tones.

3.14.16 Statistical analysis

The data collected from the experimental plots were statistically analyzed according to final out the variation(s) resulting from experimental treatments following F- variance test. The significance of difference between pair of means were performed by Duncan's Multiple Range Test (DMRT) test at 5% levels of probability (Gomez and Gomez, 1984).

Chapter 4

RESULTS AND DISCUSSION

The experiment was conducted to investigate the effects of number of plants per hill and different levels of potassium on the growth and yield of carrot. Data on different parameters were analyzed statistically and results have been presented in tables 1 to 3 and figures 2 to 7. The result of the present study have been presented and discussed in this chapter under the following headings.

4. Effects of Potassium and number of plant(s) per hill on the growth and yield of carrot

4.1 Plant height

Application of potassium significantly influenced on plant height at 45, 60, 75 and 90 DAS of observations. The plant increased gradually with the advancement of time and continued up to 90 days after sowing (DAS) (Appendix iii). However, al 45 DAS, the tallest (22.23 cm) plant height was found in K_2 which was statistically similar (22.01 cm) to K_3 and the shortest (21.09 cm) plant height was recorded in K|. The tallest (38.53 cm) plant was obtained in K_2 (200 kg/ha) and the shortest (33.02 cm) plant height was found in K_0 at 60 DAS. At 75 DAS, the tallest (45.05 cm) plant height was obtained in K_2 whereas the shortest (39.42 cm) was recorded in K| which was similar to K_3 and K_0. The tallest plant height (46.75cm) was found from K_2 (200 kg K_20/ha) and the shortest (42.94 cm) plant height was obtained by K| (180 kg K_20 /ha) at 90 DAS which was statistically similar to control (K_0) and K_3 (220 kg/ha) treatment (Fig.2).

Plant height was significantly affected due to the variation in number of plant(s) (1,2, and 3) per hill. The plant height increased gradually with the advancement of time and continued up to 90 days after sowing (DAS)

(Appendix iii). The tallest (22.23 cm) plant height was recorded in P| (Single plant per hill) which statistically similar (22.42 cm) to 1*2 (two plants per hill) and the shortest (21.05 cm) plant height was produced by P_3 (three plants per hill) at 45 DAS. At 60 DAS, the longest (37.63 cm) was produced by P_2 (two plants per hill) and the shortest (34.83 cm) plant height was recorded in P_3 which was similar to P| (34.52 cm).The longest (42.73 cm) plant height was recorded in P| and the shortest (41.01 cm) was obtained in P_3 which was identical (40.84 cm) to Pj at 75 DAS. The highest plant height (44.89 cm) was obtained when one plant was grown per hill and the lowest (43.60cm) plant height was obtained when three plants was grown per hill at 90 DAS (Fig. 3). The lowest plant height at all date of observations were found when three plants were grown per hill.

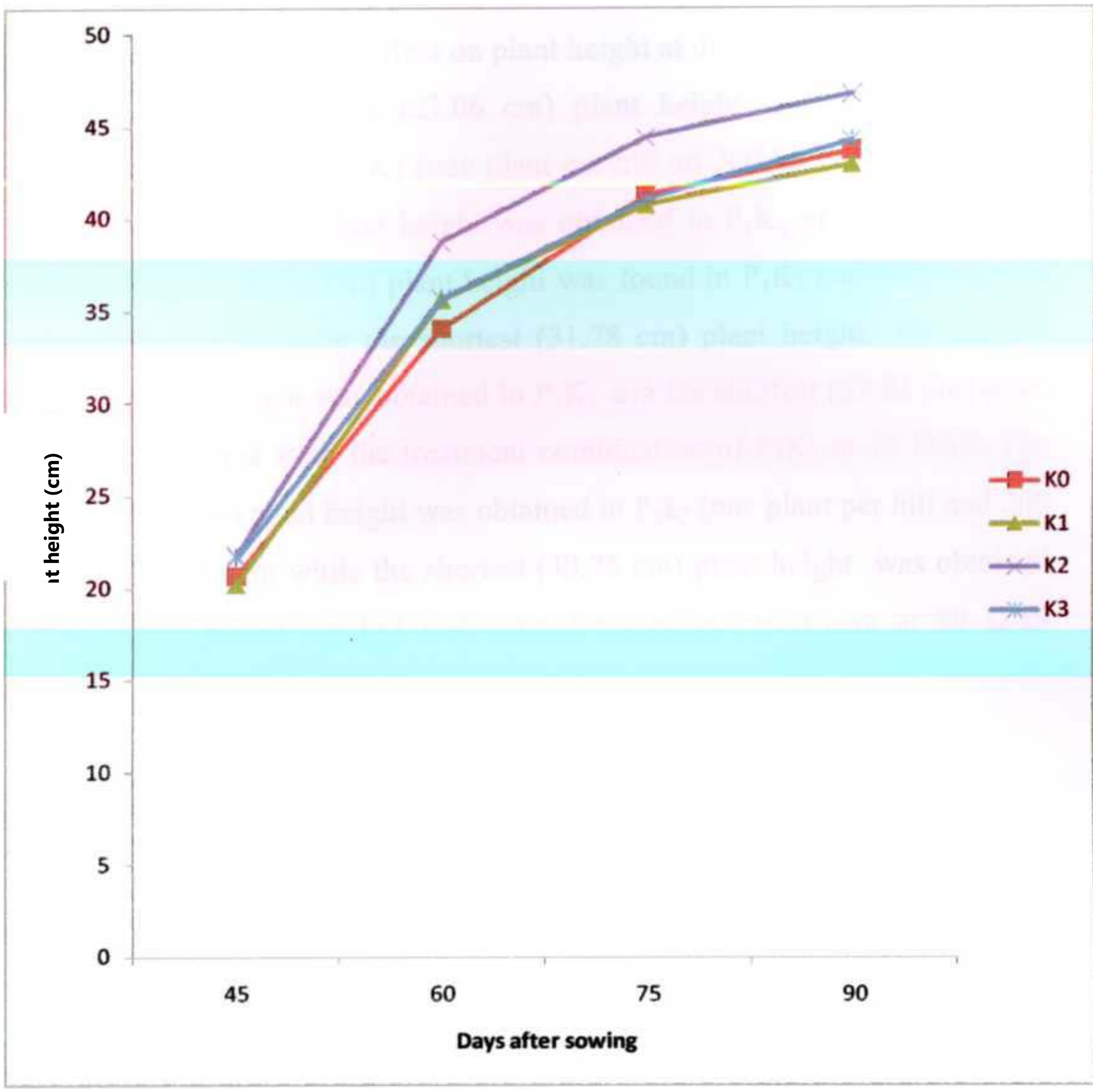


Figure 2. Effect of potassium on the plant height of carrot at different days after sowing

K_0 = 0 kg K_20/ ha

K, =180 K_20/ ha

K_2 = 200 K_20/ ha

K_3 = 220 K_20/ ha

Different number of plant(s) per hill and level of potassium was found to be significant due to combined effect on plant height at different days after sowing (Appendix iii). The longest (23.06 cm) plant height was obtained in the treatment combination of P|K_2 (one plant per hill ad 200 kg $K_2$0/ ha) whereas the shortest (18.99 cm) plant height was obtained in P|K| at 45 DAS. At 60 DAS, the longest (42.72 cm) plant height was found in P|K_2 and the treatment combination of $P_3K_($) gave the shortest (31.78 cm) plant height. The longest (48.20 cm) plant height was obtained in P|K_2 and the shortest (37.93 cm) plant height was obtained from the treatment combination of P|K_3 at 75 DAS. The longest (48.29 cm) plant height was obtained in P|k_2 (one plant per hill and 200 kg $K_2$0/ha) treatment while the shortest (40.75 cm) plant height was obtained in P_3K_0 (three plants per hill and control potassium) treatment at 90 DAS (Table 3).

4.2 Number of leaves per plant

Application of potassium also significantly influenced on the number of leaves per plant at 45, 60, 75 and 90 DAS of observation (Appendix iii). The number of leaves per plant increased gradually with the period of time and continued up to 90 (DAS) (Fig. 4). The highest (3.99) number of leaves per plant was obtained in K_2 and the lowest (3.53) was found in K_0 at 45 DAS. At 60 DAS, the maximum (7.54) number of leaves were obtained in K_2 whereas, the minimum (6.73) was recorded in k_3. The maximum (9.03) number of leaves per plant was obtained in K_2 and the minimum (8.23) was founded in K| treatment at 75 DAS .The number of leaves per plant was the highest (9.23 cm) performed by K_2 treatment and the lowest (8.74

cm) number of leaves per plant was obtained in K| (180 kg $K_2$0 /ha) at 90 DAS. It was possible that the application of potassium increased the height of plants and ultimately the leaf number was also increased due to the influence of this nutrient. The results of this experiment were in accordance with those of Dhcsi *et al.* (1964) who noticed significant effect of potassium on leaf number per plant.

The number of plant(s) per hill had significantly influenced on the number of leaves per plant at 45, 60, 75 and 90 DAS of observation. The highest (4.32) number of leaves per plant was recorded in P| and the lowest (3.85) was counted in P_3 at 45 DAS. The maximum (7.92) number of leaves were obtained in P| whereas treatment P_3 showed the minimum (7.12) number of leaves at 60 DAS. At 75 DAS, the highest (9.32) number of leaves per plant was recorded in P| and the treatment P_3 performed the lowest (7.42) number of leaves. File number of leaves per plant increased gradually with the period of time and continued up to 90 DAS (Fig. 5). The number of leaves per plant was the highest (10.02) at 90 DAS when one plant was grown per hill and the lowest (8.44) number of leaves per plant was obtained when three plants were grown per hill. However, the highest (10.02) number of leaves per hill significantly differed from two and three plants per hill.

15

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45 60 75 90

Days after sowing

Figure 3. Effects of number of plants per hill on plant height of carrot at different days after sowing.

Pi = One plant/hill,

P_2 = Two plants/hill and

P_3 = Three plants/hill.

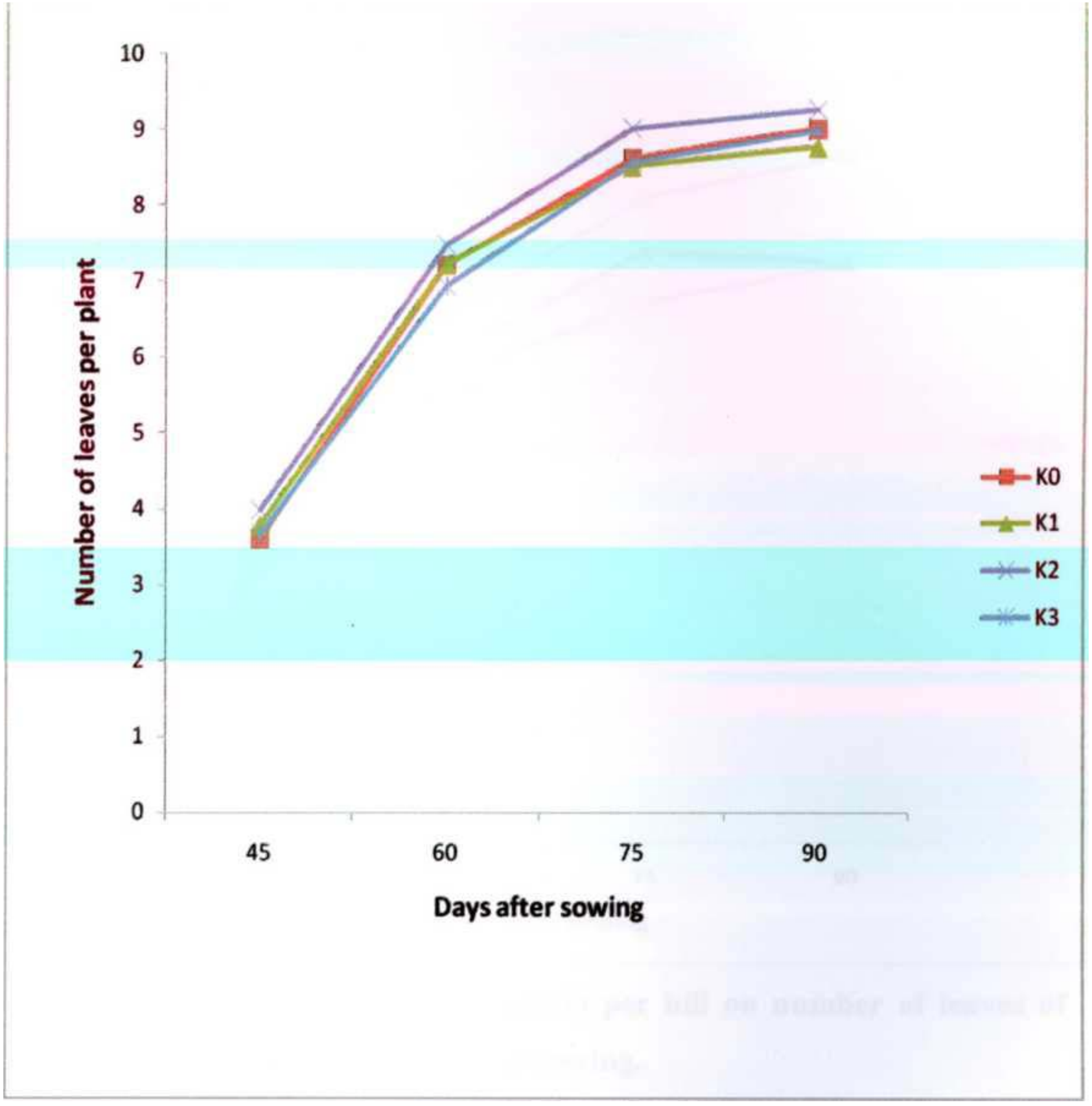

Figure 4. Effect of potassium on the number of leaves per plant of carrot at different days after sowing

K_0 = 0 kg K_20/ ha

K, =180 K_20/ ha

K_2 =200 K_20/ ha

K_3 =220 K_20/ ha

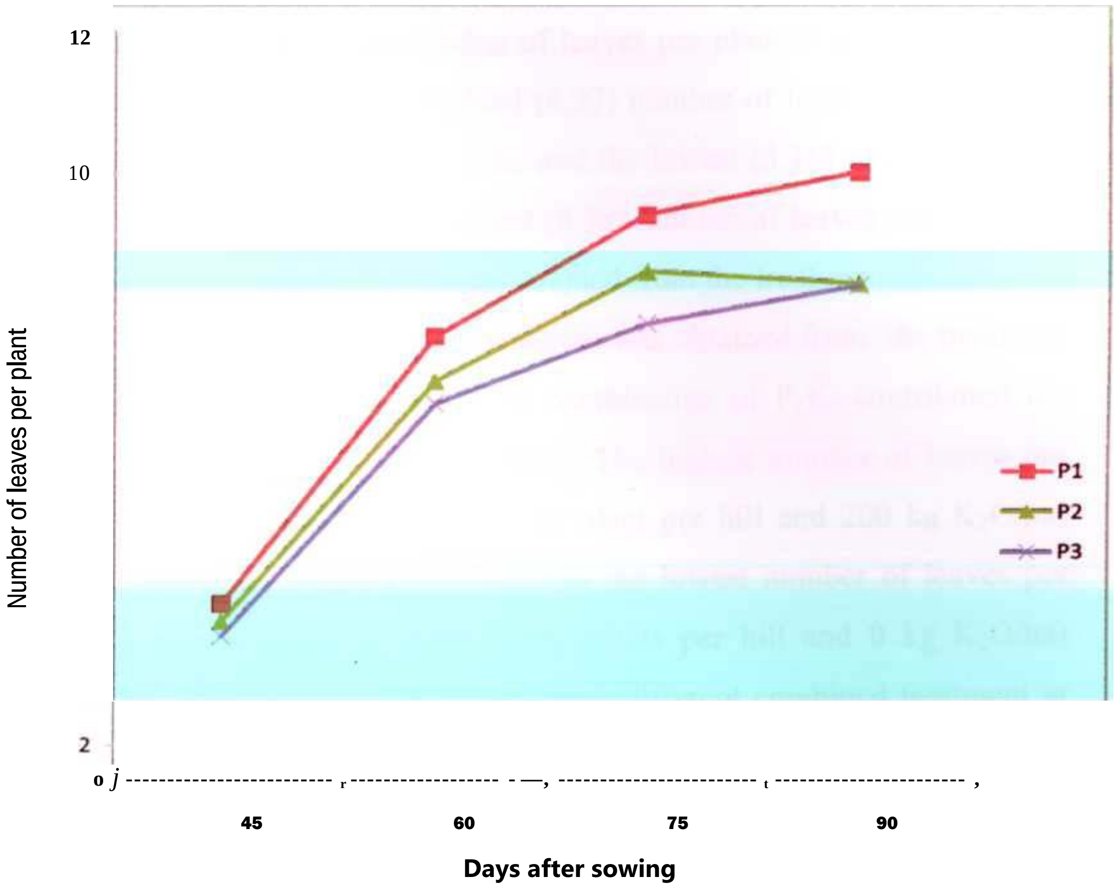

Figure 5: Effects of number of plant(s) per hill on number of leaves of carrot at different days after sowing.

Pi = One plant/hill,

P_2 = Two plants/hill and

P_3 = Three plants/hill

The combined effects of number of plant(s) per hill and potassium had significantly influenced on the number of leaves per plant at different DAS ol observation (Appendix iii). The highest (4.27) number of leaves was obtained from the treatment combination of P|K_2 and the lowest (3.16) was found from P,Ki at 45 DAS. At 60 DAS, the highest (8.30) number of leaves was obtained in P|K_2 whereas the lowest (6.57) was obtained from the treatment combination of P_3K_0 The highest (10.19) number of leaves was obtained from the treatment combination of P|K_2 and the treatment combination of PjK_0 contributed the lowest (7.70) number of leaves at 75 DAS. The highest number of leaves per plant (10.47) was counted with P|k_2 (one plant per hill and 200 kg $K_2$0/ha) treatment combination at 90 DAS, whereas the lowest number of leaves per plant (8.20) was obtained in P_3k0 (three plants per hill and 0 kg $K_2$0/ha) treatment. The number of leaf increased with different combined treatment at different days (Table 3). Similar trend of results was also reported by Sarker (1999).(2).

4.3 Length of root per plant

The length of underground modified root of carrot was significantly influenced with the application of different levels of potassium (Appendix iv). The root length was observed to be gradually increased with increasing level of potassium. The highest root length per plant was produced the highest (16.56 cm) when the plant having received 200 kg $K_2$0/ha (K_2) and the lowest (13.33cm) was obtained in control condition. The root length of carrot is increased significantly with the increasing levels of potassium and after reaching a peak at K_2 treatment it began to decrease due to senescence (Table 1). Sarker (1989) and Farazi (1983) obtained no significant effect of potassium on root length.

Tablel. Main effect of potassium on the growth and yield of carrot

Treatment	Diameter of root	length of root	Fresh weight of leaves / plant (g)	Fresh weight of root / plant (g)	Dry matter content of leaves (%)	Dry matter content of root (%)	Yield kg/plot	Cra (%)
K_0	8.30 b	13.33 a	147.73 c	51.67 c	11.77 c	7.27 b	2.96 b	2.07
Ki	10.07 ab	16.36 a	153.72 b	57.18 b	14.30 b	10.82 ab	3.10 ab	2.03
K_2	11.02 a	16.56 a	161.84 a	64.21 a	16.62 a	12.83 a	3.98 a	2.41
K_3	9.67 ab	15.85 a	155.56 b	58.57 b	15.01 b	11.77 a	3.40 a	2.13
LSD^O.05)	1.791	5.30	3.271	3.365	0.930	4.860	0.624	1.88
Level of significant	*	*	**	* *	**	* *	*	NS
CV (%)	8.85	9.673	8.91	7.97	7.72	8.81	8.82	5.57

Table 2. Main effect of the number of plant(s) per hill on the growth and yield of carrot

Means bearing the common letter (s) in a column do not differ significantly at 5% level of pro
Non Significant

Treatment	Diameter of root (cm)	length of root (cm)	Fresh weight of leaves / plant (g)	Fresh weight of root / plant (g)	Dry matter content of leaves (%)	Dry matter content of root (%)	Yield (kg/plot)	Cr ro
Pi 1	10.29 b	16.11 a	128.99 a	48.60 a	10.12	11.40	2.850 c	1.9
P_2	10.51 a	16.40 a	125.14 b	46.26 a	12.75	11.10	3.12b	2.4
P_3	8.62 b	15.0 b	118.25 c	40.33 b	11.86	10.22	3.37 a	2.9
; LSD,oo5)	1.860	0.825	3.790	4.291	4.33	5.665	0.170	2.3
Level of I significant	* *	**	**	**	NS	NS		
|*: V (%) I	8.85	5.30	8.910	7.97	7.72	9.81	8.82	5.5

Table 2. Main effect of the number of plant(s) per hill on the growth and yield of carrot

Means bearing the common letter (s) in a column do not differ significantly at 5% level of probab
Significant

The length of underground modified root of carrot was significantly influenced by the number of plant(s) per hill (Appendix iv). The root length was observed to be gradually decreased with increasing number of plant(s) per hill. The root length per plant was produced the highest (16.40 cm) when two plants were grown per hill which was followed by single plant per hill (16.11cm). However, the three plants per hill showed the lowest root length (15.0 cm) (Table 2). These findings are in agreement with the result of (Bose and Soin, (1990). They noted that the root length of carrot is decreased with the increasing plant population.

The combined effects length of underground modified root of carrot was significantly influenced by the number of plant(s) per hill and potassium (Appendix iv). The root length per plant ranged from 10.75 to 17.41 cm. The root length per plant was produced the highest (17.41cm) in $P|K_2$ the treatment combination of one plant per hill and 200 kg K_20/ha, whereas the lowest root length (10.75 cm) was observed in $P|K_{()}$ one plant per hill with 0 kg K_20/ha (Table 3).

4.4 Diameter of root per plant

Significant variation in root diameter of carrot was found due to application of different levels of potassium. The highest (11.02 cm) diameter of root was recorded when the plants having received 200 kg K_20/ha (K_2) and the lowest (8.30 cm) was in control (K_0) treatment. The root diameter of carrot was increased gradually with the levels of potassium and after reaching a peak at K_2 treatment it began to decrease due to senescence (Table 1). This finding is in agreement with the findings of Sarker (1989) and Farazi (1983) also reported that potassium had significantly effect on the diameter.

The number of plant(s) per hill was significantly influenced on diameter of root per plant (Appendix iv). The highest (10.51cm) diameter of root was recorded in

P_2 (two plants/hill) that significantly higher than others. The minimum (8.62 cm) in this regard was found in the treatment of three plants per hill (Table 2). In case of two plants per hill, the plant got sufficient nutrient, water, space, air and light which might have encouraged more photosynthesis resulting in higher photosynthetic production and translocation of the same to the storage organ (root) which ultimately increased the root diameter compared to three plants per hill.

The combined effect was also found significant variation due to number of plant(s) per hill and levels of potassium on diameter of root per plant (Appendix iv). The root diameter ranged from 8.28 to 12.53 cm. The highest (12.53 cm) diameter of root was recorded from the treatment combination of (P_2K_2) two plants per hill with 200 kg K_20/ha, whereas the lowest (8.28 cm) root diameter was observed in (P|K_0) one plant per hill with 0 kg K_20/ha (Table 3).

4.5. Fresh weight of leaves per plant

Different levels of potassium showed significant difference on fresh weight of leaves per plant (Appendix iv). The highest (161.84 g) fresh weight of leaves per plant was recorded in K_2 (200 kg/ha) and the lowest (147.73 g) was found in K_0 (control) treatment (Table 1).

Fresh weight of leaves per plant was also showed significant variation due to number of plant(s) per hill (Appendix iv). The maximum (128.99 g) fresh weight of leaves was obtained in P| (Single plant per hill) whereas the minimum (118.25 g) was recorded in P_3 (Table 2).
The combined effect between different levels of potassium and number of plant(s) per hill significantly influenced on fresh weight of leaves per plant (Appendix iv).

The highest (175.41 g) fresh weight of leaves per plant was recorded from the treatment combination of $P|K_2$ (Single plant per hill with 200 kg k20/ha) and the treatment combination of $P|K_{()}$ performed the lowest (138.36 g) fresh weight of leaves per plant (Table 3).

4.6. Dry matter content of leaves

There had a significant influenced among different levels of potassium on dry matter content of leaves (Appendix iv). The maximum dry matter content of leaf (16.62%) was obtained at K_2 (200 kg K_20/ha), while the minimum dry matter content of leaves (11.77%) was obtained in control treatment (Table 1).

The number of plants per hill had no significant influence on dry matter content of leaves. The maximum dr)' matter content of leaves (12.75%) was recorded in P_2 (two plants/hill). The minimum (10.12%) was found in the treatment of one plant per hill (Table 2).

The combined effect between number of plants per hill and levels of potassium was observed significant variation on dry matter content of leaves (Appendix iv). The dry matter content of leaves ranged from 8.02% to 14.0%. The highest (14.0%) dry matter content of leaves was recorded in the treatment combination of two plants per hill with 200 kg K_20/ha, while the lowest (8.02%) dry matter content of leaves was observed from one plant per hill with 0 kg K_20/ha (Table 3)

Table 3. Combined effect of potassium and number of plant(s) per hill on the growth and yield of carro

Treatment	Plant height (cm)				Number of l	
	45 DAS	60 DAS	75 DAS	90 DAS	45 DAS	60 DAS
PiKo	22.18 a	34.75 be	42.18 abc	45.20 ab	4.09 ab	7.82 ab
PiK_t	18.99 b	35.86 be	42.22 abc	44.44 ab	3.16 be	7.43 abc
PIK_2	23.06 a	42.72 a	48.20 a	48.29 a	4.27 a	8.30
PtK_3	22.23 a	33.76 be	37.93 c	41.87b	3.94 abc	7.61 abc
P_2K_0	21.01 ab	39.30 b	43.43 abc	45.31 ab	3.67 c	7.19 be
P_2K,	20.71 ab	38.05 ab	41.56 be	43.36 ab	3.80 be	7.42 be
P_2K_2	21.19 ab	37.52 ab	41.90 abc	45.43 ab	4.70 ab	7.37 be
P_2K_3	21.31 ab	38.16 a	43.52 abc	45.82 ab	3.61 c	6.71 c
P3K0	19.06 b	3L78 c	40.43 be	40.75 b	3.19 d	6.57 e
P_3K,	21.10 ab	36.37 be	40.62 be	41.32 b	3.96 abc	7.03 be
P_3K_2	21.52 ab	39.29 ab	45.28 ab	47.62 a	3.72 c	6.90 be
P_3K_3	21.63 ab	37.96 ab	44.95 ab	45.29 ab	3.64 c	6.68 c
LSD(o.o5)	2.40	5.10	6.82	4.62	0.351	0.819
Level of significance	*	* *		**		*
CV (%)	7.53	8.55 ! 9.21		6.66	6.92	7.73

Means bearing the common letter(s) in a column do not differ significantly at 5% level of proba

K_0=0 kgk$_2$0/ha P[=
One plant per hill Ki = 180 kg k$_2$0/ha P_2 = Two plants per hill K_2 = 200 kg k$_2$0/ha P_3 = Three plants per hill K_3 = 220 kg k$_2$0/'ha

Table 3. (Contd.)

Treatment	Length of root (cm)	Diameter of root (cm)	Fresh weight of leaves (g)	Dry matter content of leaves (%)	Fresh weight of root (g)	Dry matter content of root (%)	Cracked root (%)	Branched (%)
PiKo	10.75c	8.28e	138.36 f	8.02 e	50.13 be	9.20 f	1.31c	4.
P,K,	16.78a	10.03 bed	171.35 be	8.22 be	52.89 be	13.57b-e	2.37abc	6.
PiK_2	17.41a	11.02 b	175.41 a	11.32 ab	55.23 a	16.56 ab	2.43 abc	5.
PiK_3	16.81a	9.66 cd	172.27 b	6.99 cd	53.58 b	16.61 ab	1.96 be	5.
P_2Ko	15.20ab	9.31 f	116.43 h	8.50 be	48.96 c	8.84 f	2.60 ab	5.
P_2K,	15.3 lab	10.78 be	139.43 e	9.14 be	51.72 be	12.98cde	1.84 be	4.
P_2K_2	16.80a	12.53 b	143.49 de	14.0 a	56.40 a	17.95 a	2.69 a	6.
P_2K_3	15.95ab	11.30 b	140.35 e	8.52 c	52.41 be	14.93a-d	2.35 abc	6.
P_3Kc	13.60b	9.25 de	132.99 g	9.13 d	46.01 d	10.77 ef	2.68 ab	6.
p_3k,	16.69a	10.39 bed	115.98 h	10.12 cd	48.75 c	I5.35abc	2.23 abc	5.
P_3K_2	15.20ab	11.07 b	170.04 be	10.33 cd	52.57 be	11.74 def	1.56 be	4.
P3K3	14.46ab	9.69 cd	116.90 h	12.24 ab	49.45 be	12.78 cde	3.37 ab	7.
$LSD_{(oo5)}$	2.601	1.165	2.043	3.679	2.001	3.196	1.123	5.4
Level of significance	**	**	**	*	*	*	*	*
CV (%)	5.3	8.85	8.91	7.72	7.97	9.81	5.57	7.3

Means bearing the common letter (s) in a column do not differ significantly at 5% level of probabilit

4.7. Fresh weight of root per plant

Fresh weight of root per plant significantly varied due to the application of different levels of potassium (Appendix iv). The maximum (64.21 g) fresh weight of root per plant was obtained in K_2 while the minimum (51.67 g) was noted from (K_0) control condition. (Table l).

There was significant result of fresh weight of root per plant due to number of plant(s) per hill (Appendix iv). The maximum (48.60 g) fresh weight of root per plant was noted in P| (Single plant per hill) whereas the treatment P_3 showed the minimum (40.33 g) fresh weight of root per plant (Table 2)

The combined effect was also found significant variation due to different levels of potassium and number of plant(s) per hill (Appendix iv). The highest (56.40 g) fresh weight of root per plant was noted in P_2K_2 while the lowest (46.01 g) was obtained from the treatment combination P_3K_0 (Table 3).

4.8. Dry matter content of root

The dry matter content of root was also varied significantly with the application of different levels of potassium. The maximum (12.83%) dry weight of root was obtained at K_2 (200 kg K_2O/ha), while the minimum (7.27%) dry matter content of root was obtained in control treatment (Table 1). The dry matter content of root was increased gradually with the level of potassium.

The dry matter content of root was not varied significantly with the different number of plant(s) per hill (Appendix iv). The maximum (11.40%) dry matter content of root was recorded when Pj (single plant/hill) and the minimum (10.22%) in this regard was found in the treatment of three plants per hill (Table 2). The dry matter content of root obtained from two and three plants per hill were not statistically different. A similar finding was reported by Haque (1999).

The combined effect of number of plant(s) per hill and different levels of potassium showed significant variation on dry matter content of root. The highest (17.95%) dry matter content of root was recorded from the treatment combination of two plants per hill with 200 kg K_20/ha, while the lowest (9.20%) diy weight of root was observed from one plant per hill with 0 kg K_20/ha (Table 3).

4.9 Percentage of cracked root

There was no significant variation on percentage of cracked root due to application of different levels of potassium (Appendix iv). The highest (2.412 %) percentage of creaked root was produced by the plants having received 200 kg K_20/ha and the lowest (2.031%) was found in K| treatment (Table 1).

Significant variation in the percentage of cracked root was not found due to the number of plant(s) per hill (Appendix iv). The maximum (2.93 %) cracking percentage of root was recorded when P_3 (three plants/hill), which significantly different from the remaining treatment. The minimum (1.94%) in this regard was found in the treatment of one plant per hill (Table 2). The increasing trend of cracking percentage of root with the increasing number of plant(s) per hill might be due to overcrowding of per hill, facing high inter plant competition for sufficient nutrient, water, space, air and light producing small and thinner root having minimum diameter and possibly that might have contributed to resist cracking of roots.

The combined effect of number of plant(s) per hill and levels of potassium treatment on cracking percentage of root was significant. The highest (3.37%) cracking percentage of root was recorded from the treatment combination of three plants per hill with 220 kg K_20/ha **(P_3K_3),** while the lowest (1.31%) cracking percentage of root was observed from one plant per hill with 0 kg K_20/ha (Table 3).

4.10 Branched root

Application of potassium had significant effect on the percentage of branched root in carrot. However, the highest dose of potassium (220 kg K_20/ha) produces the highest (6.71%) percentage of branched root and the lowest (5.22%) was obtained from control treatment (Table 1).

The number of plant(s) per hill had no significant effect on the percentage of branched root in carrot. It was observed that the branching percentage of root was decreased with the increase in plant population. The highest (5.99%) branching percentage was recorded in P_2 (two plants per hill) while the lowest (5.42%) was in P_3 (three plants per hill) treatment (Table 2).

The combined effect of number of plants per hill and different levels of potassium had no significant differences on branching percentage of roots. The highest (7.12 %) branching percentage of roots was recorded from the treatment combination of three plants per hill with 220 kg K_20/ha **(P_3K_3),** while the lowest (4.13%) branching percentage of roots was observed from one plant per hill with 0 kg K_20/ha (Table 3)

4.11. Root yield per plot

Per pot yield of root was significantly varied due to the application of different levels of potassium in carrot (Appendix iv). The highest (3.40 kg/plot) yield per plot was obtained in K_3 (220 kg K_20/ha) where the lowest (2.96 kg/plot) was obtained from control treatment. Polch (1982) reported that application of potassium at 196 kg/ha gave the best yield and quality carrots.
Per plot yield of root was significantly varied due to the number of plant(s) per hill (Appendix iv). The yield of carrot per plot was the highest (3.37 kg/plot) was obtained when three plants were grown per hill, which significantly different from the remaining treatment. The lowest yield (2.85 kg/plot) was found when one plant was grown per hill (Table 2). Similar result showed by Tarafdcr (1999).

The combined effect of number of plant(s) per hill and different levels of potassium showed significant variation on root yield per plot (Appendix iv). The highest (3.86 kg/plot) root yield per plot was recorded from the treatment combination of three plants per hill with 200 kg K_20/ha, while the lowest (2.01 kg/plot) root yield per plot was observed from one plant per hill with 0 kg K_20/ha (Table 3).

4.12 Root yield per hectare

Per hectare yield of root was significantly varied due to different potassium doses applied in carrot (Fig. 6). The highest (25.23 t) root yield of carrot per hectare was obtained in K_2 (200 kg K_20/ha) treatment while the control treatment (K_0) was produced the lowest (18.25 t) in this respect. It was clearly observed that yield increased with increasing level of potassium (K_20). Different doses of potassium produced significantly different yields. Out Burleson (1957) and Sein (1975) reported that potassium did not show any significant effect on the yield of carrot roots. Polach (1982) reported that application of potassium at 196 kg/ha gave the beset yield and quality carrots. Szwonek (1980) reported that root yield was depressed by high K rates.

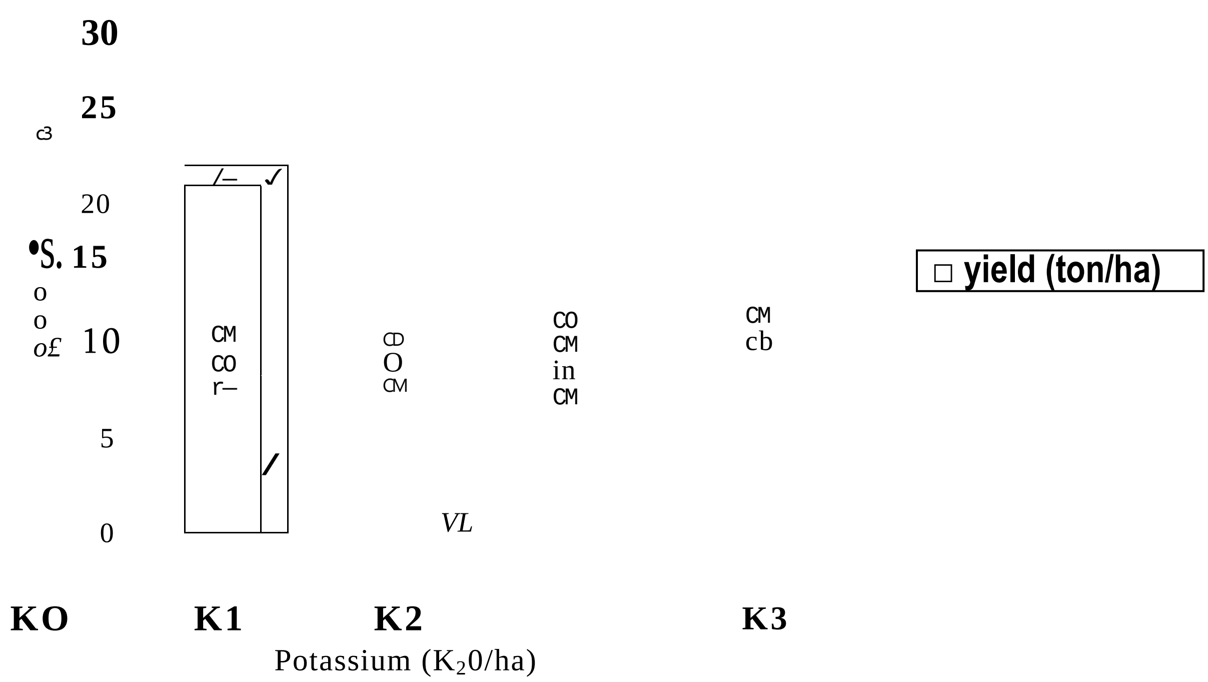

Figure 6. Effect of potassium on yield per hectare of carrot.

K_0 = 0 kg $K_2$0/ha K,

= 180 kg $K_2$0/ha

K_2= 200 kg $K_2$0/ha

K_3 = 220 kg $K_2$0/ha

Per hectare yield of root was significantly varied due to the number of plant(s) per hill (Appendix iv). The yield was found to increase with increasing number of plant(s) per hill. The yield of carrot per plot was the highest (22.32 t/ha) was obtained when three plants were grown per hill, which significantly different from the remaining. The lowest yield (19.27 t/ha) was found when one plant was grown per hill (Fig. 7). Similar trends of result showed by Tarafdcr (1999)

The combined effect of number of plant(s) per hill and levels of potassium treatment on root yield per hectare was significant. The highest (26.24 t/ha) root yield per hectare was recorded from the treatment combination of three plants per hill with 200 kg K_20/ha, while the lowest (13.81 t) root yield per hectare was observed from one plant per hill with 0 kg K_20/ha (Table 3).

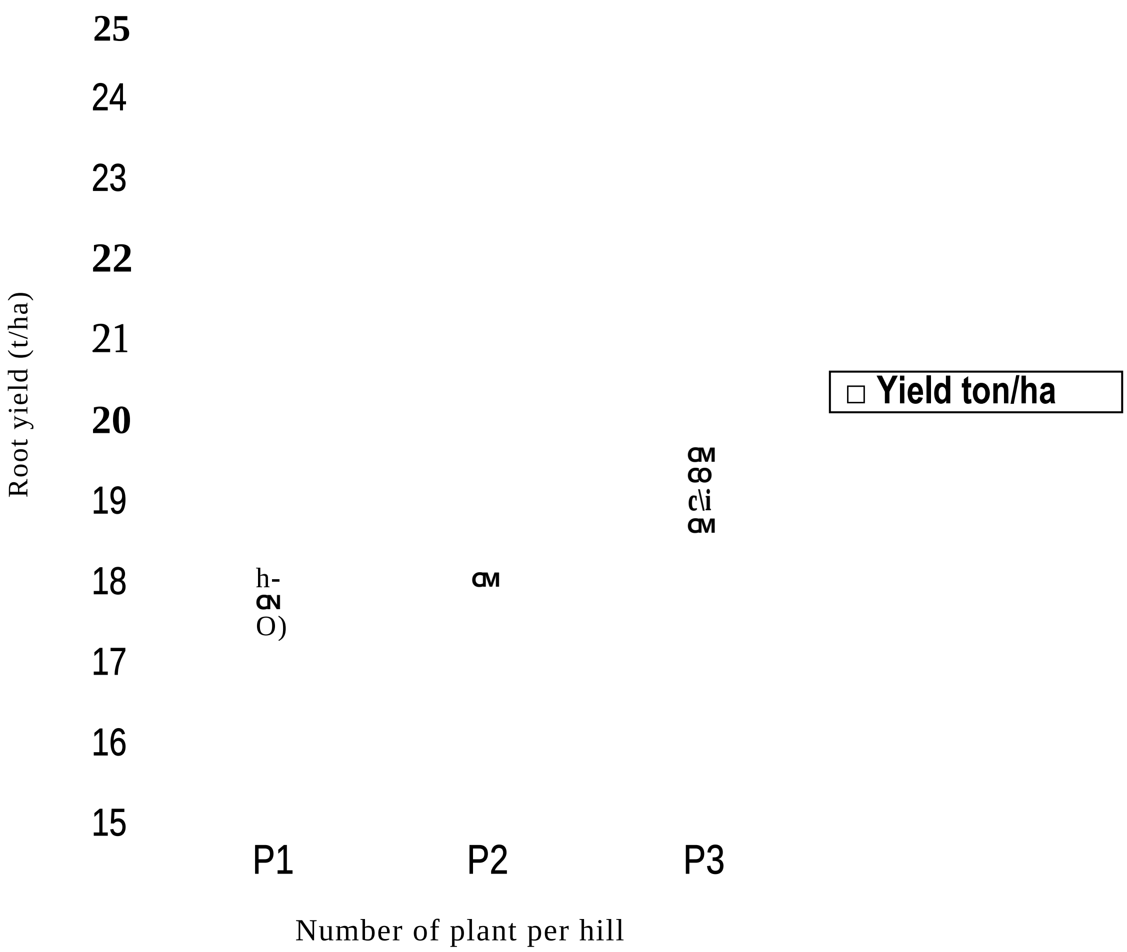

Figure 7. Effect of number of plant(s) per hill on the yield per hectare of carrot.

Pi = One plant/hill P_2

= Two plants/hill P_3

= Three plants/hill

Chapter 5

SUMMERY AND CONCLUSION

The present experiment was carried out at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207 to evaluate the effect of number of plant per hill and levels of potassium on the growth and yield of carrot during the pried from November, 2006 to March, 2007. The experiment consisted of three levels of number of plant(s) per hill (viz. 1, 2 and 3 plants per hill) and four levels of potassium (viz. 0, 180, 200, 220 kg K_20/ha).

The two-factor experiment was set up in Randomized Complete Block Design (RCBD) with three replications. In total there were 12 treatment combinations in this study. A unit plot was 1.5 mxl m and the treatments were distributed randomly in each block. There were 40 hills in single plot maintaining a spacing of 25 cm x 15 cm. The experimental plot was fertilized at the rate of 10 t/h cow dung/ha, 150 kg TSP/ha and 300 kg N/ha per hectare along with the potassium as per treatment. The carrot seed were sown on 30 November, 2006. The crop was harvested on 15 March, 2007. Ten hills were randomly selected for data collection from each plot. Data on growth and yield parameters were recorded and analyzed statistically. The differences were evaluated by Duncan's Multiple Range Test (DMRT) test.

The result showed that number of plant(s) per hill had significant influence on all the parameters, except cracking percentages of roots. The longest (44.89 cm) plant height, the maximum (10.02) number of leaves at 90 DAS, diameter of root (10.51 cm), length of root (16.40 cm), and dry matter content of leaf (12.75 %) were obtained when two plants per hill. The highest (11.40%) dry matter content of root was obtained in single plant per hill. On the other hand, highest yield per plot and yield per hectare (3.37 kg/plot and 22.32 t/ha, respectively) were recorded when three plants per hill and the lowest (2.85 kg/plot) was from one plant per hill.

Potassium had significant influence on the growth and yield contributing characters of carrot. The longest plant height (46.75 cm), number of leaves (9.23), diameter of root (11.02 cm), length of root (16.56 cm), dry matter content of leaf (16.62 g), dry matter content of root (12.83 %), yield per plot and yield per hectare (3.98 kg/plot and 25.23 t/ha, respectively) were obtained in application of 200 kg K_20/ha (K_2) plant per hill.

Combined effect of number of plants per hill and different levels of potassium showed the significant variation in respect of yield and yield contributing characters. The highest (48.29 cm) plant height, number of leaves (10.47) were obtained in the treatment combination of one plant per hill with 200 kg K_20/ha and diameter of root (12.53 cm), length of root (16.80 cm), dry matter content of root (17.95 g), and dry matter content of leaf (14.0 %) were obtained at the treatment combination of two plants per hill with 200 kg K_20/ha. The highest (2.69 %) cracked root was found in two plants per hill with 200 kg K_20/ha. The highest (6.99 %) branched root was found in three plants per hill with 0 kg K_20/ha. The yield per plot and yield per hectare were highly interacted with the number of plants per hill and different potassium levels. The highest yield per plot and yield per hectare (3.86 kg/plot and 26.24 t/ha, respectively) were recorded when three plants per hill with 200 kg K_20/ha and the lowest was in one plant per hill with 0 kg K_20/ha.

Therefore, from the present study it may be suggested that, the three plants per hill with 200 kg K_20/ha produced the highest yield. Further study may be conducted in different agro ecological zones of Bangladesh for more confirmation in order to get the higher yield.

References

REFERENCES

Abo-Sedera, F. A . and Eid. S. M. M. 1992. Plant growth, chemical composition, yield and quality of carrot as affected by N and K fertilization and NAA foliar spray. *Assiut j . Agril. Sci.*, 23 (2):209- 225.

Alam .M. S. ,Iqbal. T. M. T., Amin. M. S. and Gaffar.M.A.1989.Krishitattik Fasaler utpadan O unnayan (in Bengali). Jubair Bin Iqbal. T. M., Sirajgon, Bangladesh pp. (231-239).

Anjaiah, T; Padmaja, G and Raju, A. S. 2005. Influence of levels of K and FYM on yield and K-uptake by carrot (*Daucus carota* L.) grown on an alfisol. *Journal of Research ANGRA U* 33 (3): 82-86

Anonymous. 1989. Annual Report, 1987-88.Bangladesh Agricultural Research Institute, Joydebpur, gazipur, p. 133.

Balooch, A. F., Balooch M. A.and Qayyum, S. M.1993. Influence of phosphorous and potassium fertilizer combination levels with standard dose of nitrogen on the productivity of carrot (*Daucus carota* L.). *Sarh gric.*

Expt. .Slat .p. 186.

BBS, 2005. Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Ministry of Planning, govt, of people's Republic of Bangladesh.

Bose, T.K. and Som , M. G.1990. Vegetable crops in India. NayaProkash, 206 Bidhan Sarani, Calcutta-6, India, pp. 408-442.

Bruckner, U. 1986. Nutrient supply to carrots. Institute fur Boderkundu and pflanzenerach 6222, Geisenheim, German federal Repuublic .22 (2):58-60.[Cited from Hort.Abst.,60 (7): 1226,1990]

Burlesen, C.A. 1957. The response of carrots to fertilizer applications. *Hart. ScL,* 11: 97-98

Dragland, S. 1986. Plant density and row spacing in Carrots. Forskning og Forsoki Landbruket, statens Forskingsstasjon kise,Norway. 37:3,139-145.[cited from Hort. Abstr., 59 (3): 59,1989]

Dyachenko, V. S. and Kurumli, N.I. 1978. Fertilization and Carrot Storability. Kh-Va, 10:252-257.[cited from Host.Abstr., 49 (12): 809, 1978].

Evers, A. M. 1988. Effects of different fertilization practiccs on the growth, yield and dry matter content of carrot, *j. Agril. Sci. (Finland).* 60 (2): 135-152.

Farazi ,M. A. 1983. Effect of plant spacing and different levels of nitrogen and potash on the yield of carrot .M.Sc. Ag. Thesis, in the Department of Horticulture, Bangladesh Agricultural University, Mymcnsingh. pp. 20-32

FAO, 2002. FAO, Production Yearbook. Food and Agriculture Organization, Rome, Italy. 56: 163-164.

Frcman, R. E. and Simon, P. K. 1983. *J. Amer. Soc. Hort. Sci.* **108** (1): 50-56

Gomez, K. A.and Gomez A. A. 1984. Statistical Producers for Agricultural Research (2nd edn.). A Wiley Interscience Publication , *John Wiley and Sons*, Ncwyork. P. 680.

Grigorov , M.S. ; Sarana, S.V and Trcgubov, V.P. 1990. How to increase the efficiency of carrot growing. Kartofel'-i-Ovoshchi. (5): 19-20.

Haider, K. R. 2001. Effect of Plant Spacing, Number of plants per hill and mulching on the growth and yield of carrot. MS Thesis,Dept, of Ilort., BAU, Mymensingh. pp. 29-75.

Ilassan, M. N. M; Abdel, A. Y.Y and Farrag, M .1992.Effect of planting arrangement and NPK fertilizers on carrot under El-Minia conditions. Assiut Journal of Agricultural Sciences. **23 (4):** 121-135

Haider, Ilassan, M., Ahmad, F. and Mustaq, I'. 1991. Role of physio- morphic characters imparting resistance in cotton against some insect pests. *pak.Entomol.,* **21** (6): 1-6

Inal, A.; Gunes, A.; Alpaslan, M. and Demir, K.1998. Nitrate versus chloride nutrition effects in a soil-plant system on the growth, nitrate accumulation, and nitrogen, potassium, sodium, calcium, and chloride content of carrot. *Journal of Plan! Nutrition.* **21** (9): 2001-2011.

Jacobson, R., J. Kellman and J. Menis. 1968. Hybrid carrots of Nantes group, Hassadeh. 60 (10): 1812-1813.

Kadi, N., Chasin, F., Zapata, F. and Albarracin, M. 1994. Fertilation [illegible]

Krarup, II. A., Grandon B. M. and Berner, K. C. 1984.Effects of factorial fertilization of the yields and N,P and K contents and calculated extraction by carrots (*Daucas carota* L.) under vildivia conditions. Agro Sur., 12 (2) 85-92.

Lyngdoh, G. B. S. 2001. Response of carrot to different levels of nitrogen, phosphorus and potassium. *Horticultural Journal.* 14(2): 163-169.

Mandal, R. C., Singh, K .D. and Maini, S. B. 1973. Effect of plant density, fertility level and shoot number on tuber yield and quality of tapioca hybrids. *Indian J. Agron.*, 18 (4): 494-503.

.Maurya, K. R. and Goswami, R. K. 1985. Effects of NPK fertilizers on growth, yield and quality of carrot. Prog. Ilort., 17 (3): 212-217.

Michalik B. 1987. Seasonal variations in varietals characters of carrot roots. Hod. Rosl Alimat Basienn, 21: 101-112. [Cited from llort. Abst., 60(12): 1106, 1990.

Peirce, L. C. 1987. Vegetable Characteristics, Production and Marketing. John Wiley and sons. Inc. Newyork. pp. 251-252.

Pill, W.G. and Evans, T.A.1991. Seedling emergence and economic yield from osmotically primed or hydrated seeds of carrot *(Daucus carota* L.) *J. Horti. Sci.* 66(1): 67-74.

Polach, K., Dastane, N. G, and Parashad, M. 1975. Effect of soil moisture regimes, plant population and nitrogen levels on yield attributes and their contribution towards the roots of Sugar beet .*Indian J. Agron.*, 20 (1): 53-56.

Portz, A ; Martins, C. A-da-C; Lima, E and Zonta, E 2006.Lcvcls and accumulation of nutrients in Peruvian carrot as affcctcd by the application of nitrogen, phosphorus and potassium. Ilorticultura - Brasilcira. 24 (3): 329-333

Rashid, M. M. 1993. Shabje Bigjan (in Bengali). (l^{s,}Edn) Bangle Academy, Dhaka, pp. 502-507

Rashid, M. M. 1999. Shabje Bigjan (in Bengali), 2nd edn. Rashid Publishing House, 94 old D. O. II. S., Dhaka-1206, pp. 498-508

Rikabdar, F. H. 2000. Adhunik Upaya Shabje Chush (in Bengali). Agriculture Information Service, Khamarbari, Dhaka, pp. 29-30.

Roa, M. H. 1994. Growth, yield and quality of Tomato, Carrots and Cauliflower as influenced by levels and sources of potassium. *J. Potassium Res.*, 10 (4): 402-406

Saladaga,E. P. and Rodolfo, G. E. 1987. Comparative evolution of traditional methods and recommended practice of planting Sweet potato. Ann. Trop. Res., 9 (2): 104-109[citcd from Biological Abst. 84 (10): 104-109, 1987.1

Salo , T ; Raisio , R ; and Tiilikkala, K . 1999. Effectiveness of fertilizer recommendations in Finnish carrot and pea production. Acta Ilorticulturac. (506): 37-40.

Sarkcr, N. K. 1989. Effect of nitrogen, phosphorous and potash on the yield of carrot. M. Sc. thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. pp. 18-24.

Selvi, D ; Thiyageshwari, S. and Chitdeshwari, T. 2005. Effect of different levels of NPK on root yield of carrot *{Daucus carota)* in an acid soil at Nilgiris. Advances in Plant Scienccs. 18 (2): 799-801

Siddique, M. A. and Rabbani, M. G. 1987. Effect of length of vine cutting, part of vine inserted into the soil at planting and number of vines planted per hill in Sweet potato. *Thai. J. Agril. Sci.,* 20 (4): 315-321.

Singh, A. K. and Singh, A. K. 1996. Effect of nitrogen and potash on seed yield of carrot *(Daucus carota* L.) cv. *Pusa Kesar.* Crop Research Ilisar. 12(2): 182-184

Sharangi, A. B. and Paria, N. C. 1995. Growth yield and qualitative responses by carrot to varing length levels of nitrogen and potassium. *Hort., J.,* 8(2): 161-164.

Sharangi, A. B. and Paria, N., C. 1996. Effect of nitrogen and potassium on some physical attributes of *Pusa kesar* carrot roots. Env. and Ecol., India, 14 (2): 408-410.

Sharma, A ; Sharma, R . P. ; Sonia, S. and Shartna, J. J. 2003. Influence of integrated use of nitrogen, phosphorus, potassium and farmyard manure on the yield-attributing traits and marketable yield of carrot *(Daucus carota)* under the high hills dry temperate conditions of north-western Himalayas. *Indian Journal of Agricultural Sciences.* 73 (9): 500-503.

Subrahmanyam, S. V. S., Raju, D. V. R. 2000. Influence pf foliar feeding with water soluble specialty fertilizers on three vegetable crops . *Advances-in-plant Sciences.* 13 (2) :589-594.

Szwonek, E.1980. Principles of fertilizing Nantes carrots grown for streaking and seed with major and minor elements. IV. Fertilization with potassium. Nawozenie potaseum, Biuletin Wavywincy, 24: 165- 189 [Cited from Ilort., Abst., 7962, 1983].

Tarafder, M. E. II. 1999. Effect of plant spacing and number of plants per hill on the growth and yield of carrot .MS Thesis, Dept, of Ilort., BAU, Mymensingh. pp. 25-54.

Thompson, H. C. and Kelly, W.C. 1957. Vegetables Crops 5(h Edn. McGraw till Book Co. Newyork, USA, pp. 327-335.

Uddin, A. S. M. M.; Hoque, A. K. M. S; Shahiduzzaman, M. ; Sarkcr, P. C ; Patwary, M M. A and Shiblce, S. M. A. 2004. Effect of nutrients on the yield of carrot. *Pakistan Journal of Biological Sciences.* 7 (8): 1407-1409.

Woolfe, J. A. 1989. Nutrition Aspects of Sweet Potato Roots and Leaves. Improvement of Sweet Potato *(Jpomea batatas)* in Asia; CIP. 1989. pp. 167-182.

Yawalker, K. S. 1985.Vegetable Crops in India .3rd edn. Mrs. Yawalker, K. K., Agri- Horticultural Publishing Mouse, 52, Bajaj Nagar-440010, pp. 210-220.

Zdravkovic, M.; Damjanovic, M.; Cvikic, D. and Zdravkovic, J. 2007. Effects of fertilizers on nutritive characteristics of carrot. Acta-Ilorticulturac. (729): 361-365

Appendices

APPENDIX

Appendix I. Monthly record of year temperature, rainfall, soil temperature Relative humidity and sunshine

during the period from October 2006 to March 2007 (Site-Dhaka).

Year	Month	Air Temperature(0 C)			Relative Humidity (%)	Rain Fall (mm)	Soil temper	
		Maximum	Minimum	Mean			5 cm depth	10 cm depth
2006	Oct	30.60	24.20	27.40	75.87	204	16.07	17.1
	Nov	29.85	18.50	24.17	70.12	00	13.70	14.5
	Dec	26.76	16.72	21.74	70.63	00	12.80	13.7
2007	Jan	4.05	13.82	18.93	68.79	05	11.30	11.1
	Feb	28.90	18.03	23.46	62.04	03	12.60	12.9
	Mar	32.24	22.10	27.17	67.01	160	16.50	16.70

Sources: Bangladesh Meteorological Department (Climatic Division), Agargoan, Dhaka-1212.

APPENDIX

Appendix II. Characteristics of soil from Shcr-E-Bangla Agricultural University is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

A. Morphological Characteristics of the experimental field

Morphological Features	**Characteristics**
Location	Sher-E-Bangla Agricultural University
ALZ	Madhupur Tract (28)
General Soil Type	Shallow Red Brown Terrace Soil
Land Type	I ligh Land
	1
Soil Series	Tejgoan *
Topography	Fairly Leveled
Flood Level	Above Flood Level
Drainage	Well Drained
Cropping Pattern	Fellow-Carrot

B. Physical and Chemical properties of initial soil

Characteristics	Value
PARTIAL SIZE ANALYSIS	
% Sand	28
% Silt	42
% Clay	30
TEXTURAL CLASS	5.6
PH	0.46
Organic carbon (%)	0.08
Organic Matter Total N	0.05
Available P	20.00
Exchangeable K (me/IOOgm soil)	0.12
Available S (ppm)	46

Appendix III. Analysis of variaance of different characters of carrot as influenced by plant(s) per hill and different levels o potassium

Sources of variation	Degrees of freedom	Mean square values					
		Plant height				Number	
		45DAS	60DAS	75DAS	90DAS	45DAS	60D
Replication	2	2.10	48.103	56.013	21.013	0.691	0.7
Factor A: (Number of plant(s) per hill	2	1.376	18.222	0.697	8.881	0.963	5.6
Factor B: (Levels of potassium)	3	6.082*	39.734*	35.221*	42.331*	0.315	0.5
Interaction (A x B)	6	4.971	26.962*	27.334*	15.123*	0.635	0.6
Error	22	1.861	7.192	12.614	12.310	0.915	0.4

Appendix IV. Analysis of variance of different characters of carrot as influenced by plant(s) per hill and levels of potassium

Sources of variation	Degrees of freedom	Mean square values							
		Length of root (cm)	Diameter of root (cm)	Fresh weight of leaves (g)	Dry matter content of leaves (%)	Fresh weight of root (g)	Dry matter content of root (%)	Cracked root (%)	Bra d re (%)
Replication	2	3.753	0.837	0.379	46.472	0.936	15.72	0.601	7.1
Factor A: (Number of plant(s) per hill	2	2.1132	12.663*	4.312*	34.120 NS	5.914*	7.301 NS	0.819 NS	0.8 NS
Factor B: (Levels of potassium)	3	24.936*	12.963 NS	21.348*	66.361*	25.005*	57.426*	0.776 NS	3.9
Interaction (A x B)	6	8.686*	3.695*	9.6533	41.472*	41.863**	15.444*	1.779*	12. NS
Error	22	4.003	0.983	3.0640	4.110	1.913	3.803	0.094	0.7