EFFECT OF PHOSPHORUS AND POTASSIUM ON THE GROWTH AND YIELD OF CARROT

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CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF PHOSPHORUS AND POTASSIUM ON THE GROWTH AND YIELD OF CARROT (*Daucus carrota* L.)** " submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka. In partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by **LOBNA YESMIN**, Registration No. **07- 02507**, under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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Dated: June, 2014
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ABSTRACT

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of phosphorus and potassium on the growth and yield of carrot during the period from November 2012 to March 2013. The two-factor experiment was laid out in a Randomized Complete Block Design with three replications. The experiment consisted of four levels of phosphorus, viz. P_0 (control) , P_1:65 kg, P_2 :80 kg , and P_3 :95 kg P_2O_5/ha and four levels of potassium, viz. K_0 (control), K_1:150 kg , K_2 :175 kg , K_3 :200 kg K_2O/ha, respectively. The highest root length (16.27 cm), and marketable yield (36.03 t/ha) were obtained from P_3 whereas, the control treatment gave the lowest results. On the other hand, treatment K_3 performed the highest root length (16.78 cm), and marketable yield (36.70 t/ha) and the control treatment showed the lowest results. `For combined effect P_3K_3 produced the highest root length (19.74 cm) and highest marketable yield (38.37 t/ha) and the lowest root length (10.10 cm) and lowest marketable yield (22.24 t/ha) were produced by the control. So, 95 kg P_2O_5/ha with 200 kg K_2O/ha was suitable for growth and yield of carrot.

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LIST OF ABBREVIATED TERMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
DAT	=	Days after Transplanting
DAS	=	Days After Sowing
DAP	=	Days After Planting
SRDI	=	Soil resources Development Institute
SAU	=	Sher-e-Bangla Agricultural University
et al	=	And others
mM	=	Millimolar
EC	=	Electrical Conductivity
TSP	=	Triple Super Phosphate
MoP	=	Murate of potash
RCBD	=	Randomized Complete Block Design
UNDP	=	United Nations Development programme
LSD	=	Least Significant Difference
CV	=	Percentage of Coefficient of Variation
ANOVA	=	Analysis of Variance

CHAPTER I

INTRODUCTION

Carrot (*Daucuscarota* L) is a member crop ofApiaceae family (Prince, 1987) is considered to be a native of Mediterranean region (Shinohara, 1984). It consists of about 250 genera and approximately 2800 species of widely distributed generally herbaceous plant (Rubatzky*etal.* 1999). It is mainly a temperatecrop grown during spring in temperate countries and during winter in tropical and subtropical countries of the word (Bose and Som 1990). 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, 2004).

From nutritional point of view carrot is a very important root crop. It contains appreciable amount of carotene, thiamine and riboflavin (Sharfuddin and Siddique, 1985). It is an excellent source of iron, vitamin-A, vitamin-B, vitamin-C sugar (Yawalkar, 1985). Carrot roots play an important role to protect the blindness of children proving vitamin-A. Furthermore, it has some other important medicinal values (Bose and Som, 1990). In Bangladesh the production statistics of carrot in not available.Rashid (2004) mentioned an average yield of carrot was27 tons per hectare. This production is relatively low compared to other carrot producing countries, like Switzerland, Denmark, Sweden, U.K. Australia and Israel, where the average per hectare yields are reported to 40.88, 42.67, 51.88, 54.88, 56.70 and 64.20 tones, respectively (FAO, 2004).

The low yield of carrot in Bangladesh however is not an indication of low yielding potentially of this crop, but the low yield potentialitymay be attributed to a number of reasons, viz. unavailability of quality seeds of high yielding varieties, fertilizer management, disease and insect infestation and improper irrigation facilities. To attain considerable production and quality yield of any crops it is necessary to confirm proper management including ensuring the availability of essential nutrient components in proper doses. Carrot thrives well in fertile, clay loam soil because it requires considerable amount of nutrients to sustain rapid growth in short time. A large amount of fertilizer is required for the growth and development of vegetable crops (Openа*et al.,* 1988).

Phosphorus is one of the important essential macro elements for the normal growth and development of plant. The phosphorus requirements vary depending upon the nutrient content of the soil (Bose and Som, 1990). Phosphorus shortage restricted the plant growth and remains immature(Hossain, 1990). Carrot is a short duration crop, for that easily soluble fertilizer like phosphorus should be applied in the field. On the other hand nutrient availability in a soil depends on some factors, among them balanced fertilizer is the important one.

Carrot cultivation requires supply of plant nutrients. Use of potassium fertilizer is essential for its growth and root development. All root crops respond to liberal application of potassium helps in the root development and it is essential for photosynthesis and for starch formation and its translocation from upward to downward. It is also necessary for quality of carrot.Among the yield contributing factors, application of proper doses of potassium is of great importance. However, excessive or under dose of potassium can affect the growth and yield of the crop. Only and optimum dose of potassium is necessary to produce maximum yield of good quality carrot(Farazi,1993). Muriatic of Potash (MoP) is widely used as the source of potassium because of its maximum availability from potassium and cheaper than any potash fertilizer.

From the above stated facts, it is apparent that growing plants with phosphorus and potassium may bring some promising effects on the growth and yield of carrot.

Therefore, the present study was undertaken with the following objectives:

i) to find out the optimum doses of phosphorus for maximizing the growth and production of quality carrot.

ii) to investigate the optimum doses of potassium for proper growth and higher yield of carrot.

iii) to find out the suitable combination of phosphorus and potassium for ensuring the maximum growth and higher yield of carrot.

CHAPTER II

REVIEW OF LITERATURE

Carrot (*Daucuscarota* L) is one of the most important vegetable crops of the world. From the nutritional point of view, it received much attention to the researches throughout the world to develop its production technology. So, many research works related to carrot cultivation have been carried out in our country.Some of the important and informative words and research findings related to the application of phosphorus and potassium on modified root crops so far been at home and abroad reviewed here.

2.1 Literature on phosphorus

Tareen*et al.* (2005) conducted an experiment with N, P fertilizers at 0: 0, 50:50, 65: 60, 80: 70,95: 80 and 110: 90 kg/ha were supplied to carrot cv. 'Nantes' during 2001-02 and 2003-2004 in Pakistan. The parameters tested were: leaf length, root length, number of leaves/plant, root diameter, leaf weight/plant, single root weight and root yield/ha. N: P at 110:90 kg/ha produced the maximum values for all parameters, but these values were not significantly different from those obtained with 95:80 kg/ha. During the second year, N:P at 95:80 kg/ha produced 12.24 m t/ha, while N:P at 110:90 kg/ha produced 15.25mt/ha.

A study was conducted by Araujo*et al.* (2004) in Dourados, MatoGrosso do Sul, Brazil, in 1998 to evaluate the effects of P (at 2.97, 17.68, 29.47 41.26 and 56.02 kg/ha) and chicken manure (CM) at 1.0, 6.0, 10.0, 14.0 and 19.0 t/ha on yield and shelf life of carrot cv. Brasilia roots. Harvest of plants was performed at 90 and 105 days after sowing. The combination of intermediate levels of P and CM promoted the greatest production of commercial root fresh matter, as well as small mass loss in storage for the 2 dates of harvest. The tolerable value of mass losses (14.64%) when the roots wither was higher than presented in literature (8.00%).

Uddin *et al*. (2004) conducted a 2 year field experiment 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 cowdung (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 , of NPKS and 5 t/ ha cowdung produced the highest root yield of 27.22 t /ha, which was 30.30% higher over control treatment. The highest marginal rate of return (76.33%) also obtained from the same treatment.

Anez and Espionza (2002) carried out an experiment on a Typical Humitropept sandy loam soil at santa Rosa experimental station, State of Merida, Venczuela, to determine if part of total amount of nutrient (N, P, K) of carrot (cv. Colmar) requirements, supplied with chemical fertilizer, could be substituted for organic fertilizer (poultry manure – fertipollo) without decreasing significantly the crop yield. Five levels of poultry manure “E” (0, 5, 10 or 20 t/ha) and four doses of chemical fertilizer “Q” (0, 50 kg N/ha + 16. 67 kg P_2O_5/ha + 66.67 kg k_2O/ha, 100 kg N/ha + 33.33 kg P_2O_5/ha + 133.33 kg k_2O/ha and 150 kg N/ha + 50 kg P_2O_5/ha) were tested using a split-plot arrangement of treatments in a randomized blocks design with four replications. The yield of marketable roots was significantly influenced by E × Q interaction proving that organic and chemical fertilizers complemented their effects to increase such a yield. Total root yield and biomass of top production were significantly and independently affected by the chemical fertilizer doses used.

An experiment was conducted by Lazar and Dumitras (1997) in Romania, during 1195-97 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 KCI + 150 kg NH_4NO_3/ha; and 150 kg KNO_3 + 100 kg NH_4NO_3/ha and reported that the application of KNO_3 increased the yield and quality of carrot roots.

A study was conducted by Aslam*et al.* (2003) to assess the effect of NPK fertilizers on NO_3 accumulation in carrot (*Daucuscarota*) at Ayub Agricultural Research Institute, Faisalabad, Pakistan. Four N (0, 25, 50, 75 kg /ha), three P_2O_5 (0, 50, 75 kg/ ha) and two k_2O rates (0, 25 kg/ ha) were applied. They reported that increasing fertilizer rates increased NO_3 concentration over the control in carrot. Conversely, the NO_3 concentration in carrot increased significantly over the control either with N applied alone or with P.A balanced use of N and P (2:1) fertilizers reduced the NO_3 accumulation. Additionally, the doses of NPK fertilizers applied in this study did not pose health hazards to the consumers.

Akhilesh*et al.* (2003) conducted a field experiment during the summer season of 2000 and 2001 in Lahaul valley under high-hill dry-temperate zone of Himachal Pradesh, India to study the effects of integrated use of farmyard manure, and N, P and K fertilizers on the yield components and root yield of carrot. 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_2O/ha) and 3 levels of farmyard manure (0, 10 and 20 t/ha) were evaluated in split-plot design with 3 levels of farmyard manure (0, 10 and 20 t/ha) where evaluated in split design with 3 replications. 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 highest net return (1,55,000 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 effects of N (40, 60, and 80 kg/ha) and P (20, 40 and 60 kg/ha) rates on the performance of carrot cv. ‘Nantes’ were studied by Ravinder and Kanwar (2002) in Solan, Himachal Pradesh, India during 1997/98 and

1998/99. P and 50% of the N were applied during transplanting. The remaining N was applied in equal splits and seed yield was positively correlated, whereas number of days to 50% flowering was negatively correlated with the N rate. Thus, 80 kg N/ha resulted in the greatest plant height (169 cm), secondary (10.5) and tertiary (33.8) umbels per plant, and seed yield per plant (40.5 g) or hectare (15.25) quintal). The lowest number of days to 50% flowering (166) was obtained with 0 n/ha. Similarly, the highest P rate (60kg/ha) gave the highest number of secondary (10.7) and tertiary (24.4) umbels per plant, and seed yield per plant (30.9 g) or hectare (11.65 quintal)

Dry matter content and concentration of macro elements (N, C, P, K, Ca. Mg) in field-grown cabbage and carrot produced in Estonia were determined by Lies and Lepik (2001). Concentrations of macronutrients in cabbage were N=153 and 187; P=20 and 29; K=208 and 187; Ca=28 and 33; Mg=10 and 12 mg/100 g of raw material, in 1999 and 2000 respectively. In carrot the Mean values were N=155, P=30, K=276. Ca=23, and Mg=13 mg/100 g row material. Macronutrient levels, except N, in studied crops were low compared with values published in literature.

Data on soil analysis, fertilizer use and yields were collected from carrot producers converting to integrated production in 1997, to identify changes in fertilizer practice and effects on yield by Salo*et al.* (1999). On carrot fields, the average total N rate was 80 kg/ha, which was unaffected by soil organic matter content by the preceding crop. Corresponding P rates averaged 35 kg/ha and K rate 131 kg/ha. The P rate was reducewhen 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.

Fertigation was compared to broadcast application of soild NPK fertilizer with cabbage (cv. Castello), carrot (cv. Panther) and onion (cv. Sturon) by salo*et al.* (2002) In the broadcast application. P and K were given as single application in spring and N was split according to the existing recommendations. 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 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.

A pot experiment was conducted by Gaweda (2001) during 1997-98, in Poland to study the effect of P treatment (50, 200 and 800 kg/dry weight) on Pb accumulation by carrot cultivars Karo F1 and Kama F1 and lettuce cultivars ‘Syrena’and‘Ara’. Raising P contents in the substrate from 50 to 800 mg/kg decreased carrot root Pb content on the average by 44% and in lettuce leaves on the average by 33%.

An experiment was conducted by Lyngdoh (2001) 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 starong 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 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 under the agro climatic conditions of Meghalaya.

Soils ploughed in autumn were loosened by different tillage tools, or compacted to a depth of 25-30 cm by a tractor weighing 3 Mg (once or three times) before seed bed preparation for carrot under moist soil condition was reported by Pietola and Solo (2000). Sprinkler irrigation was also applied to mineral soils when the soil moisture in top soil was 50% of plant-available water capacity, and the response of additional N application of 30 kg ha[1] was studied in an organic soil. Higher soil moisture tended to promote nutrient uptake, as the P content of carrot tap roots was increased by irrigation in loam. Compaction of organic soil low in P increased P and K contents and uptake by carrot roots and shoots. In severely compacted clay soil, the nutrient use decreased by increasing soil compactness. NO_3-N contents were the highest in early season (25-30 mg kg $^{-1}$ fresh matter) and decrease with advancing seasons.

An experiment was conducted by Zdravkovic*et al.* (2007) with different types of fertilization on some carrot cultivars. The cultivars used were: ‘Nantes SP-80’, ‘Amsterdam early’, ‘Long blunt heartless – Laros’, ‘Flaker’ and ‘Braunsvajska’ In the course of two years, 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. A non-fertilized group was also used as the control. There were significant differences depending upon the manner of fertilizer application. The average yield achieved by fertilizer application was significant. Chemical analyses were also conducted on the carrot roots and juice. NPK fertilizer application increased the contents of dry matter, ash protein, calcium and copper.

Six field studies over a 3 year period evaluated the yield response of carrot on sandy to loamy sand OrthicPodzol soils by Sanderson and Sanderson (2006) Treatments consisted of pre-plant broadcast applied P at 0, 33, 66, 99 or 132 kg /ha on sites where residual P levels ranged from 81 to 162 micro g P. When the total yield response of carrots to increasing P levels was fitted to a quadratic response curve, 110 kg p/hawas required to achieve maximum yield, but an application of as little as 22 kg P/ha resulted in 95% of maximum marketable yield. This reduce application rate resulted in a saving of 88 kg P/ha and slowed the buildup of soil P levels. Therefore, by applying more conservative amounts of P fertilizer carrot growers can maintain excellent crop yield while reducing the potential for environmental damage caused by the buildup of soil P.

A research project was carried out by Hasanoghli*et al.* (2007) in Tehran region. Iran for two years to investigate the capabilities of soil and plant in the absorption and storage of waste water contaminants, namely phosphorus, and its transport to drain depth as a result of irrigation practice. A series of lysimeters based on a statistical l fact pea experiment in the form of randomized complete design (3×3×3) were used. Raw and treated domestic waste water, obtained from Ekbatan Housing Complex and well water (control) were used to irrigate raw edible vegetables including parsley, carrot and tomato. Results showed that the amount of phosphorus leaching through soil to drain depth was between 0.90% and 3.56%, and between 1.03%, and 4.15% of the phosphorus concentration in raw waste water and treated one entered into the soil, respectively. Also, mass balance analyses showed that the average phosphorus reduction ranged from97.2% to 99.9% of the phosphorus that entered with waste water.

The level and accumulation of nutrients in Peruvian carrot under 3 levels of N (0,150 and 300 kg/ha), P_2O_5 (0, 80 and 160 kg/ha) and k_2O (0, 80 and 160 kg/ha) were studied by Portz*et al.* (2006). The nutrient contents of leaves, corms 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,and at 300 DAT, respectively. The fertilizer treatments had significant effects on the nutrient content, but had no significant effects on commercial root production.

A field study was conducted by Selvi*et al.* (2005) 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 day 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 170:135:170 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.

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 by sady*et al.* (2004). The level of nitrate accumulation in carrot roots depended more on the soil (organic matter content) and on the climate conditions then on the fertilizer application factors. Bioaccumulation of cadmium in carrot roots depended both on the soil properties and on the applied fertilizers.

An experiment was conducted by Nigussie*et al*. (2003) in a glasshouse with six P levels: 0, 12, 27, 73, 124 and 234 mg P/kg soil, and with six replications. Cabbage attained 80% of its maximum yield already at the level of no P supply, whereas carrot and potato reached only 4 and 16% of their highest yields respectively at this level of p supply. This indicated that cabbage was P-efficient compared to carrot and potato. Root/shoot ratio increased in the order of cabbage<carrot> potato, and was enhanced at lower P levels. Root hair length was not affected by P level, and averaged 0.22, 0.03 and 0.18 mm for cabbage, carrot, and potato respectively.

Pietola and Salo (2000) reported that higher soil moisture tended to promote nutrient uptake, as the P content of carrot tap roots was increased by irrigation in loam. Compaction of organic soil low in P increased P and K contents and uptake by carrot roots and shots. In severely compacted clay soil, the nutrient use decreased by increasing soil compactness. NO_3-N contents were the highest in early season (25-30 mg/ kgfresh matter) and decreased with advancing season. In loam, NO_3-N content was increased by irrigation of loosening Increasing the N fertilization of organic soil from 30 kg /ha to 60 kg/haincreased the NO_3-N content 30% soil type and its nutrient status, weather conditions, and growth stage had much more significant influence on the P, K, and Mg contents of carrots then soil treatments.

In a field experiment was conducted by Sparrow and Salardini (1997) on Tasmanian ferrosols (humiccutrudox), potatoes (*Solamumtuberosum*) were planted successively for 2 more seasons on plots which had been limed 2 or 3 years earlier. Carrots (*Daucuscarota*) cv. Red Count were grown in these plots 5 years after the liming. Tuber cadmium (Cd) concentrations were not affected by liming in the first potato crop. In the 2nd potato crop. In the 2nd potato crop, lime decreased tuber Cd by about 30% and carrot root Cd by about 50%. This decrease was attributed to more even and deeper mixing of the lime with the soil during the first potato harvest. Phosphorus (p) fertilizer residues from the earlier potato crops did not significantly affect tuber or root Cd, but there was a positive effect I site where some high Cd-containing P fertilizer had earlier been used. Neither time nor P fertilizer residues affected potato nor carrot yields.

Vieira *et al*. (1997) carried out field trials in 1993 in Dourados, MatoGrosso de sul, Brazil. They applied 5 rates of P ranging from 4.3 to 81.7 kg/ha, as triple superphosphate, and 5 rates of poultry manure ranging from 1 t/ha to 19 t/ha. In general, there was negative interaction between high rates of P and high rate of poultry manure. The physiological causes of physiological of poor performance under regimes of excessive P are examined.

Jaiswal*et al.* (1997) conducted three pre-production cortication trials, one each on off-season (summer) radish, carrot and Chinese cabbage. Carrot cultivars ‘New kuroda’ ‘Early Nantes’ performed well during the off-season (summer) with‘Early Nantes’ performing slightly better than ‘New Kuroda’. On average (over 10 locations) ‘Early Nantes’ out yielded “New Kuroda’ by 14% irrespective of mulching practice. Farmers and consumers from most of the sites preferred ‘Early Nantes’ for its good yield, attractive root colour and shape, and comparatively higher root sugar content. The use of mulching in carrot was not found useful at any location and produced 710% higher root yields than ‘Minu Early’ and was much preferred by farmers for its bolting resistance, fiber-less roots, marketable root size and shape, low damage in transport and ability to grow even under moisture stress conditions. Similarly, application of chemical fertilizers (80 kg N + 40 kg P_2O_5 + 30 kg K_2O/ha) in addition to compost (40 t/ha) was beneficial at most sites and on average it increased root yield by 43%.

In studies by Volkova (1996) in 1993-94 growing carrots on a sod-podzolic medium clay loam soil, it was found that plant nitrate content depends on the carious conditions under which the plants are grown. Application of increasing rates of N in the form of ammonium nitrate increased of nitrates in the carrots. The optimum fertilizer rate to obtain acceptable crops on this soil is 120 kg N + 120 kg P + 120 kg K, producing a yield of 40-50 t carrots/ha. Using ammonium and amide forms of N plus potassium sulfate and trace Clements, it is possible to produce carrot crops without exceeding the permissible NO_3 level.

Carrots of the table cultivar ‘Losinoostrovskaya 13’ were grown on floodplain alluvial soils in the Moscow region with various NPK fertilizer regimes by Petrichenko*et al.* (1996). The carrots were stored in a cool chamber at 0-1 degrees C, RH 90-95%, in polyethylene bags of capacity 20-25 kg. The carrots were sampled periodically, and quality and losses were determined. The results showed that storage quality depended on the fertilizer regime. Disease incidence and losses were lowest in carrot given 60 kg P + 150 kg K/ha or 90 kg N + 60 kg P+ 150 kg K/ha, which gave yields of 60 t/ha.

Konopinski (1995) carried out a field trials near Lublin, Poland, with carrot cv. ‘Perfection’ and beetroot cv. ‘Czerwona Kula’ 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% P_2O_5, 1.5% SO_3plus all essential microelements. Super Fertilizing was applied at 50 or 100 kg/ha. Using the 100 kg/ha rate give the best yield increase in carrots beetroots, viz. 70 and 30% over the control, respectively. Crop quality was also best in this variant.

In a trial conducted by Kadi*et al.* (1994) at the BajoSeco experimental stat in Venezuela, carrot cv. Super Flakkee seeds were sown on 22 Feb. on an OrthoxicTropudultsUltisol soil to which 0-200 kg P_2O_5, 0-300 kg K_2O and 0-40 t poultry manure/ha had been applied. Thinning was carried out on 15-18 Apr. So that the distance between was 3, 6, 9, 12 or 15 cm.

The highest yield at harvest (95.6 t/ha) was obtained with 150 kg P_2O_5 + 222 kg K_2O + 10 t poultry manure/ha and a distance of 12 cm between plants (equivalent to 5,55,555 plants/ha), but the results were not statistically significant.

The effects of N, P, K, S and Ca rate and irrigation regime were studied by Eppendorfer and Eggum (1995) on pot experiments on carrot cv. Nandor. Carrot root DM yields ranged from 27 to 320 g/pot. Yields were reduced most by P and least by s deficiency fiber content was only slightly affected by the treatments. In balance trials with rats, increasing protein concentrations in carrot DM increased the true digestibility of protein 70 to 78%. Digestible energy and gross energy were also increased, from 73 to 83% and from 16.2 to 17.4 g/kg, respectively.

Carrot (cv. Kangston) plants were grown by Hole and Scaife (1993) from seed for 28 days in a range of nutrient solutions omitting N, P, K, Ca, S, Mg, Fe, B, Mn, Zn, Cu and Mo as separate treatments. All treatments except those Mn, Zn, Cu and Mo resulted in effects on plant growth and the development of deficiency symptoms. Parameters governing the shape of the relationship between fractional relative growth rate and plant nutrient concentration were altered until the model predicted the observed final mean DW of deficient plants and time of divergence of this growth curve from that of fully nourished plants. Critical concentrations so obtained were higher than those previously reported for Ca, Fe, N and P in carrots and lower for K, Mg and S.

2.2Literatures on Potassium

Zdravkovic*et el.*(2007)conducted an experiment in different types of fertilizer on some control 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. Therewere 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 cultivators (from) Amsterdam early 27.06 t/ha until Faker 57.52 t/ha and years. There were also significant differences in the cultivars and year correlation.

Pekarskas and Bartaseviciene (2007) an experiment was conducted in Lighuania,during 2001-04, to determine the effect of different potassium fertilizer forms on ecologically cultivated carrot yield and quality Treatment with 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.

Hochmuth*et al.* (2006) conducted Potassium (K) is required for successful carrot (*Daucuscarota*) 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 rated of fertilization may improve vegetable quality. Carrots were grown in three plantings during the winter of 1994-95 in Gainesville,Fa. to test the effect 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. Yield of U>S. No.1 grade carrots and total marketable carrots were not affected by K fertilization. K fertilizer was no required on this soil even though the University Florida Cooperative Extension Service Recommendation was 84 lb/c acre K. Neither soluble sugar nor icarotenodconcentrations in carrots roots were affected by K fertilization. The current K recommendation for carrot 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. Difference 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 (1.90-198%), while N at 170 kg/ha resulted in higher total N values (1.80-1.86%).

Zalewska (2005) a pot experiment was carried out to study the effect of various Ca, Mg, K and H saturations of soil CEC on the yield mineral composition of carrot. A decrease in Kg saturations of CEC to the level approximately 5.7% and 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% and a simultaneous decrease in Mg saturation from 13.3 to 4.7% caused an increase an 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.

Kancheva*et al*. (2004) cv. Nantski were supplied with 0,8, 16 and 24 kg N,P and K/ha in a field experiment conducted in Bulgaria. Results are present on the optimum combinations of fertilizer in Bulgaria. Results are presented on the optimum combinations of fertilizers that will give high carrot yield an 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 two different soils were carried out. The level of nitrate accumulation in carrot roots depended more on the soil (organic matter content) an 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 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.

Kadar (2004) results are presented of experiment conducted in Budapest, Hungary, to the study the effects of N, P and K fertilizers (alone and in combination) on the development, were infestation and yield of carrot cv. Vorosoriasan on the mineral composition of the foliage and roots.

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 (*Daucascarota* cv. Nantes). Three levels of N, P and K (50, 100 and 150% of the recommended rates of 50:40:35 kg N: P_20_5: K_2O/ha) and 3 levels of farmyard manure (0, 10 and 20 t/ha) were evaluated in split-plot design with 3 replication. The application of 20 t/ha farmyard manure 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 foot 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 (155000 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, P_2O_5 and K_2O rates by 25, 20 and 15 kg/ha, respectively.

Feller *et al.* (2003) new data are presented from an farm nutrients measurements during 1999-2001 in spring onions, bunching carrots, Japanese radish, dill, lambs lettuce, rocket salad, celeriac 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 are compared with data published in 2001.Data are within a 10% variation range, however Japanese radish an 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/ha), rocket salad (100 kg N/ha) and lambs lettuce (38 kg N/ha). For rocket salad, nitrogen uptake curves modeled and measured the uptake by 40% for June-sown plants.

Solo *et al.*(2002) fustigations was compared to broadcast application of solid NPK fertilizer with cabbage (cv. Castello), 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 spit according to the existing recommendations. In the fustigation applications, nutrient were given according to the expected nutrients uptake were monitored by monthly sampling. In 1998, growing season was expected. However, leaching seemed to have no impact in the sandy experiment soils, as broadcast application resulted in good growth of cabbage and onion. In 1999, natural rainfall was low and irrigation was applied according to tension meter measurements. Treatment did not affect carrot and onion growth, but cabbage growth and nutrients uptake were still decreased by fustigation towards the middle of growing period. At harvest, cabbage yields and nutrients 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 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. Fertilizer application 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.

Subrahmanyam*et al.* (2000) field experiments were conducted to determine the effect of foliar feeding with 0.1 and 0.5% water-soluble fertilizers (MultiK,PF 19-19-19 + micro elements (ME),PF 19-09-19+Mgo + ME an POF 17-10-27 + ME) on carrot (*Daucascapitata L*) 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 (13-0-46) alone increased yield by 25, 24.4 and 25.9% in brinjal cabbage and carrot, respectively. The highest and lowest additional yields were 12.5 and .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 spry 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 19-09-19 + ME. Both cabbage and carrot yields increased when the concentration of PF 19-09-19 + 2MgO + ME was increased. A decrease in the yields of all 3 crops was observed with the increased in concentration of PF 17-10-27 + ME.

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 identity changes in fertilizer practice and effects on yield. On carrot field, the average total N rate was 80 kg/ha. 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 not 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 and K rates 52 kg/ha. There was no evidence that these fertilizer rates were adjusted for soils 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 recommendations rates could be reduced even further.

Flick *et al.* (1988) 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 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 KCI + 150 kg NH_4NO_3/ha and 150 kg KNO_3 + 100 kg NH_4NO_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 KNO_3increased the yield and quality of carrot roots.

Singh (1996) the effect of N (50, 100 or 150 kg/ha) and K (20,40,60 or 80 kg/ha) on carrot (cv. Pusakesar) seed yield were investigated in the field during winter seasons of 1992-93 and 1993-94. Pant height, number of umbels/plants and seed yield increased with increasing rates of N. Maximum plant height (mean of 148.95 cm), number of umbles/plant (46.27) and seed yield (9.84 q/ha) were recorded following application of 150 kg N/ha. The number of umbles/plant and seed yield also increasing rates of K, the highest seed yield(mean of9.35 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 at0, 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 Lubin, Poland, with carrot cv. Perfection. The plants received N:P:K at150:150:300 kg/ha (control) or Super Fertilizer of French manufacture containing 11% organic matter, 14% Ca, 3.5% Mg, 4% P_2O_5, 2.5% SO_3 plus all essential microelements. Super Fertilizer was applied at 50 or 100 kg/ha. Using the 100 kg/ha Using the 100 kg/ha rate gave the best yield increase in carrot viz, 70 and 30% over the control respectively. Crops quality was also best in the variant.

Sharangi and Paria (1995) carried out an experiment where carrots (cv. PusaKesar) were grown in the winter seasons of 1992 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 at60 kg/ha. The crop was harvested 120 days after sowing. Shoot growth, root diameter, 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, than 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 Saco experimental station inVenezuela with carrot cv. Super Fluke. Seeds were sown on 22 Feb on an OrthoticsTropudultsUltisol soil which 0-200 kg P_2O_5, 0-300 kg K_2O and 0-40 kg poultry manure/ha had been applied. Thinning was carried out on 15-18 April so that the distance between plants was3, 6, 9, 12 or15 cm. The highest yield at harvest (95.6 t/ha) was obtained with 150 kg P_2O_5 + 225 kg K_2O) + 10 t poultry manure/ha and a distance of 123 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_2O/ha as KCI or K_2SO_4 on growth yield and quality of carrot. Mean root weight and yield were highs at 50kg K_2O/ha. Carotene content was increased by K application.

Baloochet *al*. (1993) carried out a field trial during 1988-89. Tandojam carrots were grown from seed in seedbed to which 75 and 100 kg $P_2O_5$and 75, 100 or 125 kg K_2O/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 due to increase root size and weight.

Abo-Sedera and Eid (1992) stated in a field trail 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_2O at 30 and 24, 45 and 48 or 60, 72 kg/feddan respectively in 2 equal application, 4 and 8 weeks after sowing. Overall, the best results, in terms of vegetative growth, yield and quality, weight were obtained with 60 kg N + 72 kg K_2O /feddan.

Pill *et al.* (1991) incorporation of 15 g of 9:8: 12.5 N: P: K fertilizer of fluid drilling get increased shoot fresh weight compared with untreated, primed or hydrated seeds under greenhouse condition. When these same treatments were applied under field condition, 15 g of 9: 8:12.5 N: P: K fertilizer/litter increased economic root fresh weight but the seed treatment had liter effect.

Grigrov (1990) on medium or heavy loamy soil in the 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 application (4400 m water/ha) were required in dry years and 8 applying N:P :K at 60:130: 20 kg/ha and 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 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.Theindicates that the residual effect 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 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 and significant effect on root diameter and fresh weight and had no significant effect on root length.

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

Bruckner (1986) conducted an experiment over3 years and reported that increasing the N supply (0-200 kg N/ha) produced a relatively small increases in yield. N at 100 kg/ha gave the best yield without increasing the content of carrots. Cultivars Flakkeer RZ and FalkkerKaraf had a high uptake of K_2O (242.8-326.6 kg/ha) and low uptake of P_2O_5 (62.3-64.4 Kg/ha), Ca(39.1-58.0 kg/ha) and Mg (19.0-26.98 kg/ha).

Jacobson *etal.* (1986) reported that the effect of fertilizer was studied in a field trial involving N, P, K 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 increase of cavity spot was least at the lowest rate N and at all rates of N was less with the formulation containing the lower level of K.

Krarup*et al*. (1984) conducted an experiment where chant nay carrot were fertilized with K_2O (0,100 0r 200 units/ha).There wereno difference in total yield with the medium and high K_2O levels.K_2O content regards 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 yield and content) varied with the level of application; from 63.35 to 94.33 kg/ha for K_2O. Leaf and root K_2O content and the level of K_2O extraction were lower than expected.Probably due to the characteristics of the soil, which deficient in K.

Farazi (1993) while conducting as experiment on spacing and application of fertilizer concluded that the highest yield of carrot (454 t/ha) was obtained from the crop fertilized with the highest of N (112 kg N/ha), and potash had no significant effect on then 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 and 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 content Nitrogen at 0-180 kg/ha and potash at 0-196 kg/ha were applied in 12 difference treatments. Basal nitrogen application at 60 kg/ha and basal potash 151.2 kg/ha gave the best yield an quality of carrot.

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. Pusakesar) seed yield were investigated in the field during winter seasons of 1992-93 an 1993-94. Plant height (46.27 cm) and seed yield (9.84 q/ha) were recorded following application of 150kg 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 al*. (1992) conducted a experiment on carrot cv. Red Cored Chantenay where seeds were sown (at a rate of 2 kg seeds/feddan) and 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, 80 and kg/feddan, respectively. Controls were not fertilized. Plants were harvested in January. Sowing in 3 drills/bed resulted in greater plant height. Leaf weight/plant, average root weight/plant, average root weight, root length, total plant FW and yield increased with increasing fertilize application rates up to 40 kg N+36 kg P_2O_5 + 49 kg K_2O/feddan. The highest and lowest yields were obtained with fertilizer rate (2) + 3 drills/bed(32.7 t/feddan) an no fertilizer + broadcast sowing (19.7 t/feddn), resp. (1 feddan 0.42).

Yu *et al.* (1981) found the highest tuber yield with water hyacinth mulch followed by rice straw. In another experiment of groundnut it was observed that the microbial population as fungi, actinomycetes, ammonifying bacteria, N-fixing bacteria and phosphobacteria in mulched plots were 58.3, 74.3 and 56.1% higher, respectively than the control.Mulching increased the growth of bacteria, fungi, algae and dactinomycetes in soil Gour and Mulargee (1990).

Jacobson *et al.* (1980) mentioned that black polythene sheets placed on the soil during the hot season increased soil temperature by 4-120C in the upper 5 cm layer and thereby controlled the weed in the mulched plots where carrot grew normally.

Roa (1994) conducted a field experiment on red sandy loam soils, the effect of K at 0, 50, 100 and 0, 50, and 200 kg K_2O/ha asKCl or K_2SO_4on growth, yield and quality of carrot. Mean root weight and yield were highest at 50 kg K_2O/ha Carotene content was increased by K application.

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

The above literature showed the importance of phosphorus and Potassium in case of carrot production. Hence the research work has been under taken to examine the influence of phosphorus and potassium on the growth yield of carrot.

CHAPTER III

MATERIALS AND METHODS

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

3.1 Experimental site

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2012 to

March 2013. The site is situated between 23 ^{0} 41$^/$ N latitude and 90 ^{o} 22$^/$ E longitude and at a altitude of 8.6 m from sea level.

3.2 Climate

The experimental area is situated in the subtropical zone, characterized by heavy rainfall during Kharifseason (April to September), and scanty in Rabi season (October to March). Rabi season is characterized by plenty of sunshine. Information regarding average monthly maximum and minimum temperature, rainfall and relative humidity, soil temperature as recorded by the Bangladesh Meteorological Department (climate division) Agargaon, Dhaka, during the period of study have been presented in Appendix III.

3.3 Soil

The soil of the experimental area was medium high land type and belongs to the Modhupur Tract and AEZ No. 28 (UNDP and FAO, 1988). The analytical data of the soil sample collected from the experimental area were determined from the Soil Resource Development Institute (SRDI), Farmgate, Dhaka,have been presented in Appendix II. The experimental site was a medium high land and the pH of the soil was 6.7.

3.4 Experimental design and layout

The two-factor experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 195.75 m^2 was divided into three equal blocks. Each block was divided in to 16 plots where 16 treatments were allotted at random. Thus, there were 48 (16×3) unit plots altogether in the experiment. The size of each plot was 1.5×1 m. The distance between blocks and between plots were kept respectively 1 and 0.5 m. A layout of the experiment is shown in figure 1.

3.5 Treatments of the experiment

The experiment was designed to study the effect of different levels of Phosphorus and Potassium on growth and yield of carrot. The experiment consisted of two factors which are as follows:

Factor A: Phosphorus (four levels)

i)P_0:0 kg P_2O_5/ha (control)

ii) P_1 : 65 kg P_2O_5 /ha

iii) P_2: 80 kg P_2O_5 /ha

iv)P_3: 95 kg P_2O_5 /ha

Factor B: Potassium (four levels)

i) K_0 : 0 kg K_2O/ha (control)

ii) K_1:150 kg K_2O/ha

iii) K_2: 175 kg K_2O/ha

iv) K_3: 200 kg K_2O/ha

There were altogether 16 treatment combinations such as: P_0K_0, P_0K_1, P_0K_2, P_0K_3, P_1K_0, P_1K_1, P_1K_2, P_1K_3, P_2K_0, P_2K_1, P_2K_2, P_2K_3, P_3K_0, P_3K_1, P_3K_2 and P_3K_3.

3.6 Land preparation

The land which was selected to conduct the experiment was opened on 5 November, 2010 with the help of a power tiller and then it was kept open to sun for 7 days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. Deep ploughing was done to have a good tilth, which was necessary for getting better yield of this crop. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth.

3.7 Application of Manures & Fertilizers

The following doses of manure and fertilizers were used for carrot production according to Rashidand Shakur(1986).

Manures/fertilizer	Dose
Cowdung	10 t/ha
Urea (as Nitrogen)	140 kg/ha
Triple Super Phosphate (as P_2O_5)	as treatment
Muriate of Potash (as K_2O)	as treatment

In the experimental plots total amount of Cowdung (10 ton /ha) and Phosphorus (as per treatment) were used as basal dose. Nitrogen & Potassium were used equal three splits according to the experimental design. The applied manures were mixed properly with the soil in the plot using a spade.

3. 8 Collection and sowing of seeds

The seeds of carrot cv. 'New Kuroda', was used in the experiment. The seeds were in a sealed container, and procured by the Dhaka Seed Store, Dhaka. The seeds were soaked in water for 24 hours and then wrapped with piece of thin cloth. The socked seed were then spreaded over polythene sheet for 2 hours to dry out the surface water. This treatment was given to help quick germination of seeds.The treated seeds @3Kg/ha (Rikabdar, 2000) were sown is field on 29 November 2013. Small holes of about 1.5 cm depth were made at a distance of 15 cm. Along the row spaced at a distance of 25 cm, three or four seeds were placed in each hole and covered with loose soil.

3.9 Intercultural operations

3.9.1 Thinning out

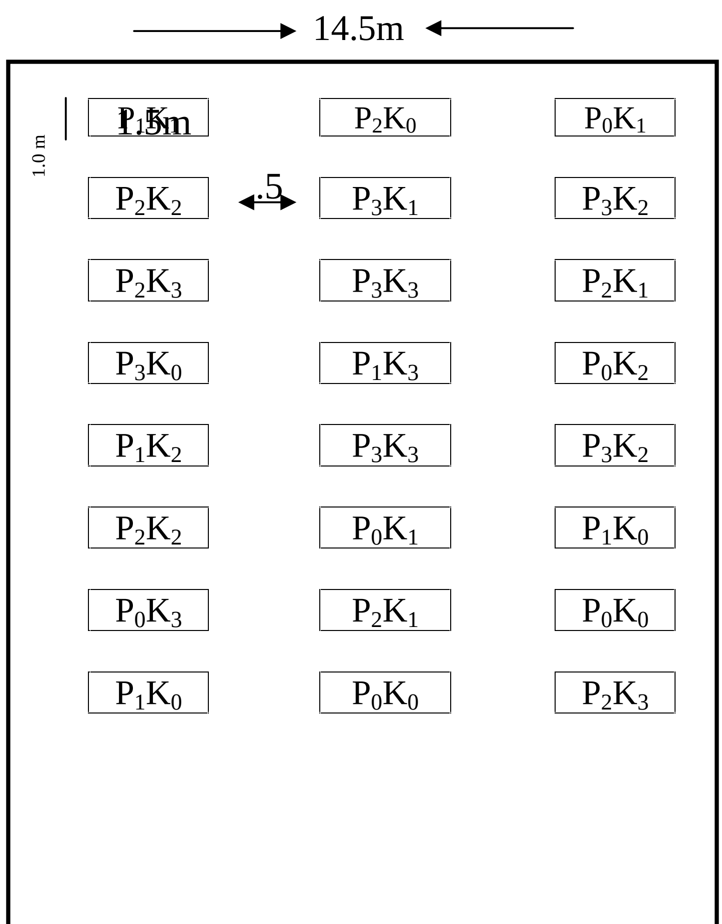
Seedling emergence was completed within ten days and when the attained a height about 20 cm were thinned out two times. First thinning was done after 20 days of sowing, leaving two seedlings in each hill. The second thinning was done ten days after first thinning, keeping only one seedling in each hill.

3.9.2 Weeding

Weeding was done four times in plots to keep plots free from weeds.

3.9.3Pest management

Mole cricket, field cricket and cutworm attack were the serious problems for carrot cultivation. As a preventive measure against the insect pest, Dursban 20 EC was applied @ 0.2% at 15 days interval for three times starting from 20 days after sowing.



P_2K_0	P_0K_1	P_1K_2
P_3K_0	P_3K_0	P_0K_2
P_3K_3	P_1K_1	P_3K_2
P_2K_2	P_2K_1	P_2K_0
P_1K_3	P_2K	P_0K_2
P_0K_3	P_0K_0	P_1K_3
P_1K_2	P_1K_0	P_3K_1
P_1K_1	P_2K_2	P_3K_3

Number of treatment combinations =16,Unit plot size=1.5 × 1m
Plot spacing:=0.5m
Between replication=1.0 m

Factor A: Phosphorus (Four levels)
P_0 = Control (0 kg P_2O_5/ha)
P_1 = (65 kg P_2O_5/ ha)
P_2 = (80 kg P_2O_5/ ha)
P_3 = (95 kg P_2O_5/ ha)

Factor B: Potassium(Four levels)
K_0 = Control (0 kg K_2O/ha)
K_1 = (150 kg K_2O/ha)
K_2 = (175 kg K_2O/ha)
K_3= (200 kg K_2O/ha)

Fig 1. Layout of the experimental field

3.9.4 Diseases management

The crop was healthy and disease free and no fungicide were used.

3.10 Harvesting

The crop was harvested on 19 March 2014 i.e.90 days after sowing (DAS). Harvesting of the crop was done plot wise. It was done by uprooting the plants by hand carefully. The soil and fibrous roots adhering to the conical roots were removed and cleaned.

3.11 Data collection

Data on the following parameters were recorded from the sample plants during the course of experiment. Ten plants were sampled randomly from each unit plot for the collection of data. The whole plot was harvested to record per plot yield.Data were collected on different growth, yield components and yield. The plants in the outer rows and at the extreme end of the middle rows were excluded from the random selection to avoid the border effect. The following observations were made regarding plant growth, yield and yield attributes.

The following parameters were recorded:

3.11.1 Plant height

Plant height was measured in centimeter (cm)by a meter scale at 45, 60, 75 and 90 DAS from the point of attachment of the leaves to the root (ground level) up to the tip of the longest leaf.

3.11.2 Number of leaves per plant

Number of leaves per plant of ten random selected hills was counted at 45, 60, 75 and 90 DAS. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from the counting andthe average number was calculated.

3.11.3 Fresh weight of leaves per plant

Leaves were detached by a sharp knife and fresh weight of the leaves was taken by a triple beam balance at harvest (90 DAS) and was recorded.

3.11.4 Dry matter percent of leaves

From the random samples of leaves weighing 200 g were cut into small pieces and then sun dried for two days. Sun dried samples were then put in paper packets and oven dried for 72 hours at 70 to 80^{0}C in an oven. After oven drying, leaves were weighed. An electric balance was used to record the dry weight of leaf and it was calculated on percentage basis. The percentage of dry matter of leaves was calculated by the following formula.

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

3.11.5 Length of root

The length of the conical roots was measured in cm with the help of a meter scale from the proximal end of the conical root to the last point of the tapered end of the root (distal end) in each treatment.

3.11.6 Diameter of root

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

3.11.7 Fresh weight of root per plant

Underground modified carrot roots of ten selected plants were made detached by a knife from the attachment of the stem and after cleaning the soil and fibrous root fresh weight was taken by the triple beam balance in gm and then the average value was calculated.

3.11.8 Dry matter Percent of root

Immediately after harvest, the roots were cleaned thoroughly by washing with water. Then from the roots, a sample of 100 g was taken randomly and cut into small pieces. The small pieces were sun dried for 3 days, and then oven dried for 72 hours at 70 to 80^0C. Immediately after oven drying, the dried root pieces were weighed and the dry matter content of the roots was calculated by the following, formula.

$$\frac{\text{Constant dry weight of roots}}{\text{Fresh weight of roots}} \times 100$$

% Dry matter of root = $\frac{\quad}{\quad}$

3.11.9 Percentage of cracked roots

At harvest, among the carrot roots the number of cracked roots was counted. Then percentage of crack roots was calculated according to the following formula.

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

3.11.10 Percentage of rotten roots

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

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

3.11.11 Gross yield of roots

A balance was used to record the gross weight of the harvested roots. All leaves were removed from the plant by a sharp knife and weight of the roots was taken in kilogram (kg) from each unit plot.

3.11.12 Marketable yield of roots per plot

It consisted of only good quality roots per plot other than cracked and rotten roots. The marketable roots were weighed and expressed in kilogram (kg).

3.11.13 Gross yield of roots per hectare

The yield of roots per hectare was calculated in tonne by converting the total yield of roots per plot.

3.11.14 Marketable yield of roots per hectare

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

3.12 Statistical analysis

The data collected from the experimental plots were statistically analyzed. The mean value for all the treatments was calculated and the analysis of variance for most of the characters was accomplished by F variance test. The significance of difference between pair of means was tested by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the effect of different levels of phosphorus and potassium on the growth and yield of carrot. The analyses of variances for different characters have been presented in Appendices IV. Data on different parameters were analyzed statistically and the results have been presented in Tables 1 to 8 and Figures 1 to 6. The results of the present study have been presented and discussed in this chapter under the following headings.

4.1 Effect of phosphorus and potassiumon growth and yield of carrot.

4.1.1 Plant height

The plant height was recorded at different stages of growth i.e. 45, 60, 75 and 90 (DAS) (Appendix IV). The plant height varied significantly due to the application of different levels ofphosphorus and potassium (Fig. 2). During the period of plant growth, the highest plant height was observed in treatment (P_3) which was followed by (P_2), (P_1) and control (P_0) respectively. At 75 days after sowing the longest plant (46.52 cm) was obtained from $P_3$and the shortest plant (42.93 cm) was obtained from the control treatment (P_0).The plant height at 90 DAS (44.95 cm) which was found less than that of 75 DAS probably due to senescence of the plant. In general, plant height increased gradually in the early stages of sowing and decreased at the later stage of the plant development. Rashid (1986) also reported similar results in plant height variation over the period of crop growth.The plant height varied also significantly due to application of different levels of potassium (AppendixIV). The plant height of carrot increased linearly with increasing time up to a certain level and then decreased (Fig. 3). At 75 DAS, the longest plant (48.66cm)was obtained from K_3which was similarto K_2(47.16cm) and the control treatment (K_0)gave the shortest plant (43.89 cm).At 90 DAS,the plant height 46.46 cm was obtained from K_3 and the shortest plant (41.12 cm) was found from K_0. This decrease in plant height was probably due to senescence of plant. Mesquta*et al*. (2002) in their experiment reported that after a certain periodthe plants became short due to senescence of the longest leaves in plants.The plant height was significantly influenced by the combined effect of phosphorus and potassium (AppendixIV). However, thelongest plantof 48.13 cm was found from the treatment combination of P3K_3 and the shortest plant 34.50 cm was obtained from the control treatment combination (P_3K_3) at 75DAS (Table 1).

4.1.2 Number of leaves per plant

A significant variation was found due to application of different levels of phosphorus on number of leaves per plant (Appendix IV). At 75 DAS, the maximum number of leaves per plant was produced for all the treatments having the highest number of leaves per plant (12.40) by the application of 95 kg P_2O_5/ha (P_3)and the minimum number of leaves (10.73) was found under the control treatment). However, after 75 DAS the number of leaves per plant was found to be decreased gradually. At 90 DAS, the maximum number of leaves (12.04) was produced by the application of 90 kg P_2O_5/ha(P_3) and minimum number of leaves (8.90) was recorded under control treatment. The comparison showed that the number of leaves was greater at 75 DAS than that of 90 DAS (Fig 4). It may be mentioned here that, the number of leaves increased more rapidly during early period of crop growth and leaf number decreased at later stage due to senescence phase of plant.

Table 1. Combined effect of different levels of phosphorus and potassium on plant height of carrot

Treatments combination	Plant height (cm) at different days after sowing			
	45 DAS	60 DAS	75 DAS	90 DAS
P_0K_0	16.42 g	30.55 f	34.50 f	28.75 h
P_0K_1	18.60 fg	36.78 c-e	40.12 c-e	36.75 ef
P_0K_2	20.71 d-f	38.57 b-d	42.10 bc	38.38 c-e
P_0K_3	22.64 def	39.18 bc	42.66 bc	39.39 c-e
P_1K_0	18.51 fg	33.50 ef	37.55 ef	31.05 h
P_1K_1`	26.58 d-f	42.99 a	47.04 a	39.97 c-e
P_1K_2	28.49 bc	43.01 a	47.46 a	45.18 a
P_1K_3	30.08 b	43.37 a	47.50 a	45.72 a
P_2K_0	18.98 e-g	34.80 de	38.08 d-f	32.74 fg

P_2K_1	21.14 d-f	38.15 b-d	40.75 b-d	37.42 bc
P_2K_2	28.31 b	43.00 a	45.59 ab	42.70 a-d
P_2K_3	28.60 b	43.16 a	47.47 a	43.67 a-c
P_3K_0	22.32 de	38.02 b-d	40.52 c-e	38.33 d-f
P_3K_1	23.70 cd	40.71 ab	44.13 a-c	38.08
P_3K_2	30.43 ab	43.23 a	47.55 a	44.46 ab
P_3K_3	32.32 a	44.29 a	48.13 a	45.53 a
$LSD_{(0.05)}$	3.410	3.301	3.640	4.621
CV (%)	9.86	7.92	8.65	8.97

In a column means having similar letters are statistically similar and those having dissimilar letter difffer significantly as per .05 level of probability.

Significant variation was found in case of number of leaves per plant due to different levels of potassium (Appendix IV). The number of leaves increased with the advancement of time up to 75 DAS and than after decreased gradually. At 75 DAS, K_3 produced the maximum number of leaves (12.79)andcontrol treatment showed the minimum number of leaves (9.76) per plant. Such response may be accounted for the physiochemical and biological improvement occurred in the soil including favorable temperature and moisture regimes, nutrient availability and microbial activity that occurred in carrot plant. But at 90DAS, the number of leaves (12.43) was found to be decreased compared to 75 DAS for all observation whichwas occurred due to leaf falling by senescence of plant (Fig. 5).

The number of leaves per plant was significantly influenced by the combined effect of phosphorus and potassium (Appendix IV). At 75 DAS, number of leaves per plant was recorded to be the highest (13.35/plant) from the treatment combination of P_3K_3. The lowest number of leaves (9.02/plant) was observed from the control plot where no phosphorus and potassium were used (Table 2). The results also agreed with the findings of portz*et al*.(2006) and Roa(1994).

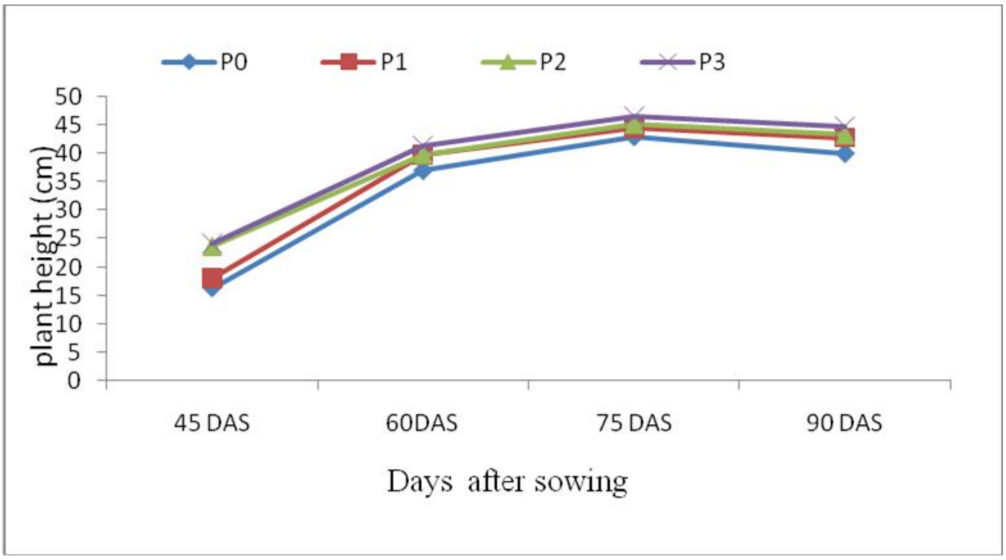


Fig.2. Effect of phosphorus on plant height of carrot

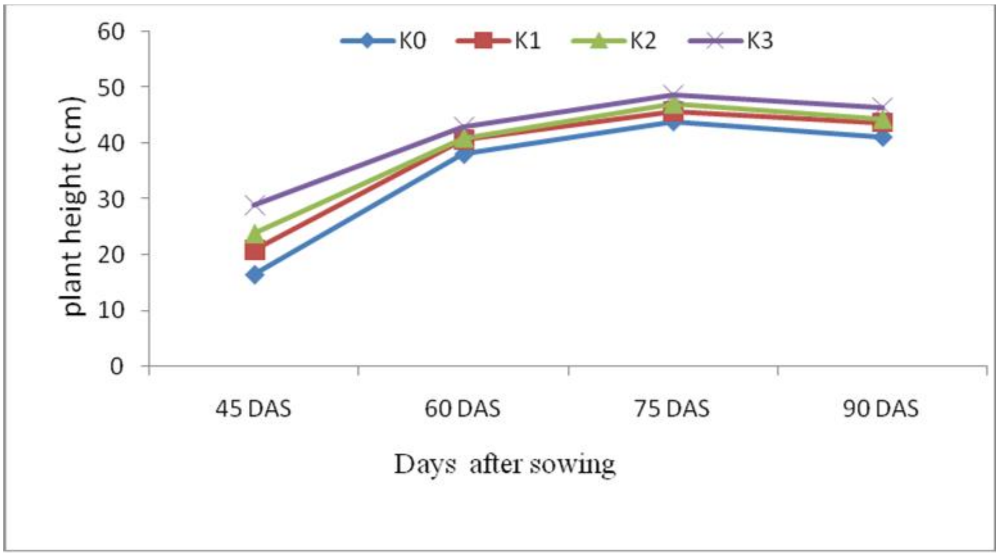


Fig.3. Effect of potasium on plant height of carrot.

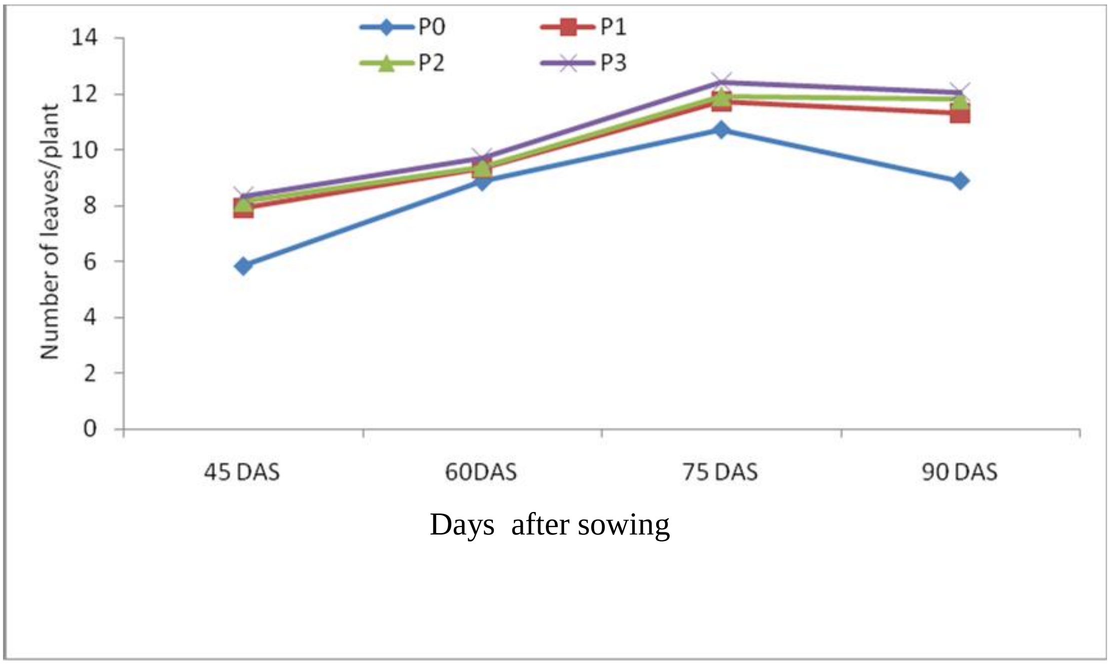


Fig.4. Effect of phosphours on number of leaves per plant of carrot

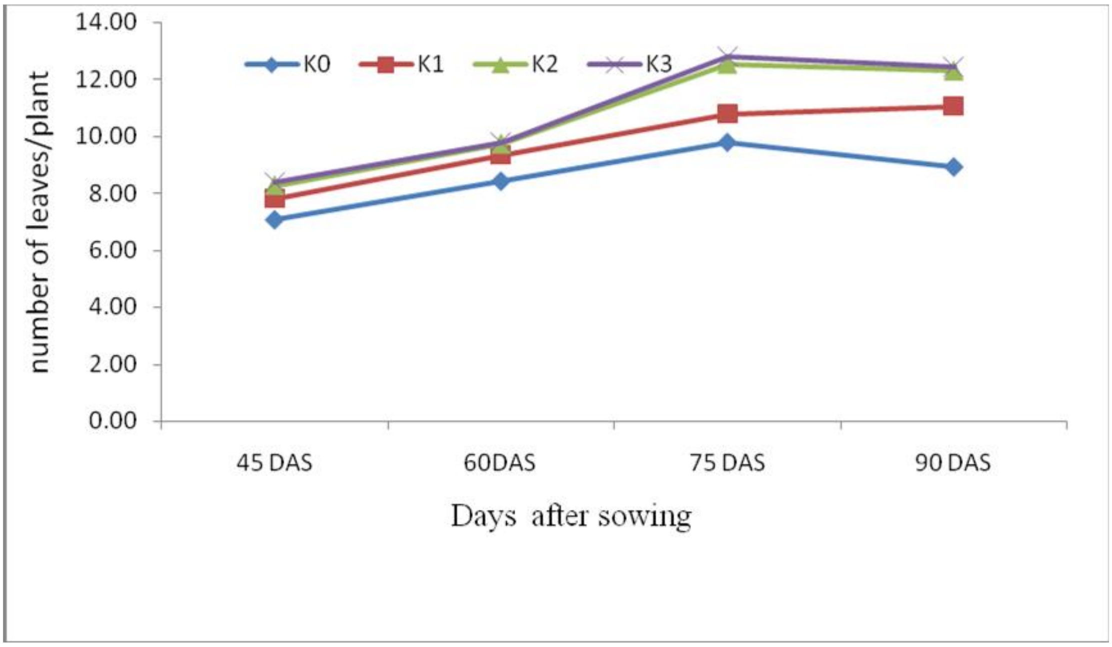


Fig.5. Effect of potasium on number of leaves per plant of carrot

Table 2. Combined effect of different levels of phosphorus and potassiumnumber of leaves of carrot.

Treatments combination	Number of leaves per plant at different days after sowing			
	45 DAS	**60 DAS**	**75 DAS**	**90 DAS**
P_0K_0	6.45f	7.68 f	9.02e	8.00e
P_0K_1	7.23d-f	9.01c-e	11.05b	10.94c
P_0K_2	7.34c-f.	9.19b-e	11.38b	11.11bc
P_0K_3	7.49b-e	9.34a-e	11.51b	11.06
P_1K_0	6.57ef	7.79f	9.46de	8.13e
P_1K_1`	8.23a-c	9.68a-d	12.99a	12.62a
P_1K_2	8.30ab	9.93ab	13.03a	12.66a
P_1K_3	8.57a	9.91ab	13.07a	12.92a
P_2K_0	7.12ef	8.79e	10.24cd	9.56d
P_2K_1	7.42b-e	8.90de	11.48b	10.99c
P_2K_2	8.78a	9.62a-c	12.90a	12.31ab
P_2K_3	8.59a	9.67a-c	13.11a	12.76a
P_3K_0	8.12a-d	9.21b-e	10.35de	9.78d
P_3K_1	8.40ab	9.81a-c	13.02a	12.55a
P_3K_2	8.85a	9.77ab	13.29a	13.15a
P_3K_3	9.01a	10.12a	13.35a	13.22a
$LSD_{(0.05)}$	0.888	0.736	0.778	1.015
CV(%)	8.04	8.98	7.86	8.71

4.1.3 Fresh weight of leaves per plant

A signification variation was observed on the fresh weight of leaves per plant due to different levels of phosphorus (Appendix IV). The fresh weight of leaves per plant increased significantly with the application of higher levels of phosphorus. The maximum fresh weight of leaves (87.48 g/ plant) was recorded from the P_3 treatmentwhile the minimum (78.17 g/ plant) was from the control treatment (Table 3).Abo-Sadera and Eid(1992), Pill *et al.*(1991)agreed to the results of the present findings.

The fresh weight of leaves per plant differed significantly due to application of different levels of potassium(AppendixIV). Treatment K_3 (200kg k_2O /ha) gave the maximum fresh weight of leaves (88.40g/plant), which was statistically identical to K_2 (87.49g/plant). However, control treatment showed the minimum fresh weight of leaves (75.49 g/plant) (Table 4). The increased fresh weight of leaf under P_3treatment may be attributed to the availability of more nutrients that possibly increased the rate of cell division and elongation producing more leaves and their development leading to increased fresh weight of leaf. Sharangi and Paria (1996) also showed similar results in their study.

A significant effect was observed due tocombined effectof phosphorus and potassium on fresh weight of leaves per plant (Appendix IV). The maximum fresh weight of leaves (91.70g/plant) was recorded from the treatment combination of P_3K_3 and the lowest (72.50 g/plant) was observed from the treatment combination of P_0K_0 (Table 5).Lyngdoh (2001) stated that due to combined effect of higher levels of phosphorus and potassium the fresh weight of carrot leaveswas increased. The present study was also supported to the findings of Lyngdoh (2001).

4.1.4 Dry matter percent of leaves

Phosphorushad significant effect on dry matter content of leaves per plant (Appendix IV). The highest dry matter of leaves (7.37%) was recorded from P_3which was identical to P_2(7.16%) and the lowest dry matter of leaves (6.57%) was recorded from the control treatment which was statistically identical (6.87%) to P_1 (Table 3).Nigussie *et al.*(2003) agreed to the present finding.

Dry matter of leaves was significantly influenced by different levels of potassium (Appendix IV). The highest dry matter of leaves (9.35%) was recorded from K_3 (200kg k_20_5/ha), which was statisticallysimilar (9.17%) to K_2(175kg k_20_5/ha).However, the lowest dry matter of leaves (8.24%) was found in control condition (Table 4).Krarup*et al.* (1984)stated that potassium increased the dry matter because of higher assimilation of various micro and macro elements.

A significant variation was found due to combined effect of different levels of phosphorusand potassium on percentage of dry matter of leaves was (and Appendix IV).The highest dry matter (7.91%) was obtained from the treatment combination ofP_3K_3 whereas,the treatment combination of P_0K_0produced the lowest (5.70%) dry matter of leaves (Table 5).

4.1.5 Length of root

The length of carrot root was found to be statistically significant due to the effect of different levels of phosphorus (Appendix IV). The longest root (16.27 cm) was obtained from P_3(95kgP_2O_5/ha)and the shortest root (11.40 cm) was from control treatment (Table 3).Krarup *et al.*(1984) reported that phosphorus occurred cell division and cell elongation which increased root length of the carrot.

Significant variation was observed due to the effect of different levels of potassium on the length of root (Appendix IV). The longest root (16.78 cm) was obtained from K_3(200 kg K_2O/ha) and the control treatment showed the shortest root length (11.75 cm) (Table 4).Selvi*et al.*(2005) stated that root length was increased due to basipetal movement of potassium in the carrot roots which produced to enhance the longest root. Their results also agreed to the present findings.

The combined effect of different levels of phosphorus and potassium showed significant differences on length of root in carrot (Appendix IV). The combined effect of P_3K_3(95 kg P_2O_5 /ha and 200 kg K_2O/ha)gave the longest (19.74 cm) root and the shortest (10.10 cm) length of root was obtained from the control treatment (P_0K_0) (Table 5).

Table 3. Main effect of phosphorus on growth of carrot

Phosphorus	Fresh weight of leaves(g)	Dry matter of leaves(%)	Root Length per plant(cm)	Diameter of root per plant(cm)	Fresh weight of root per plant(%)
P_0	78.17 c	6.57 c	11.40 c	5.12 c	103.27 c
P_1	83.27 b	6.87 bc	14.04 b	5.42 b	112.89 b
P_2	84.88 b	7.16 ab	14.43 b	5.54 b	114.44 b
P_3	87.48 a	7.37 a	16.27 a	5.94 a	119.52 a
$LSD_{(0.05)}$	2.012	0.441	0.990	0.133	4.235
CV (%)	9.36	8.85	9.97	10.32	8.56

4.1.6 Fresh weight of root per plant

The fresh weight of root per plant significantly differed with the application of different levels of phosphorus (Appendix IV). The maximum fresh weight of root (119.51 g) was recorded from P_3 (95 kg P_2O_5 /ha) which was followed by (114.44 g) P_2 treatment (Table 6). However, the control treatment gave the lowest fresh weight of root (103.27 g) (Table 6). Nigussie*et al.* (2003) supported to the result ofthe study.

The fresh weight of root per plant significantly differed due to different levels of potassium (Appendix IV). The highest fresh weight of root (119.92 g) was recorded from K_3 (200 kg K_2O/ha) and control treatment gave the lowest fresh weight of root (99.47 g) (Table 7). Pietola and Salo (2000) agreed to the results of the present findings.

The combined effect of phosphorus and Potassium showed significant variation on fresh weight of root per plant (Appendix IV). The maximum (124.12 g) fresh weight of root was recorded when plant grown from the treatment combination of P_3K_3 and the minimum (91.00 g) was found from the control treatment combination (Table 8).

4.1.7Diameter of root

Diameter of carrot root was significantly influenced by the application of different levels of phosphorus (Appendix IV). The highest diameter (5.94 cm) was obtained from P_3 (95 kg P_2O_5 /ha) and the second highest root diameter (5.54 cm) was recorded from P_2 (80 kg P_2O_5 /ha) and the control treatment gave the lowest (5.12 cm) diameter or root (Table 3). Tareen*et al.* (2005) observed similar results in their study.

Diameter of carrot roots was significantly influenced by different levels of potassium (Appendix IV). The maximum root diameter (6.05 cm) was obtained from K_3 (200 kg K_2O/ha) which was statistically similar (5.98 cm) to K_2 (175 kg K_2O/ha) and the lowest root diameter (5.23 cm) was produced from the control treatment (Table 4). Sharangi and Paria (1996) showed similar trends of results in their study.Root diameter varied significantly due to the combined effect of different levels of phosphorus and potassium (Appendix IV). The maximum diameter of root (6.35 cm) was found from the treatment combination of P_3K_3 (95 kg P_2O_5 and 200kg k_2O_5/ha) and the minimum (4.87 cm) was recorded from P_0K_0 (Table 5).

Table 4. Main effect of different levels of potassium on growth of carrot

Treatments	Fresh weight of leaves (g)	Dry matter of leaves(%)	Root Length / plant (cm)	Diameter of root/ plant(cm)	Dry matter of root(%)
K_0	75.49 c	8.24 b	11.75 d	5.23 c	8.24 b
K_1	82.59 b	8.99 a	13.43 c	5.60 b	8.99 a
K_2	87.49 a	4.17 a	15.32 b	5.98 a	9.17 a
K_3	88.40 a	9.35 a	16.78 a	6.05 a	9.35 a
$LSD_{(0.05)}$	4.396	0.224	1.032	0.146	0.224
CV (%)	9.36	8.85	9.97	10.32	7.72

4.1.8 Dry matter percent of root

The percent dry matter of root also varied significantly by the use of different levels of phosphorus (AppendixIV). The dry matter of roots was recorded to be the highest (9.31%) in plant grown by the application of (95 kg P_2O_5 /ha) which was similar to P_2 (9.15%) and P_1 (9.04%)and the lowest root dry matter of root (8.47%) was obtained from control treatment (Table 3). Similar trends of results were observed by Evers (1988).

Use of different levels of Potassium showed significant effect on the percent dry matter ofcarrot root (Appendix IV). The highest dry matter of root (9.35%) was found from K_3(200Kg $K_2$0/ha)which was statistically similar to K_2 (9.17 %)and K_3 (8.99 %) and the lowest (8.24%) was from K_0 control (Table 4).Grigrov (1990) found similartrends of findings in his study.

Significant variation was observed on dry matter percentage of roots due to combined effect of different levels of phosphorus and potassium

(AppendixIV). However, the highest dry matter of root (9.69%) was observed in the treatment combination of P_3K_3 (95Kg P_2O_5/ha with 200 kg k_2O/ha) and the lowest dry matter (7.44%) was recordedfrom P_0K_0 (Table 5).

4.1.9 Cracking percentage of roots

Phosphorus had significant effect on the cracking percentage of root (Appendix IV). The highest percentage of cracking root (3.09%) was observed from the control treatment and the lowest percentage of cracking root was found from P_3 (2.60%) (Table 6).Baloochet *et al.* (1993) reported that higher doses of phosphetic fertilizer may occur cracking in carrot root in loamy soil.

The percentage of cracked roots production of carrot was significantly influenced by the different levels of potassium (Appendix IV). The highest (3.03%) percentage of root cracking recorded from control treatment whereas, the lowest (2.51%) was found from K_3 (200 kg K_2O/ha) (Table 7).

Root cracking varied significantly due to the combined effect of phosphorus and potassium (Appendix IV). The highest cracked root (4.53%) was recorded from P_0K_0 whereas the lowest (4.13%) was observed from P_3K_3 (Table 8).

4.1.10 Rotting percentage of roots

The percentage of rotting of roots was significantly affected by the application of different levels of phosphorus (Appendix IV). However, the highest rotting percentage of roots (2.97%) was recorded in control treatment whereas, the lowest rotting percentage (2.42%) was observed in P_3 (95 kg P_2O_5/ha) (Table 6).

Table 5. Combined effect of different levels of Phosphorus and

potassiumongrowth of carrot.

Treatment combinations	Freshwt. of leaves (g)	Drymatter of leaves (%)	Root length (cm)	Diameter of root (cm)	Drymatter ofroot (%)
P_0K_0	72.50g	5.70 d	10.10 e	4.87 j	7.44 d
P_0K_1	77.41ef	6.27 cd	11.14 de	5.25 hi	8.61 bc
P_0K_2	80.77d-f	7.15 a-c	11.65 de	5.50 f-h	8.84 bc
P_0K_3	81.76de	7.17a-c	12.63 de	5.60 e-g	8.86 bc
P_1K_0	72.71 g	6.40 cd	10.53 de	4.97 ij	8.42 c
P_1K_1`	87.96 a-c	6.73 bc	15.71 c	6.01 b-d	9.35 a
P_1K_2	88.64 ac	6.47 cd	16.80 bc	6.21 ab	9.43 a
P_1K_3	90.54 ab	7.19 a-c	18.20bc	6.25 ab	9.67 a
P_2K_0	77.04f	6.33 cd	11.79 de	5.12 hi	8.48c
P_2K_1	79.53 ef	7.14 a-c	12.50 d	5.36 gh	9.15 a-c
P_2K_2	86.72 bc	7.46 ab	15.84 c	6.02 b-d	9.37 ab
P_2K_3	90.82 ab	7.83 a	16.67 bc	5.99 b-d	9.33 ab
P_3K_0	79.19 ef	6.48 b-d	12.79 d	5.85 c-e	8.53 c
P_3K_1	84.76 cd	7.81 a	12.70 d	5.76 d-f	8.92 bc
P_3K_2	89.80 ab	7.87 a	18.85 bc	6.07 a-c	9.14a-c
P_3K_3	91.70 a	7.91a	19.74 a	6.35 a	9.69 a
$LSD_{(0.05)}$	4.560	0.885	1.886	0.273	0.640
CV (%)	8.96	8.85	9.97	10.32	7.72

In a column means having similar letter are statistically similar and those having dissimilar letter differ significantly as per .05 level of probability

The percentage of rotting roots of carrot was significantly influenced by different levels of potassium (Appendix IV). The highest rotting percentage of roots (2.93%) was recorded from control treatment and the lowest (2.31%) rotting percentage was observed in K_3 (200 kg k_2O/ha) (Table 7).Feller*et al.*(2003) found similar results in their study.

The combined effect of different levels of phosphorus and potassium was observed significant on rotting percentage of roots (Appendix IV). The highest percentage of rotten root (3.38%) was recorded from control treatment combination and the lowest (3.23%) was obtained from the treatment combination of P_3K_3 (95 kgP_2O_5/ha with 200 kg K_2O/ha) (Table 8).Pekarskas and Bartaseviciene (2007) supported to the present study and they also observed similar trends of results in their trial.

4.1.11 Gross yield of roots per plot

Statistically significant variation was found due to effect of different levels of Phosphorus on gross yield of roots per plot (Appendix IV). The maximum gross yield per plot (4.78 kg) was obtained from the application of P_3 (95 kg P_2O_5/ha) while the (control treatment) produced the minimum (4.13 kg) yield (Table 6).

The yield of carrot root per plot was found statistically significant due to the effect of different levels of potassium (Appendix IV). K_3 (200 kg K_2O/ha) produced the highest yield (4.79 kg). However, control treatment produced the lowest root yield (3.97 kg) per plot (Table 7).

The combined effect of different levels of phosphorus and potassium showed significant differences on gross yield of root per plot (Appendix IV). The maximum gross yield per plot (4.96 kg) was found from the P_3K_3 (95 kg P_2O_5/ha and 200 kg K_2O/ha). On the other hand, the minimum gross yield of root (4.05 kg/plot) was recorded from the control condition (Table 8). Kader (2004) reported that combination of certain levels of phosphorus and potassium increase the gross yield in carrot. Suitable combination of phosphorus and potassium in presence of nitrogen also increase the gross yield of carrot.

4.1.12 Marketable yield of roots per plot

The marketable yield of carrot root per plot was found statistically significant due to effect of phosphorus (Appendix IV). P_3 (95 kg P_2O_5/ha) treatment produced the highest (4.59 kg/plot) yield. The lowest marketable yield (4.03 kg/plot) was recorded from the control treatment (Table 6).

Marketable yield of roots per plot varied significantly due to the application of different levels of Potassium (Appendix IV). The highest marketable yield of root (4.77 kg/plot) was obtained from K_3 (200 kg K_2O/ha) and the lowest yield (4.05 kg/plot) was recorded from K_0 (Table 7).The present study also agreed to the findings of Hochmuth*et al.* (2006).

Table 6. Main effect of different levels of Phosphorus treatments on the yield ofcarrot

Treatments	Fresh weight of root per plant (g)	Gross yield of root per plot(kg)	Marketable yield of root per plot(kg)	Root cracking (%)	Dry matter of root (%)
P_0	103.27 c	4.13 c	4.03 d	3.09 a	8.47 b
P_1	112.89 b	4.51 b	4.36 c	3.01 b	9.04 a
P_2	114.44 b	4.57 b	4.41 b	2.83 c	9.15 a
P_3	119.52 a	4.78 a	4.59 a	2.60 d	9.31 a
$LSD_{(0.05)}$	4.235	0.201	0.161	0.0327	.323
CV (%)	8.56	7.72	8.99	10.25	7.72

The combined effect of marketable yield of root per plot was significantly influenced by different levels of phosphorus and potassium (Appendix). The highest marketable yield of root per plot (4.90 kg/plot) was observed from P_3K_3 (95 kgP_2O_5/ha and 200 kg K_2O/ha) whereas, the lowest yield (3.85 kg/plot) was obtained from P_0K_0(Table8).

Table 7. Main effect different levels of potassium on the yield of carrot

Treatments	Fresh weight of root per plant(g)	Gross yield of root per plot(kg)	Marketable yieldof root per plot(kg)	Rootcracking(%)	Rootrotting(%)
K_0	99.47 c	3.97 d	4.05 c	3.03 a	2.93 a
K_1	110.70 b	4.42 c	4.42 b	2.96 a	2.66 b
K_2	117.80 a	4.71 b	4.50 b	2.77 b	2.40 c
K_3	119.92 a	4.79 a	4.77 a	2.51 c	2.31 c
$LSD_{(0.05)}$	3.885	0.072	0.203	0.170	0.251
CV (%)	8.56	7.72	8.99	10.25	8.96

4.1.13 Gross yield of roots per hectare

Gross yield of carrot roots per hectare was influenced significantly by the application of different levels of phosphorus (Appendix IV). The maximum gross yield (38.37 t/ha) was observed from P_3 (95 kg P_2O_5/ha) and the controltreatment gave the lowest (27.52 t/ha) gross yield (Fig. 6).Gross yield of roots per hectare was significantly influenced by thedifferent levels of potassium (Appendix IV). The highest yield (42.22 t/ha) was obtained from K_3 (200 kg K_2O/ha) and the lowest (27.20 t/ha)was obtainedfromK_0 (Fig.7). Kader (2004)observed same trends of results in his trial.

The combined effect of different levels of phosphorus and potassiumshowed significant differences on the gross yield of carrot root per hectare (Table8 and Appendix). The highest gross yield of root (40.58 t/ha) was found from P_3K_3 (95 kgP_2O_5/ha and 200 kg k_2O/ha). On the other hand, the lowest gross yield of carrot root (24.00 t/ha) was recorded from P_0K_0.

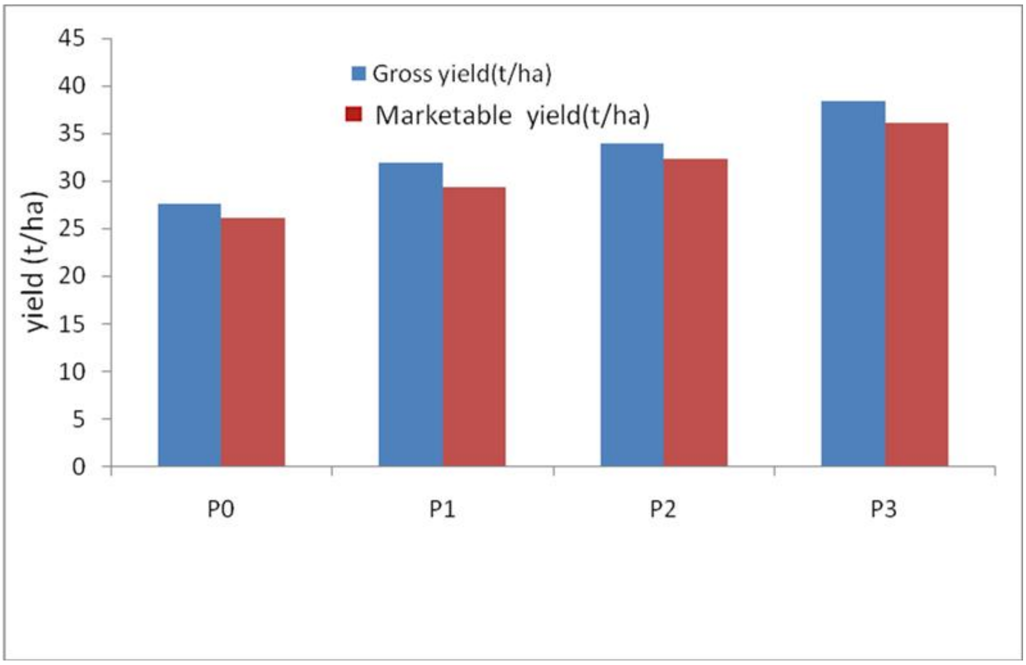


Fig.6. Effect of phosphorus on gross and marketable yield of carrot

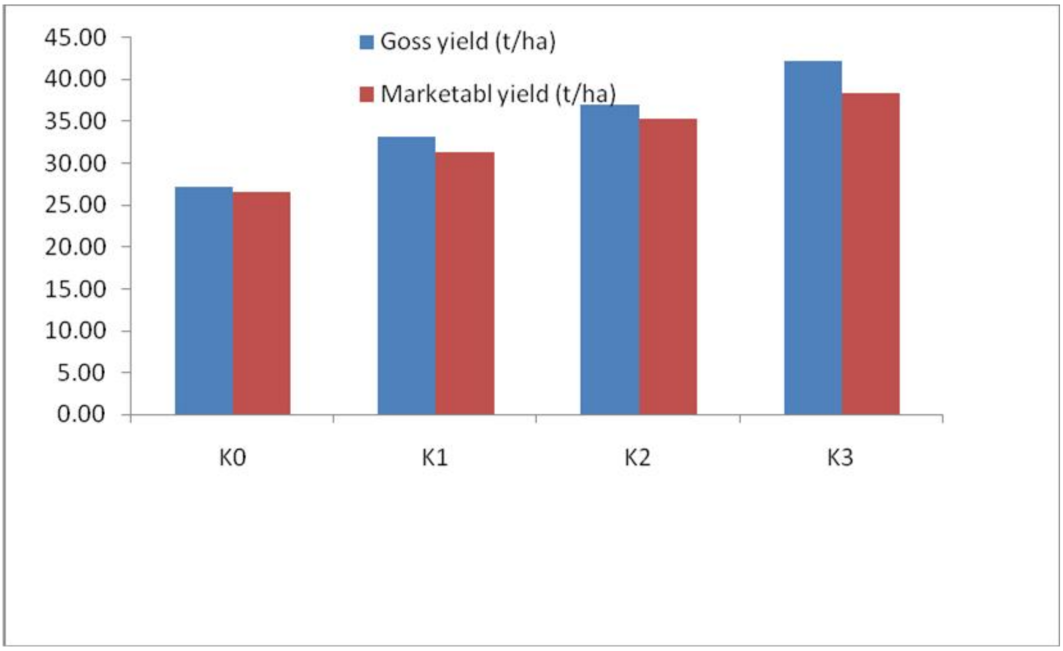


Fig.7. Effect of potasium on gross and marketable yield of carrot

4.1.14 Marketable yield of roots per hectare

Marketable yield of roots varied significantly due to the application different levels of phosphorus (Appendix IV). The maximum marketable yield (36.03 t/ha) was obtained from P_3 (95 kg P_2O_5/ha) treatment, while the minimum yield (26.08 t/ha) was found from control treatment (Fig. 6).

The marketable yield of carrot per hectare was found statistically significant due to the application of different levels of potassium (Appendix IV). The highest yield (38.33 t/ha) was obtained from K_3 and the lowest (26.53 t/ha) from K_0 (Fig.7). Hochmuth*et aL.*(2006) supported to the results of the present study.

A significant variation was found due to combined effect of different levels of phosphorus and potassium on marketable yield of carrot root per hectare (Appendix IV). The highest marketable yield of root per hectare (37.14 t/ha) was recorded from P_3K_3 (95 kg P_2O_5/ha and 200 kg k_2O/ha), whereas the lowest marketable yield of carrot root per hectare (22.24 t/ha) was found from the treatment combination of P_0K_0(Table 8). Feller *et al.* (2003) and Portz*et al.* (2006) observed similar trends of results in their trial.

Table8. Combined effect of Phosphorus and potassium on the yield ofcarrot

Treatment combinations	Fresh weight of root/plant	Gross yield	Marketa-ble	Gross yield	Marketa -ble	Root cracki	Root rotting

	(g)	of root/ plot (kg)	yield of root /plot (kg)	of root (t/ha)	yield of root (t/ha)	ng (%)	(%)
P_0K_0	91.00 i	4.05 a	3.85 i	24.00 c	22.24 e	4.53 a	3.38 a
P_0K_1	104.15 fg	4.16 ab	4.08 g	34.10 b	30.45 bc	4.49 ab	3.37 ab
P_0K_2	108.09 d-g	4.32 ab	4.16 f	34.19 b	30.69 bc	4.41a-c	3.33 b-d
P_0K_3	109.81 c-g	4.39 c	4.26 e	34.50 b	30.89 bc	4.38 bc	3.32 b-d
P_1K_0	92.74 hi	3.70 ab	3.61 ij	26.65 c	26.25 d	4.29 cd	3.31 cd
P_1K_1`	116.79 a-d	4.67 a	4.57 d	35.81 ab	31.32 bc	4.28 cd	3.30 a-c
P_1K_2	123.50 a	4.94 a	4.80 b	37.07 ab	32.53 a-c	4.24 d	3.29 a-c
P_1K_3	123.88 a	4.95 a	4.81 b	38.52 ab	33.37 a-c	4.24 d	3.28 c-e
P_2K_0	101.08 gh	4.03 bc	3.95 i	33.37 b	29.01 cd	4.21 d	3.27 de
P_2K_1	105.93 e-g	4.23 ab	4.02 c	35.93 ab	33.18 a-c	4.18 d	3.30 a-c
P_2K_2	119.97 ab	4.79 a	4.65 c	36.52 ab	33.32 ab	4.17 d	3.26 de
P_2K_3	118.34 a-c	4.73 a	4.68 c	38.85 ab	33.54 ab	4.21 d	3.24 de
P_3K_0	113.00b-f	4.52 ab	4.01 d	34.53 b	31.09 bc	4.22 d	3.25 de
P_3K_1	115.83 a-d	4.63 a	4.55 a	40.02 a	35.73 a	4.18 d	3.27 de
P_3K_2	123.00 ab	4.92 a	4.86 a	40.06 a	35.80 a	4.15 d	3.19 fg
P_3K_3	124.12 a	4.96 a	4.90 a	40.58 a	38.37 a	4.13 d	3.23 ef
$LSD_{(0.05)}$	8.401	0.750	0.041	4.652	3.764	0.129	0.053
CV (%)	8.56	7.72	8.99	7.77	8.76	10.25	8.96

In a column means having similar letters are statistically similar and those having dissimilar letters differ significantly as per .05 level of probability.

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of phosphorus andpotassium on the growth, yield of carrot during the period from

November 2013 to March 2014. The experiment consisted of four different levels of phosphorus, viz. no P_2O_5 (control), P_1(65 kg P_2O_5/ha), P_2(80 kg P_2O_5/ha), and P_3(95 kg P_2O_5/ha), and four levels of potassium viz. K_0 (control), K_1 (150 kg K_2O/ha), K_2 (175 kg K_2O/ha), K_3 (200 kg K_2O/ha).

The two-factor experiment was laid out in Randomized Complete Block Design with three replications. There were altogether 16 treatment combinations in this experiment. A unit plot size was 1.5 $\times$ 1.0 m keeping 1.0 m and 0.5 m gap between the blocks and plots, respectively. Data on growth and yield parameters were collected from 10 randomly selected plants of each plot and analyzed statistically. The mean differences were adjudged by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Phosphorus significantly influenced all the parameters. P_3(95 kg P_2O_5/ha) gave the maximum plant height (46.52 cm) at 75 days after sowing and the maximum number of leaves (12.69/plant) at 75 DAS.The maximum fresh weight of leaves (87.48 g) per plant was recorded from the P_3 treatment while the control treatment performed the minimum (78.17 g) minimum number of leaves. The maximum dry matter percentage of leaves (7.37%) was obtained from P_3(95 kg P_2O_5/ha) treatment and the minimum (6.57%) was recorded from P_0 control condition. The maximum length of root (16.27 cm), diameter of root (5.94 cm), fresh weight of root (119.52 g/plant), dry matter root (9.31%), gross yield of root per plot (4.78 kg), marketable yield of root per plot (4.59 kg), gross yield of roots per hectare (38.37 t/ha) and marketable yield of roots per hectare (36.03 t/ha) was recorded from P_3(95 kg P_2O_5/ha) treatment which was significantly superior to all other treatments but the maximum cracking of roots (3.09%) and rotting of roots (2.97%) was found in control treatment.

Potassium showed a significant effect on plant height, number of leaves, fresh weight of leaves per plant, dry matter percentage of leaves, length of root, diameter of root, fresh weight of root, dry mater percentage of root, gross yield of root per plot, marketable yield of root per plot, gross yield of roots per hectare and marketable yield of roots per hectare. All these parameters were found to be the maximum results from K_3(200 kg K_2O/ha) and the minimum was recorded from K_0 (control treatment). In case of cracking and rotting percentage of root was the highest from control treatment (K_0) where no potassium was used.

At the maximum vegetative growth of 75 DAS, the highest plant height (48.66 cm) was obtained from K_3 (200 kg K_2O/ha) and the lowest (43.89 cm) from treatment (K_0). The maximum number of leaves (12.79) was obtained from K_3 and control treatment gave the lowest (9.76). The maximum fresh weight of leaves (88.40 g) and per cent dry matter of leaves (9.35 %) were observed from K_3 and the minimum from K_0. The highest length of root (16.78 cm) was recorded from K_3 (200 kg K_2O/ha) from while the minimum length of root (11.75cm) was found from 'K_0. The maximum diameter of root (6.05cm) was found from K_3 (200 kg K_2O/ha) and the minimum diameter of root (5.23 cm) was recorded from K_0. The maximum fresh weight and dry matter percent of root were obtained 119.92 g and 9.35% respectively and were found from K_3 (200 kg K_2O/ha) and the lowest fresh weight 99.47 g and dry matter percentage of roots per plant 8.24% was found from treatment (K_0). The highest root cracking (3.03%) was found control condition (K_0) and the lowest (2.51%) was recorded from K_3 (200 kg

K_2O/ha). The highest root rotting (2.93%) was observed from K_0 and the lowest (2.31%) was found from K_3 treatment. The highest gross yield of roots (4.79 kg /plot, 42.22 t/ha) was recorded from from K_3 (200 kg K_2O/ha) and the lowest (3.97 kg/plot, 27.20t/ha) were observed from K_0 treatment. The highest marketable yield of roots (4.77 kg/plot, 38.33 t/ha) was recorded from K_3 (200 kg K_2O/ha) and the lowest (4.05 kg/plot, 26.53 t/ha) was obtained from control treatment.

Due to combined effect of different levels of phosphorus and potassium showed significant variation on plant height at all other dates of observations. P_3K_3 (95 kg P_2O_5/ha with 200 kg K_2O/ha) showed the highest plant height (48.13 cm) while the lowest height ((34.50 cm) was observed from the control condition at 75 DAS. The combined effect of different levels of phosphorus and potassium showed significant variation on number of leaves per plant at different days after sowing. The maximum number of leaves per plant (13.35) was observed from P_3K_3 and the minimum number of leaves per plant (9.02) was recorded from the control treatment combination.

The maximum fresh weight of leaves per plant (91.70 g) was found from P_3K_3 (95 kg P_2O_5/ha with 200 kg K_2O/ha) while the minimum (72.50 g) was obtained from the control condition. The maximum dry matter percentage of leaves (7.91%) was recorded from P_3K_3 (95 kg P_2O_5/ha with 200 kg K_2O/ha) whereas the minimum (5.70 %) was found from P_0K_0. The combined effect of different levels of phosphorus and potassium also showed significant effect on root length and root diameter per plant. The maximum root length and its diameter were 19.74 cm and 6.35 cm, respectively by the application of 95 kg P_2O_5/ha and 200 kg K_2O/ha while the minimum root length was obtained 10.10 cm and root diameter was 4.87 cm from the control treatment combination.

The fresh weight of root and dry matter percentage of root showed significant influence due to the effect of different levels of phosphorus and potassium. The maximum fresh weight of root and dry matter percentage to root were obtained from P_3K_3, they were 124.12 g and 9.69%, respectively. The minimum fresh weight 91.00 g and dry matter percentage (7.44%) were found from control treatment combination (P_0K_0). The combined effect of different levels of phosphorus and potassium showed significant effect on percentage of cracked root and rotten root production. The maximum cracked root (4.53%) was observed from control treatment combination and the lowest cracked root (4.13%) was recorded from the treatment combination of P_3K_3 (95 kg P_2O_5/ha with 200 kg K_2O/ha). On the other hand, the maximum rotten root (3.38%) was found from P_0K_0 whereas, the minimum (3.23%) was observed from P_3K_3. The highest gross yield of carrot root (4.96 kg/plot, 40.58 t/ha) was recorded from P_3K_3 (95 kg P_2O_5/ha with 200 kg K_2O/ha) and the lowest gross yield (4.05 kg/plot, 24.00 t/ha) was observed from control treatment combination (P_0K_0).

The marketable yield was also significantly influenced due to different levels of phosphorus and potassium. The highest marketable yield (4.90 kg/plot, 37.14 t/ha) was found from the treatment combination of P_3K_3.

Conclusion

It may concluded that, the treatment combination of 95 kg P_2O_5/ha with 200 kg K_2O/ha may be used for carrot production. However, such type of study may be carried out in other agro-ecological zones of Bangladesh before final recommendation.

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APPENDICES

Appendix I. Major carrot producing countries of the world, 2009.

Country	Area ('000 ha)	Production ('000 mt)	Yield (t/ha)
Israel	1	80	61.538
Australia	1	48	53.333
Sweden	2	100	54.348
UK	12	692	57.683
Spain	7	300	46.154
Denmark	2	77	42.667
France	16	700	43.001
Germany	8	364	42.878
Italy	10	492	46.35
Tazilistan	1	42	42

Source: FAO, 2000

Appendix II.Soil analysis data of the experimental plot.

Mechanical analysis

Constituents	**Percentage (%)**
Sand	35.4
Silt	62.6
Clay	5.8
Textural classification	Silty loam

Chemical analysis

Soil properties/constituents	**Values**
pH	6.5
Organic carbon	0.84%
Total nitrogen	0.08%
Available P	18 ppm
Available K	45 ppm
Available S	8 ppm

Source: SRDI, 2013

Appendix III. Monthly records of air temperature, relative humidity, rainfall and sunshine during the period from November 2012 to March 2013

Year	Month	** Air temperature (^0C)			** Soil temp. at different depth			**Relative humidity (%)	*Rainfall (mm)	**Sunshine (Hours)
		Max.	Min.	Mean	5 cm	10 cm	20 cm			
2013	November	28.79	18.54	23.76	25.4	25.9	26.2	82.53	83.1	235.0
	December	25.32	14.40	19.86	21.4	22.0	22.5	84.06	0.00	196.4
2014	January	21.77	10.17	15.97	17.5	16.9	18.3	83.65	Trace	165.6
	February	26.77	15.49	21.13	21.1	21.6	21.4	75.21	27.10	229.2
	March	27.95	18.11	23.03	24.1	24.5	24.3	75.39	114.00	199.3

*Monthly total, ** Monthly average

Source: Bangladesh Metrological Department (Climate division), Agargaon, Dhaka.

Appendix IV. Analysis of variance of different characters of carrot

Sources of variation	Degree of freedom	Mean of sum of square			
		Plant height			
		45 DAS	60 DAS	75 DAS	90 DAS
Block	2	122.425	12.540	6.123	18.590
Factor-A (Phosphorus)	3	199.461**	243.351**	666.829**	823.663**
Factor-B (Potassium)	3	130.663**	144.445**	425.246**	487.236**
Interaction (A × B)	9	8.891**	8.506*	30.593**	18.987**
Error	30	0.777	3.626	5.527	3.790

** = Significant at 1% level

* = Significant at 5% level

Appendix IV.Cont'd.

Sources of variation	Degree of freedom	Mean of sum of square			
		Number of leaves			
		45 DAS	60 DAS	75 DAS	90 DAS
Block	2	6.032	0.643	1.653	2.098
Factor-A(Phosphorus)	3	11.215**	9.654**	8.430**	10.012**
Factor-B (Potassium)	3	8.453**	7.703**	7.812**	7.851**
Interaction (A × B)	9	0.432**	0.332**	0.657*	0.432**
Error	30	0.769	0.328	0.492	1.765

** = Significant at 1% level

* = Significant at 5% level

NS = Non significant

Sources of variation	Degree of freedom	Means square					
		Fresh weight of Leaves per plant (g)	Dry matter of leaves (%)	Root length (cm)	Diameter of root (cm)	Fresh weight of Root per plant (g)	Dry matter of root (%)
Block	2	1.765	1.098	0.943	0.432	0.237	0.0795
Factor-A (Phosphorus)	3	1287.210**	13.431**	11.710**	4.432**	1001.143**	4.623**
Factor-B (Potassium)	3	1054.134**	6.327**	4.907**	3.087**	565.980**	4.548**
Interaction (A × B)	9	123.876**	0.980**	0.0.932*	0.307**	47.521**	0.087**
Error	30	3.980	0.659	0.654	0.064	0.674	0.189

Appendix IV.Cont’d.

** = Significant at 1% level
* = Significant at 5% level

Appendix IV.Cont'd.

Sources of variation	Degree of freedom	Means square					
		Root cracking (%)	Root rotting (%)	Gross yield of root per plot (kg)	Marketable yield of root per plot (kg)	Gross yield of root (t/ha)	Marketable yield of root (t/ha)
Block	2	0.342	0.987	0.912	0.093	0.487	0.094
Factor-A (Phophorus)	3	5.983**	9.916**	2.384**	1.098**	42.093**	33.780**
Factor-B (Potassium)	3	4.481**	2.825**	1.894**	1.018**	40.065**	14.450**
Interaction (A × B)	9	0.683**	1.030*	1.406**	0.978**	5.036**	2.860**
Error	30	0.0836	0.082	1.056	0.083	0.805	0.672

** = Significant at 1% level
* = Significant at 5% level