EFFECT OF POTASSIUM AND EARTHING UP ON GROWTH, YIELD AND ECONOMIC BENEFIT OF CARROT

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF POTASSIUM AND EARTHING UP ON GROWTH, YIELD AND ECONOMIC BENEFIT OF CARROT"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by **SHARMIN SULTANA RIMA,** Registration No. **13-05691** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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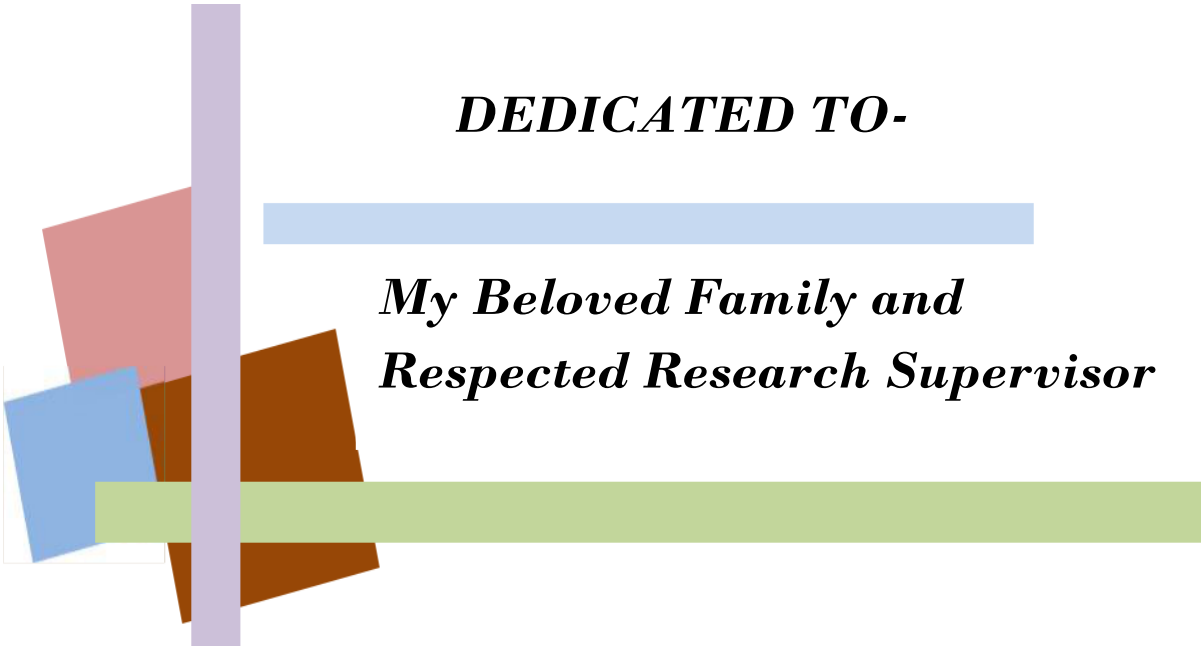

DEDICATED TO-

My Beloved Family and Respected Research Supervisor

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. The experiment consisted of two factors. Factor A: Different levels of potassium as K_0= Control, K_1= 100 kg K/ha, K_2= 120 kg K/ha, K_3= 140 kg K/ha and Factor B: E_0= no earthing up, E_1= two times earthing up, E_2= three times earthing up. The experiment was laid out in a Randomized Complete Block Design with three replications. The collected data were statistically analyzed. Results revealed that in terms of potassium application, the highest gross yield of roots/ha (38.35 t) and marketable yield of roots/ha (35.32 t) were recorded from the application of K_2 (120 kg K/ha) treatment compared to K_0 (control) treatment. Again, in terms of different earthing up treatments, the highest gross yield of roots/ha (35.71 t) and marketable yield of roots/ha (34.75 t) were found from the treatment E_2 (three times earthing up) compared to E_0 (no earthing up) treatment. Both potassium and earthing up and their combination showed significant variation on different parameters of carrot. The highest gross yield of roots/ha (43.51 t) and marketable yield of roots/ha (42.29 t) were found from the treatment combination of K_2E_2 (120 kg K/ha + three times earthing up) compared to K_0E_0 (control) treatment combination. The highest gross return (Tk. 507480), net return (Tk. 313782) and BCR (2.62) were obtained from the treatment combination K_2E_2 (120 kg K/ha + three times earthing up) where the lowest gross return (Tk. 240360), net return (Tk. 83478) and BCR (1.53) were obtained from K_0E_0 (control) treatment combination. So, It can be concluded that 120 kg K/ha with three times earthing up was the best for carrot cultivation.

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ABBREVIETION AND ACRONYMS

ABBREVIATION	FULL WORD
Abst.	Abstract
AEZ	Agro-Ecological Zone
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of coefficient of variation
cm	Centimeter
DAS	Days after sowing
Df	Degrees of freedom
Ecol.	Ecology
et al	And others
Env.	Environment
FAO	Food and Agriculture Organization
g	Gram
LSD	Least of Significant Difference
MoP	Muriate of Potash
MS	Mean square
M.Sc.	Master of Science
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate
UK.	United Kingdom
USA	United States of America
%	Per cent

CHAPTER I
INTRODUCTION

Carrot *(Daucus carota* L.) is an important carotene rich root vegetables of the world as well as in Bangladesh**.** It is grown in spring, summer and autumn in temperate countries and during winter in tropical and subtropical countries (Bose and Som, 1990) and extensively cultivated in North and South America, Europe, Asia, North Africa (Thompson and Kelly, 1957). It belongs to the family Apiaceae and said to be originated in Mediterranean region and its cultivation as a crop also began in that region (Shinohara, 1984). It grows successfully in Bangladesh during Rabi season when temperature ranges from 11.17ºC to 28.9ºC (Alim, 1974) and mid November to early December is the best time for its cultivation to get satisfactory yield (Rashid, 1993).

Vegetables are one of the most important components of human food which provides proteins, carbohydrates, fats, vitamins and minerals. 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, vitaminA, vitamin-B, vitamin-C sugar (Yawalkar, 1985). The popularity of carrot is increasing day by day in Bangladesh especially among the urban people because of its high nutritive value and possible diversified use in making different palatable foods. Carrot can be eaten either row or by making halua, a preparation of sweets in Bangladesh. Carrot root is also used as vegetable for preparing soups and curries and roots are used as salad. But large-scale production of carrot is yet to be started to meet up its demand. It has been reported that the entire production of carrot was 18,674 metric tons under 5084 acres in Bangladesh during 2017-2018 (BBS, 2019). From this report, it is proved that the production area and production of carrot was so low. An average yield of carrot is about 25 t/ha in Bangladesh which are comparatively low from major carrot producer countries (FAO, 2004).

Carrot production can be increased in two ways, namely extending the area under cultivation or by increasing the yield per hectare. But increasing the area is not possible due to land limitation in Bangladesh. The population of Bangladesh is increasing day by day so, only way to increase the production in per unit area. This can be achieved in different ways of which the most important one is the use of improved cultural management practices including judicious management of fertilizer and inter cultural

operations (especially in earthing up). Among the factors that affect crop production, fertilizer is the single most important that plays an important role in yield increase. In Bangladesh inorganic fertilizers today hold the key to success of crop production. So, there is a requirement of adding nutrients to soil through fertilization in order to get desired yield of crops (BARC, 1997).

Carrot cultivation requires ample supply of plant nutrients. Carrot is a potassium demanding plant (Kadar, 2008). Use of potassium fertilizer is essential for its growth and root development. All root crops respond to liberal applications of potassium. Potassium has a crucial role in the energy status of the plant, translocation and storage of assimilates and maintenance of tissue water relation. Also potassium plays a vital role of crop quality. It stimulates root growth. It is necessary for the translocation of sugars and formation of carbohydrates. Potassium also provides resistance against pest and diseases and drought as well as frost stresses. It is a highly mobile element in the plant and has a specific phenomenon, it is called luxury consumption (Marschner, 1995). Among the yield contributing factors, application of proper levels of potassium is necessary to produce maximum yield of good quality carrot (Farazi, 1993). Sanderson and Sanderson (2006) indicated that increasing rates of applied potassium linearly increased the potassium content of carrot petioles. However, excessive or under dose of potassium can affect the growth and yield of the crop. Only an optimum dose of potassium is necessary to produce maximum yield of good quality carrot. Muriate of potash (MoP) is widely used as the source of potassium because of its maximum available form of potassium and cheaper than any potash fertilizer.

There are different types of intercultural operation are doing on carrot cultivation such as irrigation, weeding, thinning, mulching, earthing up and so on. In which, earthing up plays an important role in growth and yield of carrot. Earthing up is the technique in agriculture and horticulture of piling up soil around the base of a plant. Earthing up provided maximum number of tuber with large size (Tesfaye *et al*., 2013). Mukherjee *et al.* (2012) reported that earthing up is an economically viable weed control practice. The well known benefits are regulating soil moisture and temperature, improving germination and emergence etc. High quality and yield, prolonged growing season, higher nutritive value of the produce, improved storability etc. are also well described

advantages of earthing up, therefore, aids in reducing cost involved in crop production with irrigation.

In consideration with the aforementioned idea, the present experiment was undertaken to evaluate the effect of potassium and earthing up on growth, yield and economic benefit of carrot. Keeping above facts in view, the present study was undertaken with the following objectives:

- to find out the optimum doses of potassium for ensuring proper growth, higher yield and economic benefit of carrot
- to determine the optimum number of earthing up on growth, yield and economic benefit of carrot
- to find out the suitable combination of potassium level and number of earthing up on growth, yield and economic benefit of carrot

CHAPTER II
REVIEW OF LITERATURE

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

2.1 Literature on potassium

An experiment was set in Eritrea by Zeru *et al*. (2016) on the effect of potassium levels on growth and yield of potato. He stated that potato requires a variety of balanced plant mineral nutrients for growth and development without which yield and qualities of tubers are reduced. Potato growers in Eritrea commonly use Di-ammonium Phosphate, Urea and Farmyard manure while potassium fertilizers are overlooked assuming that the soil is developed from K rich parent material and contains sufficient amount of K to support crop growth. However this assumption is based on the result obtained forty-seven years ago. As a result the yield and quality of potato produced is very low as compared with international standards. The experiment was conducted in factorial Randomized Complete Block Design with fifteen treatment combinations of three varieties (Ajiba, Zafira and Picasso) and five potassium levels (0, 75, 150, 225 and 300 kg K_2O/ha) replicated thrice. The results of the study showed that both variety and potassium had significant effect on growth and yield parameters. Aerial stem number, leaf number per plant and plant height were increased with increasing K levels from 0

to 150 kg while number of days to maturity was increased in the range of 0-300 kg K_2O/ha. The result also indicated that variety Ajiba treated with 300 kg K_2O/ha produced significantly highest tuber weight (1.14 kg) per plant and tuber yield of 49.38 t/ha. The economic analysis result revealed that maximum gross margin 13,665.816 USD/ha was obtained from the application of 300 kg K_2O/ha. On the whole, it gives an impression that using potassium fertilizer according to soil requirements will have good influence on growth and tuber yield.

In Nepal, Bishwoyog *et al*. (2016) found the effect of potassium on the quality and growth of potato. He stated that potassium (K) aids in maintaining osmotic potential which enhances water uptake and root permeability, control ionic balances, regulate plant stomata and activate enzymatic processes. Potassium (K) plays significant role in quality as well as yield attributes of potato such as reducing sugar, Vitamin C content, specific gravity, shelf life and total yield. K application has found to increase reducing sugar content in potato tubers to threshold level and tends to decrease after that. The reason behind this is conversion of sugar to starch at high rate of K application. Vitamin C content is found to increase at moderate level of K application and tends to decrease in high concentration. Among the different sources of K, use of Muriate of Potash (MoP) is found better than Sulphate of Potash for increasing Vitamin C content. Specific gravity and dry matter content are found to decrease with higher dose of K application. K lowers down senescence and reduces physiological disorders, increasing shelf life in potato tubers. Potassium Chloride (KCl) is more effective in reducing the incidence of physiological disorders during postharvest compared to other source of K. K application plays significant role in increasing yield of potato tubers which is either due to formation of large sized tubers or increasing number of tubers per plants or both by helping in accumulation of carbohydrate. Careful attention should be given in potassium fertilization to maximize the quality and yield of potato tuber.

Subba *et al.* (2016) carried out a field trial at Horticultural Research Station, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during the year 2014-2015 to study the effect of potassium and boron on quality parameters of carrot. Significantly the highest carotene (4.56 mg 100g/l), ascorbic acid (2.70mg 100g/l) and total sugar content (7.60%) were found in the treatment T_{12}. The highest TSS was obtained from T_{16} (9.80 °Brix) followed by T_{12} (9.43 °Brix) and T_8 (9.03

°Brix). In all the cases minimum amount of carotene (2.88 mg 100g/l), ascorbic acid (0.25mg 100g/1), TSS (6.03°Brix) and total sugar content (4.28 %) of the carrot root were obtained in control plots which received no fertilizers. It was concluded that application of potassium at higher doses had a significant and positive effect on quality root production of carrot.

Yesmin (2014) conducted the experiment at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of phosphorus and potassium on the growth, yield of carrot during the period from November, 2013 to March, 2014. The experiment consisted of four different 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 highest gross yield of roots (4.79 kg /plot, 42.22 t/ha) was recorded from K_3 (200 kg K_2O/ha) and the lowest (3.97 kg/plot, 27.20 t/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.

Two field experiments were carried out by Abou El-Nasr *et al*. (2011) at Barramoon experimental farm, Hort. Res., Institute, Dakahlia Governorate, Egypt, during the two winter seasons of 2007/2008 and 2008/2009 to study the effect of different rates of potassium fertilization (0, 25, 50 and 75 kg K_2O /fad.) as potassium sulfate in addition to foliar application by water (control), liquid potassium (3 ml/ L), potassium borate citrate (3 ml/ L) and NPK- humate (3 ml/ L) and their interaction on production and quality of carrot cv. “Chantenay Red Core". Potassium foliar applications were made 3 times at 20 days intervals with the same doses during the growing period (20, 40 and 60 days after sowing). The highest potassium fertilization rate (75 kg K_2O /fad.) gave the tallest shoot, the highest number of leaves per plant and the highest fresh weight of shoots as well as the highest total yield per fadden in both seasons. Also, the obtained results reported that the root measurements expressed as (root length, root diameter, root weight, TSS and carotenoids content, as well as leaves chemical composition (N, P and K concentrations) were increased with increasing potassium fertilization rate in both seasons. On the other hand, spraying carrot plants with potassium humate at a rate of 3 ml/ L markedly increased vegetative growth, yield, root quality and chemical composition in both seasons. The favorable effects of the potassium on the growth, total yield and root parameters were obtained when carrot plants fertilized with 75 kg K_2O

/fad. as potassium sulfate plus foliar application of potassium humate (3 ml/ L) followed statistically by 75 kg K_2O /fad. with foliar application of potassium borate citrate (3 ml/ L) in both seasons.

El-Tohamy *et al.* (2011) conducted an experiment under sandy soil conditions in Nubaria (west delta region) to study the response of carrot plants to foliar application of potassium. Different levels of foliar potassium fertilizer (0.5, 1, 1.5 and 2ml/L) were applied. Plant growth, productivity, root quality and chemical analysis of leaves (N, P and K) were recorded in response to the application of these treatments. The results showed that carrot plants responded positively to all K levels. Vegetative growth parameters (including plant height, number of leaves and fresh and dry weight of leaves) were significantly enhanced by the levels of K especially at the higher levels while control plants obtained the lowest values. The level 1.5 ml/L seems to be optimal for carrot plants as increasing the K level more than this level did not give significant increment. Similar results were observed concerning root length, diameter, fresh and dry weight of roots and total soluble solids (T.S.S.) in roots. The results indicated that foliar application of K under sandy soil conditions improved root quality as well.

Abd El-Baky *et al*. (2010) conducted a field experiment during the two successive spring seasons of 2008 and 2009 in the International Potato Center (ICP), Agriculture Research Center (ARC), Kafr El-Zayat, ElGharbia Governorate, Egypt to evaluate the effect of different levels of potassium fertilization and foliar application of different rates of zinc on sweet potato (*Ipomoea batatas* L) (cv. Abeese) performance. Four rates of potassium fertilizer (60, 90, 120 and 150 kg K_2O/fed.) in the form of potassium sulfate (48% K_2O). The individual effects showed that the highest sweet potato yield was obtained from plants received 150 kg K_2O/fed., meanwhile the lowest root yield was obtained from control treatment (60 Kg K_2O/fed.). The interaction effect between potassium and zinc fertilizer showed the highest value of vegetative growth, yield and quality of roots when potassium and zinc were applied at the highest levels.

Papree (2008) carried out an experiment to study the effect of different levels of potassium and number of plant per hill on growth and yield of carrot at the Horticultural Farm, Sher- e-Bangla Agricultural University, Dhaka during the period of November 2006 to March 2007. The experiment consisted of four levels of potassium (*viz*. 0, 180, 200, 220 kg K_2O/ha). The two-factor experiment was set up in Randomized Complete

Block Design (RCBD) with three replications. The longest plant height (46.75 cm), number of leaves (9.23), diameter of root (11.02 cm), length of root (16.56 cm), dry matter content of leaf (16.62 g), dry matter content of root (12.83 %), yield per plot and yield per hectare (3.98 kg/plot and 25.23 t/ha, respectively) were obtained in application of 200 kg K_2O/ha (K_2) plant per hill.

Pekarskas and Bartaseviciene (2007) conducted an experiment in Lithuania, during 2001-04, to determine the effect of different potassium fertilizer forms on ecologically cultivated carrot yield and quality. Treatment with potassium sulphate increased the total harvest of carrots while the marketable harvest of carrot also increased regardless of the potassium fertilizer form.

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

Hochmuth *et al*. (2006) observed that potassium (K) is required for successful carrot (*Daucus carota*) production on sandy soils US, Soil test methods for K in carrot production have not been rigorously validated. Excessive fertilization sometimes is practiced by carrot growers to compensate for potential losses of K from leaching and some growers believe that high rated of fertilization may improve vegetable quality. Carrots were grown in three plantings during the winter of 1994-1995 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. 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.

Amjad *et al.* (2005) conducted the research to observe the effect of different N and K levels on carrot growth and seed yield during 2002-2003. Plant height, number of secondary umbels per plant, seed yield of primary, secondary and tertiary umbels per hectare and total seed yield were affected by various combinations of N and K levels. A combination of 75 kg N and 90 kg K ha^{-1} was most effective for obtaining maximum seed yield per hectare.

In India, Selvi *et al.* (2005) conducted a field study 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 (1.90-1.98%), while N at 170 kg/ha resulted in higher total N values (1.80-1.86%).

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 strong influence on the vegetative growth of the plant. The moderate level of K resulted in the longest root. The highest N level and moderate K level produced the greatest yield. 'fhcrc were strong positive correlations between the levels of N and K and root weight and yield per plot. K played a key role in increasing the root TSS value. Results suggest that a fertilizer rate of N: P: K at 80: 50: 80 kg/ha may be applied to increase carrot yield with quality roots under the agro climatic conditions of Meghalaya.

Khatun (1999) conducted an experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh to evaluate the effect of different types of mulching and potassium levels on the growth and yield of carrot during the period from November, 1998 to March, 1999. Four levels of potassium *viz*., 0, 60, 120 and 180 kg K per hectare were used in her study. The two factor experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected from ten randomly selected plants from each plot. Data on growth and yield

parameters were recorded and analyzed statistically. Potassium had significant influence on the growth and yield contributing characters of carrot. Fresh weight of leaves per plant, root length and diameter, fresh weight of root were maximum in 180 kg K/ha. Potassium increased the yield but the highest yield of carrot was obtained from the highest dose of potassium (180 kg K/ha).

Lazar and Dumitras (1997) conducted an experiment in Romania, during 1995-1997 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 KCl + 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_3 increased the yield and quality of carrot roots.

Singh and Singh (1996) investigated 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 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 umbels/plant (46.27) and seed yield (9.84 q/ha) were recorded following application of 150 kg N/ha. The number of umbels/plant and seed yield also increasing rates of K, the highest seed yield (mean of 9.35 q/ha) was observed at the highest rate of K.

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

Sharangi and Paria (1995) carried out an experiment where carrots (cv. Pusa Kesar) 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_2O /ha. P was applied at 60 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 in Venezuela with carrot cv. Super Fluke. Seeds were sown on 22 February on an orthotics Tropudults Ultisol 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 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 + 225 kg K_2O) + 10 ton 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 KCl or K_2SO_4 on 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.

Balooch *et al.* (1993) carried out a field trial during 1988-89. Tandojam carrots were grown from seed in seedbed to which 75 and 100 kg P_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.

Hassan *et al*. (1992) conducted in carrot cv. Red Cored Chantenay seeds were sown (at a rate of 2 kg seeds/feddan) in 70 cm wide beds on a silty clay soil either broadcast over the whole bed or in 2 or 3 drills. N, P and K were applied (split between 1 month after planting and 3 weeks later) at (1) 20, 24 and 24 kg/feddan, respectively, (2) 40, 36 and 48 kg/feddan, respectively, or (3) 60, 48and 72 kg/feddan, respectively. Controls were not fertilized. Plants were harvested in January. Sowing in 3 drills/bed resulted in greater plant height, leaf weight/plant, average root weight, root length, total plant FW and yield than 2 drills/bed or broadcast sowing. Average root weight, root length, total

plant FW and yield increased with increasing fertilizer application rates up to 40 kg N + 36 kg P_2O_5 + 49 kg K_2O/leddan. The highest and lowest yields were obtained with fertilizer rate (2) + 3 drills/bed (32.7 t/feddan) and no fertilizer + broadcast sowing (19.7 t/feddan), resp. [1 feddan 0.42 haj.

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.

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

Bruckner (1986) conducted an experiment over 3 years and reported that increasing the N supply (0-200 kg N/ha) produced a relatively small increases in yield. N at 100 kg/ha gave the best yield without increasing the content of carrots. Cultivars Flakkeer RZ and Falkker Karaf 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 *et al*. (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.

Maurya and Goswami (1985) carried out an experiment with the cv. Nantes, N: P_2O_5: K_2O were applied at 40-60: 18-32: 75-125 kg/ha. The highest yield of 25.08 t/ha and good root quality were obtained with the 60: 32: 125 kg/ha rate. Only 7.28 t/ha was obtained from the non-fertilized plot.

Krarup *et al*. (1984) conducted an experiment where chantnay carrot were fertilized with K_2O (0, 100 or 200 units/ha). There were no 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.

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 and quality of carrot.

2.2 Literature on earthing up

Fitsum *et al.* (2019) led an experiment in Ethiopia to determine the effects of flower removal and earthing up time on growth and tuber yield of potato. In their experiment they used randomized complete block design of factorial arrangements with three replications. The experiment comprised of five earthing up time treatments. Earthing up time affected fresh shoot biomass and physiological maturity of potato. The results clearly indicated that the highest total tuber yield (30.96 t ha^{-1}) was recorded from flower bud removed potato earthed up at 15 days after complete emergence. Therefore, flower bud removed potato earthed up at 15 days after full emergence was better in terms of all yield contributing characters and tuber yield.

Monira *et al*. (2019) conducted a field research at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October 2017 to March 2018 to study the effect of vermicompost and earthing up on growth and yield of onion. The experiment consists of two factors. Factor-A Vermicompost V_0 (control), V_1 (6 t ha^{-1} vermicompost), V_2 (10 t ha^{-1} vermicompost) and V_3 (14 t ha^{-1} vermicompost) and Factor-B Earthing up E_0 (control), E_1 (Two times earthing up) and E_2 (Three times earthing up). Results revealed that in terms of vermicompost application. The highest fresh weight $bulb^{-1}$ (40.07 g), yield /plot (527.89 g) and yield/ha (5.39 t) were found from the treatment V_3 compared to V_0 (control) treatment. Again, in terms of different earthing up treatments, the highest fresh weight $bulb^{-1}$ (32.48 g), yield $plot^{-1}$ (431.67 g) and yield/ha (4.41 t) were found from the treatment E_2 (Three times earthing up) compared to E_0 (control) treatment. Both vermicompost and earthing up and their combination showed a considerable variation on different growth and yield parameters of onion. The highest fresh weight $bulb^{-1}$ (42.73 g), yield $plot^{-1}$

(567.33 g) and yield ha^{-1} (5.79 t) were found from the treatment combination of V_3E_2 compared to control V_0E_0 (control) treatment combination. And it may be summarized that 14 t/ha vermicompost with three times earthing up performed the maximum yield compared to other treatments.

A study on the effect of potato earthing up frequency on potato yield was carried out at Chinyika Irrigation Scheme in Ward 16 in Goromonzi district, Mashonaland East province by Chitsinde (2018). The experiment consisted of five treatments namely, no earthing up (control), earthing up once, earthing up twice, earthing up thrice and earthing up four times. The potato variety BPI commonly grown by the farmers in the area was used in the experiment. The experiment was laid out as a Randomized Complete Block Design in a single factorial arrangement replicated three times. Cost benefit analysis showed that earthing up thrice is profitable. The study indicated that earthing up to three times produces the maximum potato yield above 15 t/hectare and any earthing up thereafter produces no significant additional yield. The study recommended utmost earthing up frequency to be done in order to enhance yield potential.

Mahmud *et al*. (2014) conducted an experiment at the Horticultural Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2011 to May 2012 to find out the influence of earthing up on growth and yield of Japanese bunch onion (Moto kura). Three levels of earthing up *viz*. E_0 : no earthing up; E_1: earthing up (once); E_2: earthing up (twice) was set at the experiment following RCBD design with three replications. Tallest plant (60.4 cm) with maximum number of leaves (8.4), leaf area (334.7 cm^2) and maximum weight of leaves/plant (80.5 g) were found from E_2. On the other hand, longest pseudostem (28.8 g), highest yield/plot (2.88 kg) and highest yield/ha (14.4 ton) was found from E_2. E_1 was statistically similar with the E_2.

Gutema (2016) conducted the experiment for three consecutive years with the objective of determining the effects of the tuber seed size and hilling up frequencies on yield and yield traits of Potato. The result of the study revealed that the highest total tuber yield was obtained from three times hilling up frequency followed by two times, but both means are statistically similar. Three and two times hilling up frequency had significantly increased total tuber yield by 24.7% and 15.5% over the control,

respectively. Farmers can get more income when they practice three times hilling up though they invest more extra cost as compared to two times hilling up.

Tafi *et al*. (2010) conducted a field experiment to see the effects of soil adding influences on yield of four varieties of potato were studied in Dezful (Khouzestan province, Iran). The experimental design was a split plot fitted to randomized complete block with four replications and two factors including adding soil to bush foot and variety. Adding soil had two E_0 and E_1 levels, without adding soil and once soil adding and varieties including four V_1 , V_2 , V_3 and V_4 levels which were Arinda, Sante, Marafona and Ramus respectively. Quantitative and qualitative characteristics were measured during plan execution. Results showed that treatment of adding soil affected on tuber yield significantly (P>0.01). The characteristics of the tuber number and mean tuber weight in the bush had significant (P>0.05). The characteristics of tuber number, stem number and mean tuber weight have had significant at different varieties (P>0.01). Mutual effect of the varieties and adding soil view, the characteristics of tuber diameter has had significant (P>0.05). According to obtained results adding soil increase yield with amount of 43.31 t/ha for Ramos variety.

Faisal *et al*. (2009) carried out an investigation at Agricultural Research Station, Pahartali, Chittagong during February to August 2002 to select suitable size of planting material and proper time of earthing up to obtain higher yield of Mukhi Kachu. Three planting materials, primary corm (40g), half cut corm (20g), and secondary corm (10g) and four times of earthing up, 1 month, 2 months, 3 months, and 4 months after planting were used. Different planting materials showed significant difference on weight of total corms/plot, weight of total cormels/plot and cormel yield. Different times of earthing-up showed significant effects on the parameters studied except no. of cormels/hill and weight of cormels/hill. The highest (3.71 t/ha) corm yield was obtained when primary corms were planted and earthing-up was done three months after planting. The combination of P1E (primary corm × 3 months after planting) gave the highest (8.37 t/ha) cormel yield.

Ali *et al*. (2007) conducted a field experiment during the period from October 2001 to April 2002 to study the effect of earthing up and level of irrigation on yield and quality seed production of onion (cv. Taherpuri) at Rajshahi University campus, Rajshahi, Bangladesh. Two different factors were considered, factor (A): Earthing up (E_1),

without earthing up (E_0) and factor (B): irrigation level (5 levels) viz. irrigation start at 1st time and when required (I_4), irrigation start at 40 DAP and when required (I_3), irrigation start at 60 DAP and when required (I_2), irrigation start at 80 DAP and when required (I_1), no irrigation or control (I_0). The result revealed that bulb emergence, plant height, number of leaves, length of scape, tillers, bulb yield, seeded fruits, fruits set, days to blooming, seed yield, 1000-seed weight and germination percentage were significantly influenced by different treatments. The highest seed yield (405.97 kg/ha) was found from earthing up with irrigation start at first time and when required (E_1I_4). The results suggested that earthing up with 3-4 times irrigation is more effective for onion seed production in Bangladesh.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from November, 2018 to March, 2019 to investigate on the effect of potassium and earthing up on growth, yield and economic benefit of carrot. This chapter includes a brief description of the experimental period, location, soil and climatic condition of the experimental area and materials that were used for conducting the experiment such as treatment and design of the experiment, growing of crops, intercultural operations, data collection procedure and procedure of data analysis that were used for conducting the experiment.

3.1 Experimental site

The research was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. The experiment was carried out during rabi season. The location of the experimental site is situated at 90° 22' E longitude and 23° 41' N latitude. The altitude of 8.6 meters above the sea level. Map of experimental site are presented in Appendix I.

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Farmgate, Dhaka and the results showed that the soil composed of 27% sand, 43% silt and 30% clay. The soil was having a texture of sandy loam with pH and organic matter 5.47 – 5.63 and 0.83%, respectively. The details soil characteristics are presented in Appendix II.

3.3 Climatic condition of the experimental site

The experimental area was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). During the experimental period, the maximum temperature was (29.85^0C), highest relative humidity (70.63 %) and highest rainfall (09 mm). Highest rainfall (09 mm) was recorded in the month of February, 2019, whereas the minimum temperature (13.82^0C), minimum relative humidity (62.04%) and no rainfall was recorded for other three

months. The climatic conditions during the period of experiment was collected from the Bangladesh Meteorological Department, Agargaon, Dhaka and the data are presented in Appendix III.

3.4. Agro-ecological region

The experimental field belongs to the agro-ecological region of the Madhupur Tract (AEZ-28). The landscape comprises level upland, closely or broadly dissected terraces associated with either shallow or broad, deep valleys.

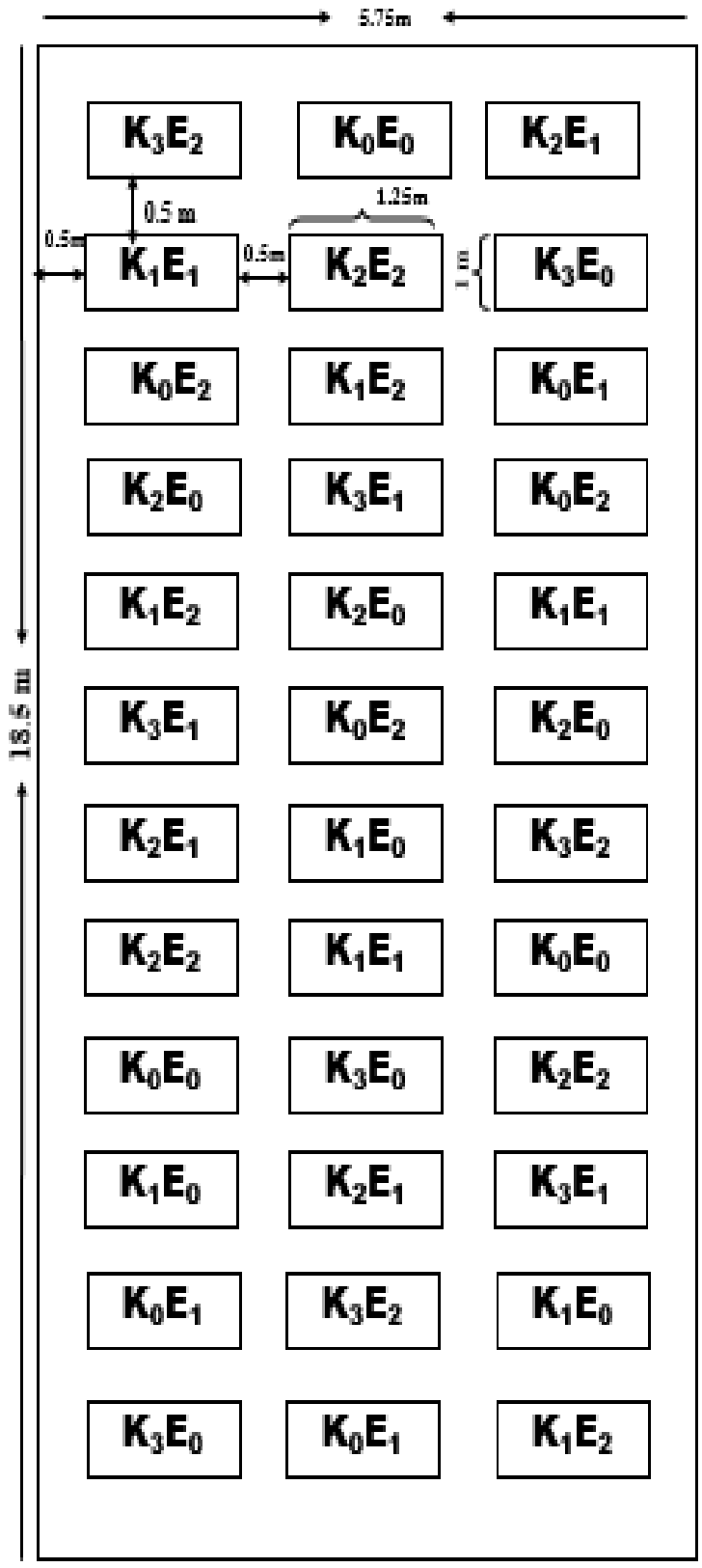
3.5. Experimental details:

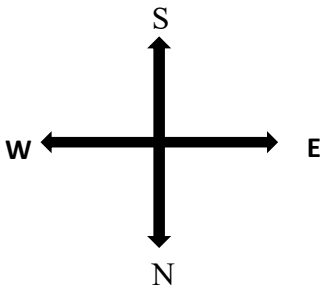
3.5.1 Planting materials

The seeds of variety Cascade F1 were collected from the Bejo sheetal seed Ltd.

3.5.2 Design and layout of the experiment

The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications where the experimental area was divided into three equal blocks representing the replications to minimize the soil heterogeneous effects. The length of the experimental area 18.5 m and width 5.75 m and the total area of the experimental plot was 106.375 m^2. The total area is divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were total 36 unit plots in the experiment. The size of the each plot was 1.25 m × 1 m. The distance maintained between two blocks and two plots were 50 cm. Both the row to row and plant to plant distances were 25 cm and 20 cm, respectively.





Plot size: 1.25m x 1m
Spacing between plot: 50 cm
Spacing between replication: 50cm
Row to Row distance: 25 cm
Plant to Plant distance: 20 cm

Factor A: Different levels of potassium

K_0 =Control
K_1 = 100 kg K/ha
K_2= 120 kg K/ha
K_3= 140 kg K/ha

Factor B: Different numbers of earthing Up

E_0 = No earthing up
E_1= Two times earthing up
E_2 = Three times earthing up

Figure. 1. Layout of the experimental plot of carrot.

3.5.3 Experimental treatments

The experiment was conducted to study the effect of four levels of potassium and three numbers of earthing up. Different levels of two factors were as follows:

Factor A: Different levels of potassium

K_0= Control (0 kg K/ha)
K_1= 100 kg K/ha
K_2 = 120 kg K/ha
K3 = 140 kg K/ha

Factor B: Different numbers of earthing up

E_0= No earthing up
E_1= Two times earthing up
E_2= Three times earthing up

There are 12 treatment combinations such as K_0E_0, K_0E_1, K_0E_2, K_1E_0, K_1E_1, K_1E_2, K_2E_0, K_2E_1, K_2E_2, K_3E_0, K_3E_1, K_3E_2 .

3.6 Seed soaking and seed treatment

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

3. 7 Land preparation

The selected land for the experiment was first opened on November, 2018 by disc plough and it was exposed to sun for seven days prior to next ploughing. The land was ploughed six times by tractor to obtain good tilth. Laddering to break the soil clods and pieces was followed with each ploughing. All weeds and stubbles were removed and the land was finally prepared through addition of the basal doses of manure and fertilizers. Plots were prepared according to design and layout. Finally soil of each plot was treated by Sevin 80 WP @ 2kg/ha to protect the young plant from the attack of mole cricket, cutworm and ants, Irrigation channels were made around each block.

3.8 Application of manures & fertilizers

The following doses of manure and fertilizers were used for carrot production according to Handbook of Agricultural Technology, 2013, BARC.

Manures/Fertilizers	Dose
Cowdung	10 ton/ha
Urea	250 kg/ha
Triple Super Phosphate (TSP)	200 kg/ha
Gypsum	100 Kg/ha
Muriate of Potash (as potassium)	As per treatment

In the experimental plots total amount of cowdung (10 ton /ha) and TSP (200 kg/ha), gypsum (100 kg/ha) and half of MoP (as per treatment) were used as basal dose and rest of MoP (as per treatment) was used after 35 DAS. Urea (250 kg/ha) was used equal three splits according to the experimental design. The applied manures were mixed properly with the soil in the plot using a spade.

3.9 Seed rate and seed sowing

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

3.10 Intercultural operations

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

3.10.1 Thinning

Emergence of seedlings started about seven days after sowing. Thinning was done at two stages like 15 and 30 days after sowing in order to keep a healthy plant in each hill.

3.10.2 Weeding

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

3.10.3 Earthing up

Earthing Up was done according to the treatments. First earthing up was done 35 DAS (Days after sowing) as per required treatment. The second earthing up was done at 55 DAS (Days after sowing) at all the plots except control plot. The third earthing up was done at 75 DAS (Days after sowing) as per treatment to identify the effect of earthing up on growth, yield and economic benefit of carrot.

3.11 Plant protection

3.11.1 Insects and pest management

The crop was infested with cut warm (*Agrostis ipsilon*), mole cricket, field cricket during the early stage of growth of seedlings. These insects were controlled initially by beating and hooking, afterwards by spraying Dieldrin 20 EC at the contrition of 0.1%.

3.11.2 Disease management

Precautionary measure against Fusarium rot was taken by spraying Dithane M 45 @ 2g /litter water.

3.12 Harvesting

Harvesting of carrots at proper stage of maturity is essential to fetch good price in the market. Delay in harvesting deteriorates the quality of the roots and becomes unfit for consumption. Every variety has certain period for harvesting. The Cascade F1 variety was harvested after 95 days after sowing. When older leaves became yellow, harvesting was done plot wise by uprooting the plants manually. Give light irrigation before harvesting to facilitate easy pulling of roots without any damage. In heavy soil, roots are removed from soil by digging. After harvesting roots are washed and cleaned.

3.13 Parameters assessed

Growth stage

1. Plant height
2. Number of leaves per plant

Maturity stage

1. Length of root per plant
2. Diameter of root per plant
3. Fresh weight of leaves per plant
4. Fresh root weight
5. Dry matter of roots
6. Dry matter of leaves
7. Cracked roots per plot
8. Branched roots per plot
9. Total yield of roots per plot
10. Total yield of roots per hectare
11. Marketable yield of roots per plot
12. Marketable yield of roots per hectare

3.14 Data collection procedure

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

3.14.1 Plant height

Plant height was measured with the help of a meter scale from the ground level of the root up to the tip of leaf at 35 DAS, 55 DAS, 75 DAS and harvest days after sowing.

3.14.2 Number of leaves per plant

Number of leaves were counted 20 days interval and was started from 35 days after sowing and continued to harvest, *i.e*. 55 DAS, 75 DAS and at harvest. Five plants in each plot were used to count number of leaves per plant. Only the smallest young leaves at the growing point of the plant were excluded from the counting and the average number was calculated.

3.14.3 Length of root

The length of the conical roots was measured in centimetres 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. The plants are selected randomly from each plot of the experimental field.

3.14.4 Diameter of root

Five selected plants are selected randomly from each plot to determine root diameter. Root diameter was measured at the time of harvesting with slide callipers and recorded in centimetre.

3.14.5 Fresh weight of leaves per plant

Underground modified carrot roots of five 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 balance in gram (g) and then the average value was calculated.

3.14.6 Fresh root weight

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

3.14.7 Dry matter of roots

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 80^0 C. Immediately after oven drying, the dried root pieces were weighed and the dry matter content of the roots was calculated by the following, formula.

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

3.14.8 Dry matter of leaves

From the random samples of leaves weighing 100 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 leaves and it was calculated on percentage basis.

The percentage of dry matter of leaves was calculated by the following formula.

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

3.14.9 Percentage of branched roots

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

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

3.14.10 Percentage of cracked roots

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

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

3.14.11 Gross yield of roots per plot

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.

3.14.12 Gross yield of roots per hectare

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

3.14.13 Marketable yield per plot

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

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

3.14.14 Marketable yield per hectare

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

3.15 Statistical Analysis

The recorded data on different parameters were statistically analyzed using Statistic 10 software. The significance of the difference among the treatments means was estimated by least significant difference test (LSD) at 5% level of probability.

3.16 Economic Analysis

The cost of production was calculated to find out the most economic combination of different levels of potassium and number of earthing up. All input cost like the cost for land lease and interests on running capital were computing in the calculation. The interests were calculated @ 13% in simple rate. The market price of carrot was considered for estimating the return. Analyses were done according to the procedure of Alam *et al.* (1989).

3.16.1 Analysis for total cost of production of carrot

All the material and non-material input cost, interest on fixed capital of land and miscellaneous cost were considered for calculating the total cost of production. Total cost of production (input cost, overhead cost), gross return, net return and BCR are presented in Appendix section.

3.16.2 Gross income

Gross income was calculated on the basis of sale of carrot. The price of carrot was determined on the basis of current market value of Kawran Bazar, Dhaka at the time of harvesting.

3.16.3 Net return

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

Net returns = Gross returns – cost of cultivation

3.16.4 Benefit cost ratio (BCR)

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

$$\text{Benefit Cost Ratio} = \frac{\text{Gross returns (Tk./ha)}}{\text{Total cost of production}}$$

Plate 1. The pictorial view of the seed used in the experimental field

Plate 2. Pictorial presentation of measuring the plant height of carrot

Plate 3. The pictorial view of the plot with earthing up treatment

Plate 4. The pictorial view of the plot without earthing up treatment

CHAPTER IV
RESULTS AND DISCUSSION

The experiment was conducted to study the growth, yield and economic benefit of Carrot (*Daucus carota* L.) as influenced by different levels of potassium and different numbers of earthing up. Data on different growth, yield attributes and economic benefit of carrot were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix section. The results have been presented with the help of graphs and tables and possible interpretations given under the following headings**.**

4.1 Plant height

The plant height was recorded at different growth stages of carrot *i.e.* 35 DAS, 55 DAS, 75 DAS and at harvest of carrot. Plant height of carrot varied significantly due to the application of different levels of potassium (Figure 2 and Appendix IV, XII). At 35 DAS, the longest plant of carrot (15.02 cm) was recorded from K_2 (120 kg K/ha) treatment which was significantly different from all other treatments, while the shortest plant height of carrot (11.99 cm) was observed from K_0 (control) treatment. At 55 DAS, the highest plant height of carrot (33.72 cm) was recorded from K_2 (120 kg K/ha) treatment, while the lowest plant height of carrot (23.16 cm) from K_0 (control) treatment. At 75 DAS, the longest plant (39.25 cm) was recorded from K_2 (120 kg K/ha) treatment and the shortest plant (29.53 cm) was obtained from K_0 (control) treatment. At the time of harvest the highest plant height (43.89 cm) was obtained from K_2 (120 kg K/ha) treatment and the shortest plant height (36.99 cm) was obtained from K_0 (control) treatment. The application of potassium significantly improved the growth of carrot. El-Tohamy *et al*. (2011) found the similar findings in their study. They found that vegetative growth like plant height was significantly enhanced by the levels of potassium especially at the proper levels while control plants obtained the lowest values.

Effect of earthing up on plant height of carrot was significantly varied (Figure 3. And Appendix V, XII). At 55 DAS, 75 DAS and at harvest there was significant differences in plant height. But at 35 DAS, the highest plant height of carrot (13.83 cm) was observed from the treatment E_2 (three times earthing up) where the lowest plant height

of carrot (13.61 cm) was obtained from E_0 (control) treatment. At 55 DAS the plant height was significantly differed. The maximum plant height of carrot (31.96 cm) was recorded from E_2 (three times earthing up) treatment, which was statistically similar (30.80 cm) to the treatment E_1 (two times earthing up) treatment. On the other hand, the minimum plant height of carrot (25.88 cm) was observed from E_0 (no earthing up) treatment. From the observation of 75 DAS, the longest plant height of carrot (38.88 cm) was recorded from the treatment E_2 (three times earthing up), which was statistically similar (36.77 cm) to the treatment E_1 (two times earthing up) treatment and the shortest plant height of carrot (27.38 cm) was found from E_0 (no earthing up) treatment. At harvest the longest plant height of carrot (44.38 cm) was observed from E_2 (three times earthing up) treatment, while the shortest plant height of carrot (36.12 cm) was observed from E_0 (no earthing up) treatment. Various scientists conducted different experiments on different crop to find out the effect of earthing up. Gutema (2016) and Tafi *et al*. (2010) observed the similar trend of results. They opined that earthing up increases the height of plant. Increase in earthing up frequency ensure a well drained cool environment being created from good crop that enables adequate amount of carbohydrate to grow properly.

Significant variation was not observed due to the combined effect of potassium and earthing up in terms of plant height of carrot at 35 DAS but plant height varied significantly at 55 DAS, 75 DAS and at harvest of carrot (Table 1 and Appendix XII). Results revealed that at 35 DAS longest plant height of carrot (15.24 cm) was observed from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination, while the shortest plant height of carrot (11.87 cm) was recorded from K_0E_0 (control) treatment combination. At 55 DAS the longest plant height was (37.53 cm) recorded from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination which was statistically similar (35.01 cm) to the treatment combination K_3E_2 (140 kg K/ha and three times earthing up) and shortest plant height of carrot (20.78 cm) was observed from K_0E_0 (control) treatment combination. At 75 DAS maximum plant height of carrot (46.66 cm) was observed from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination, while minimum plant height (22.94 cm) was observed from K_0E_0 (control) treatment combination. At harvest the highest plant height of carrot (47.40 cm) was recorded from K_2E_2 (120 kg K/ha and three times earthing up) treatment

combination and the shortest plant height of carrot (31.45 cm) was recorded from K_0E_0 (control) treatment combination.

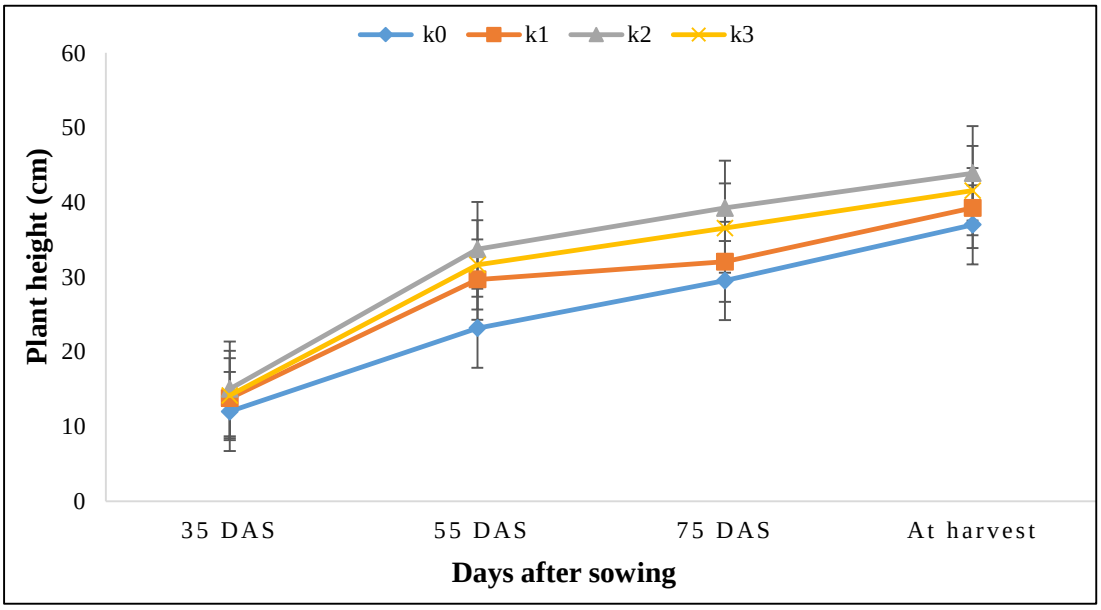


Figure 2. Effect of potassium on plant height at different days after sowing (DAS) of carrot. Where K_0= Control, K_1= 100 kg K/ha, K_2= 120 kg K/ha, K_3= 140 kg K/ha.

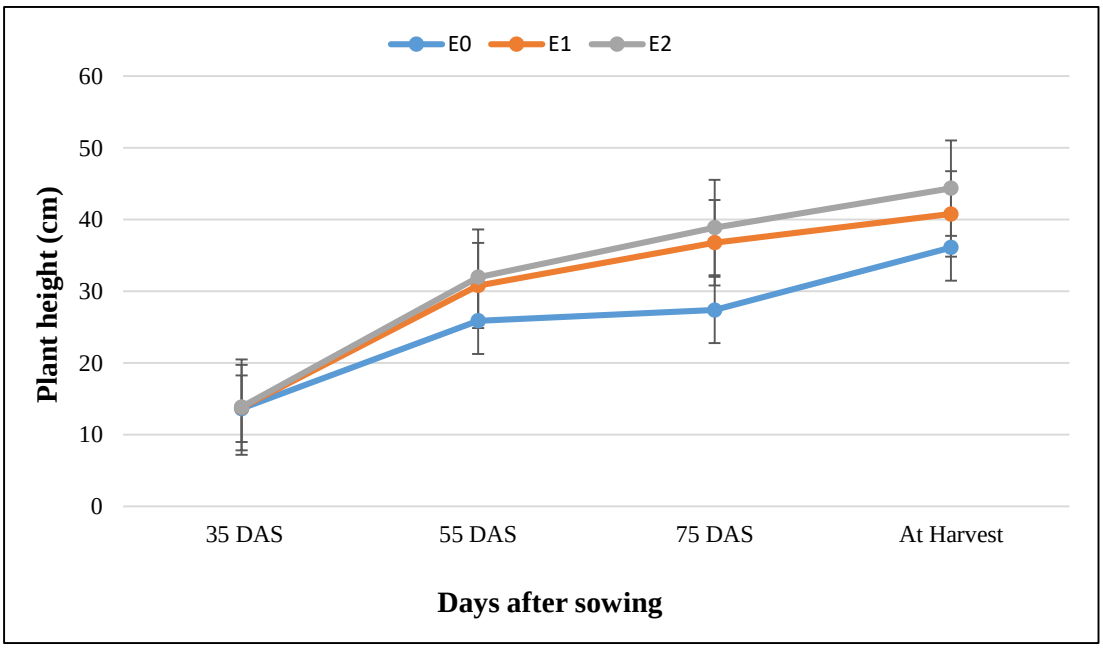


Figure 3. Effect of earthing up on plant height at different days after sowing (DAS) of carrot. Where, E_0= no earthing up, E_1= two times earthing up, E_2= three times earthing up.

Table 1. Combined effect of potassium and earthing up on plant height at different days after sowing (DAS) of carrot

Treatment combination	Plant height (cm)			
	35 DAS	55 DAS	75 DAS	At Harvest
K_0E_0	11.87	20.78 g	22.94 h	31.45 g
K_0E_1	12.17	23.95 f	32.64 ef	37.66 e
K_0E_2	11.94	24.76 ef	33.01 ef	41.88 cd
K_1E_0	13.72	27.62 de	24.84 gh	33.54 f
K_1E_1	13.79	30.85 c	34.44 de	40.56 d
K_1E_2	13.83	30.55 c	36.84 cde	43.63 b
K_2E_0	14.88	29.16 cd	28.91 fg	40.92 d
K_2E_1	14.95	34.48 b	42.18 b	43.36 bc
K_2E_2	15.24	37.53 a	46.66 a	47.40 a
K_3E_0	13.97	25.94 ef	32.81 ef	38.58 e
K_3E_1	14.17	33.93 b	37.82 cd	41.53 d
K_3E_2	14.29	35.01 ab	39.02 bc	44.61 b
LSD (0.05)	NS	2.9286	4.2796	1.4908
CV%	1.99	5.85	7.36	2.18

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, K_0 = control, K_1 = 100 kg K/ha, K_2 = 120 kg K/ha, K_3 = 140 kg K/ha, E_0 = control, E_1 = two times earthing up, E_2 = three times earthing up.

4.2 Number of leaves per plant

From the current investigation, the number of leaves per plant of carrot was recorded at different stages of growth *i.e*. 35 DAS, 55 DAS, 75 DAS and at harvest. The number of leaves per plant of carrot varied significantly due to the application of different levels of potassium (Figure 4 and Appendix VI, XII). At 35 DAS, the highest number of leaves per plant (7.51) was recorded from K_2 (120 kg K/ha) treatment which was significantly different from all other treatments and the lowest number of leaves per plant (4.51) was observed from K_0 (control) treatment. At 55 DAS, the highest number of leaves per plant (10.03) was obtained from K_2 (120 kg K/ha) treatment, while the lowest number of leaves per plant (6.36) was recorded from K_0 (control) treatment. At 75 DAS, the maximum number of leaves per plant (14.18) was recorded from K_2 (120 kg K/ha) treatment, while the lowest number of leaves per plant (10.42) was recorded from K_0 (control) treatment. At the time of harvest, the highest number of leaves per plant was (18.18) obtained from K_2 (120 kg K/ha) treatment and the lowest number of leaves per plant (13.18) of carrot was obtained from K_0 (control) treatment. Zeru *et al*. (2016) and Bishwoyog *et al*. (2016) observed the better result for the application of potassium. Potassium helps to increase the physical growth and development of carrot. Proper application of potassium fertilizer increase the plant growth, number of leaves etc.

Number of leaves per plant of carrot was significantly varied due to the effect of earthing up which was recorded at different stages of growth *i.e*. 35 DAS, 55 DAS, 75 DAS and at harvest (Figure 5. And Appendix VII, XII). Significant variation was not found in terms of number of leaves per plant of carrot at 35 (DAS) affected by different numbers of earthing up but later at 55 DAS, 75 DAS and at harvest there was significant differences in number of leaves per plant. But at 35 DAS the highest number of leaves per plant of carrot (6.48) was viewed from E_2 (three times earthing up) treatment where lowest numbers of leaves per plant of carrot (6.08) was from E_0 (control) treatment. At 55 DAS the number of leaves per plant of carrot was significantly differed. The highest number of leaves per plant (9.45) was recorded from E_2 (three times earthing up) treatment which was statistically similar (8.88) to the treatment E_1 (two times earthing up). The lowest number of leaves per plant (6.45) was observed from E_0 (no earthing up) treatment. From the observation of 75 DAS the highest number of leaves per plant

(13.60) was recorded from the treatment E_2 (three times earthing up) which was statistically similar (13.05) to the treatment E_1 (two times earthing up) and the lowest number of leaves per plant (9.52) was recorded from E_0 (no earthing up) treatment. At harvest the highest number of leaves per plant (17.76) was observed from E_2 (three times earthing up) treatment and the lowest number of leaves per plant (13.31) was observed from E_0 (no earthing up) treatment. Different scientist were conducted different experiments on different crop to find out the effect of earthing up. Gutema (2016) and Tafi *et al*. (2010) observed the similar trend of results. Earthing up regulating the soil moisture and temperature, that increases the plant growth and development. Three times of earthing up increases the number of leaves per plant, because the plant obtained proper moisture and temperature than no earthing up treatment.

Combined effect of potassium and earthing up in terms of number of leaves per plant of carrot at 35 DAS did not show the significant variation, but varied significantly at 55 DAS, 75 DAS and at harvest (Table 2 and Appendix XII). At 55 DAS, the maximum number of leaves per plant (12.91) was recorded from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination, while the lowest number of leaves per plant (5.04) was observed from K_0E_0 (control) treatment combination. At 75 DAS, the maximum number of leaves per plant (16.85) was observed from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination and the minimum number of leaves per plant (8.21) was observed from K_0E_0 (control) treatment combination which was statistically similar (9.46) to the treatment combination K_1E_0 (100 kg K/ha and no earthing up). At harvest, the highest number of leaves per plant (21.11) was recorded from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination and the lowest number of leaves per plant (10.53) was recorded from K_0E_0 (control) treatment combination.

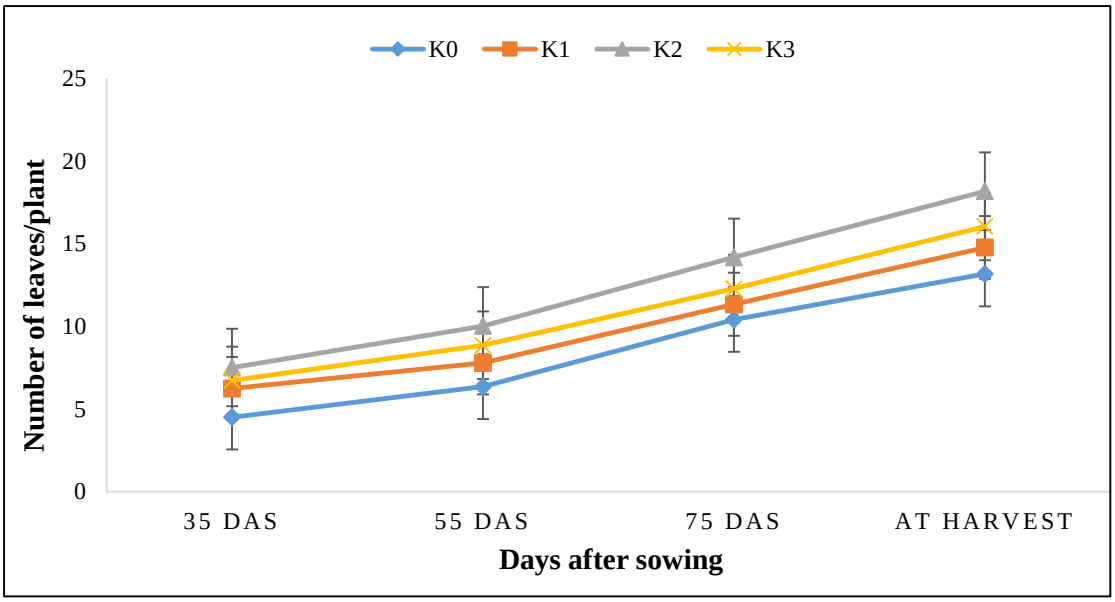


Figure 4. Effect of potassium on number of leaves per plant at different days after sowing (DAS) of carrot. Where, K_0= control, K_1= 100 kg K/ha, K_2= 120 kg K/ha, K_3= 140 kg K/ha.

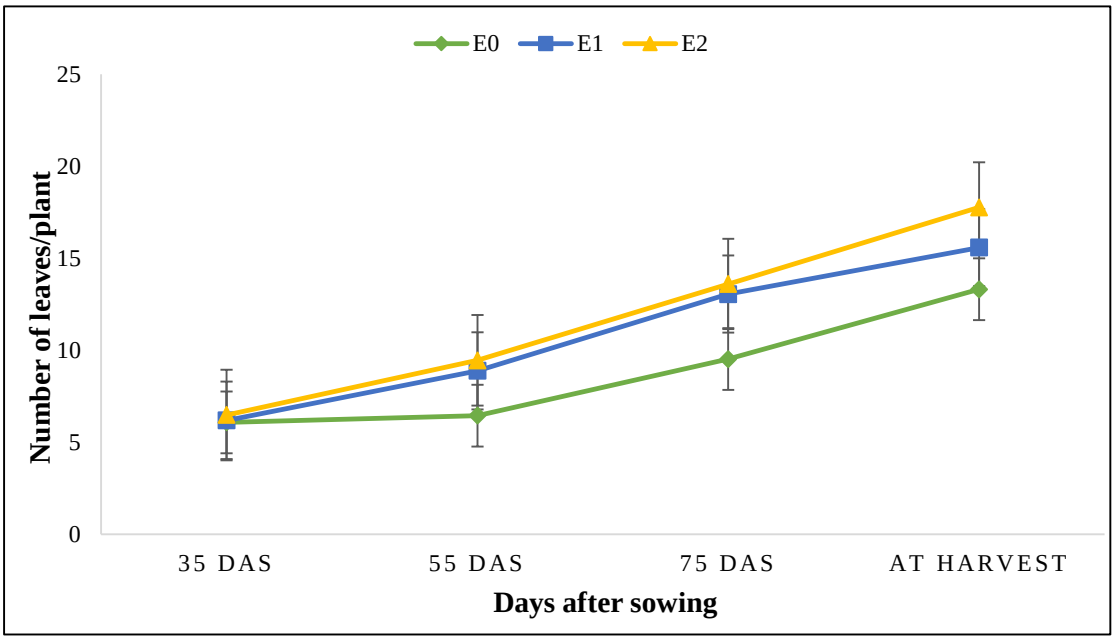


Figure 5. Effect of earthing up on number of leaves per plant at different days after sowing (DAS) of carrot. Where, E_0= no earthing up, E_1= two times earthing up, E_2= three times earthing up.

Table 2. Combined effect of potassium and earthing up on number of leaves per plant at different days after sowing (DAS) of carrot

Treatment combination	Number of leaves per plant			
	35 DAS	**55 DAS**	**75 DAS**	**At Harvest**
K_0E_0	4.31	5.04 g	8.21 i	10.53 g
K_0E_1	4.50	7.12 ef	11.78 def	12.63 f
K_0E_2	4.72	6.92 ef	11.29 efg	16.38 cd
K_1E_0	5.92	6.24 f	9.46 hi	14.01 ef
K_1E_1	6.24	8.55 cd	12.15 de	14.81 de
K_1E_2	6.56	8.61 cd	12.41 cde	15.53 de
K_2E_0	7.15	6.62 f	10.45 fgh	14.80 de
K_2E_1	7.57	10.55 b	15.23 b	18.62 b
K_2E_2	7.81	12.91 a	16.85 a	21.11 a
K_3E_0	6.94	7.88 de	9.98 gh	13.89 ef
K_3E_1	6.47	9.31 c	13.04 cd	16.25 cd
K_3E_2	6.82	9.37 c	13.86 bc	18.02 bc
LSD (0.05)	NS	1.1481	1.4867	1.9854
CV%	8.24	8.21	7.28	7.54

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, K_0 = Control, K_1 = 100 kg K/ha, K_2 = 120 kg K/ha, K_3 = 140 kg K/ha, E_0 = Control, E_1 = two times earthing up, E_2 = three times earthing up.

4.3 Fresh weight of leaves per plant

The fresh weight of leaves per plant significantly differed due to the application of different levels of potassium (Figure 6. and Appendix VIII, XIII). The maximum fresh weight of leaves per plant (113.91 g) was recorded from K_2 (120 kg K/ha) treatment. However, control treatment showed the minimum fresh weight of leaves per plant (85.47 g). The increased fresh weight of leaves under K_2 (120 kg K/ha) treatment 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 leaves. Sharangi and Paria (1996) also showed similar results in their study. Fresh weight of leaves increased by the application of proper doses of potassium. El-Tohamy *et al.* (2011) also concluded that fresh weight of leaves per plant enhanced by the levels of potassium.

A significant variation was observed on the fresh weight of leaves per plant due to different numbers of earthing up (Figure 7 and Appendix IX, XIII). The maximum fresh weight of leaves per plant (105.80 g) was recorded from E_2 (three times earthing up) treatment, while the minimum fresh weight of leaves per plant (96.35 g) was from K_0 (control) treatment. Mahmud *et al*. (2014) also found the similar trend of results in their experiment. Three times earthing up increases the fresh weight of leaves per plant. Frequency of earthing up results in plants having a larger area from which to hold waters and nutrients for plant.

A significant effect was observed due to combined effect of potassium and earthing up on fresh weight of leaves per plant (Table 3 and Appendix XIII). The maximum fresh weight of leaves per plant (121.46 g) was recorded from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination. The minimum fresh weight of leaves per plant (80.09 g) was recorded from K_0E_0 (control) treatment combination.

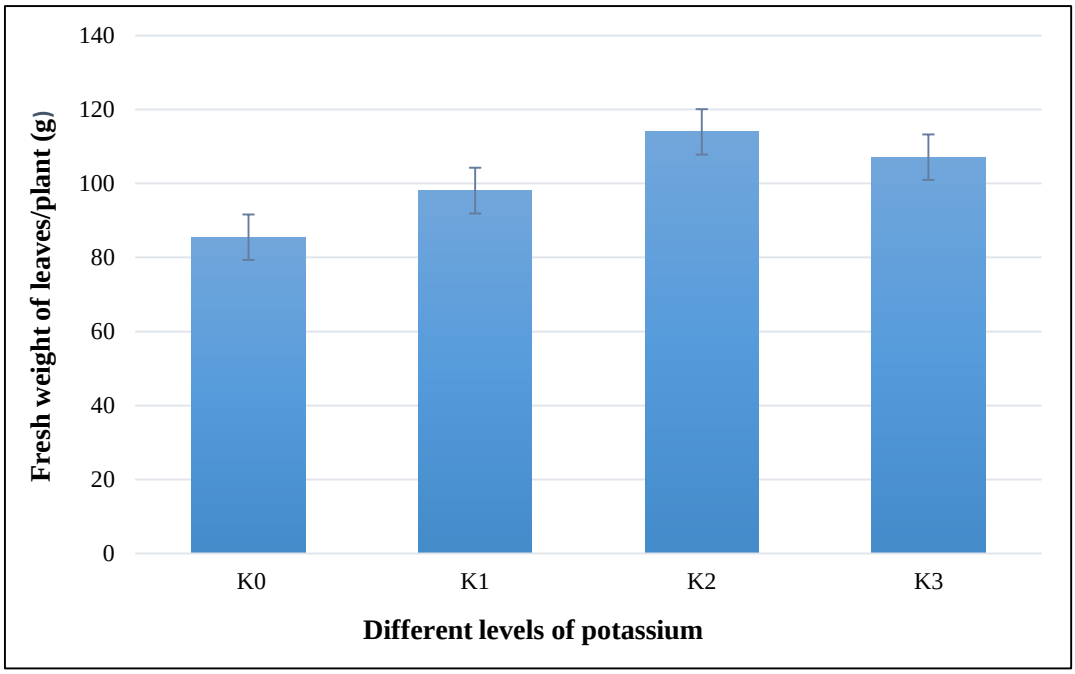


Figure 6. Effect of potassium on fresh weight of leaves per plant of carrot. Where, K_0= control, K_1= 100 kg K/ha, K_2= 120 kg K/ha, K_3= 140 kg K/ha.

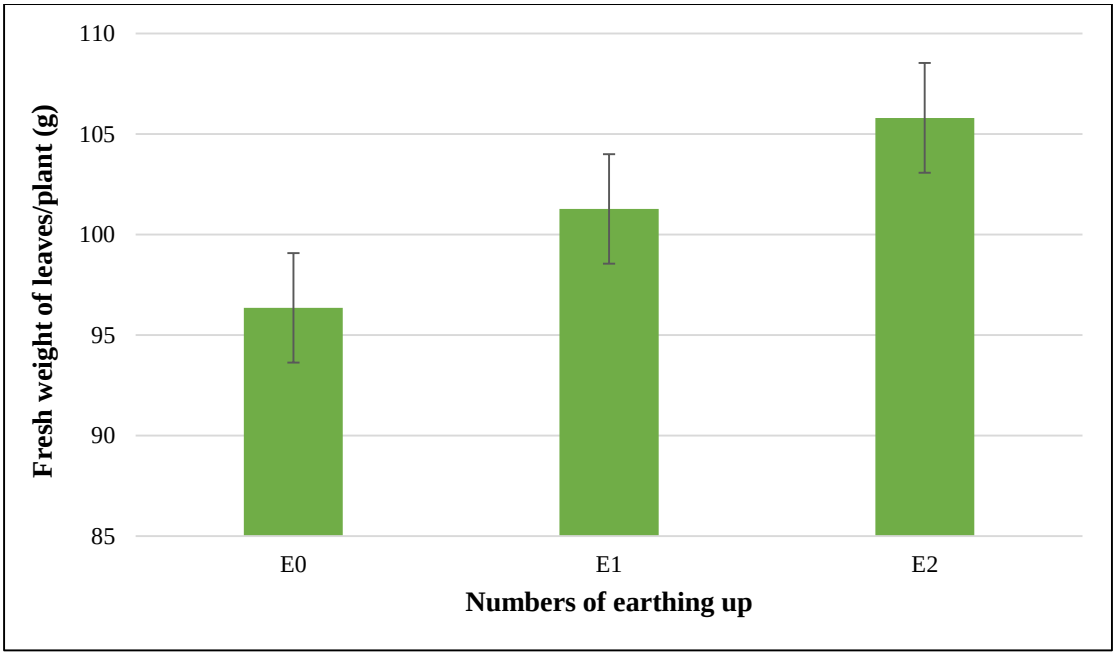


Figure 7. Effect of earthing up on fresh weight of leaves per plant of carrot. Where, E_0= no earthing up, E_1= two times earthing up, E_2= three times earthing up.

4.4 Root length

Significant variation was observed due to the effect of different levels of potassium on the length of root (Figure 8 and Appendix VIII, XIII). The longest root of carrot (16.77 cm) was obtained from K_2 (120 kg K/ha) treatment. The control (K_0) treatment showed the shortest root length of carrot (11.71 cm). 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. Sharangi and Paria (1996) found that the application of higher levels of potassium produced the longer roots than the lower ones. Their results also supported the present findings. Abou El-Nasr and Ibrahim (2011) found that root length increased with the application of potassium fertilizer.

Effect of earthing up on root length of carrot was differed significantly. The treatment E_2 (three times earthing up) showed the longest root length of carrot (17.85 cm), while the shortest root length (10.90 cm) recorded from E_0 (control) treatment (Figure 9 and Appendix IX, XIII). This is supported by Booth (2007) who postulated that adequate earthing up results in plants having a larger area from which to hold moisture and nutrients for development as compared to unridged crop which has a limited area for holding moisture and nutrients. Frequency of earthing up increases the area around root for development. For this reason three times earthing up increases the root length of carrot.

The combined effect of different levels of potassium and earthing up showed significant differences on root length of carrot (Table 3 and Appendix XIII). Combined effect of K_2E_2 (120 kg K/ha and three times earthing up) treatment combination gave the longest (22.06 cm) root of carrot. The shortest (8.95 cm) length of root was obtained from the control treatment (K_0E_0) which was statistically similar (10.36 cm) to K_1E_0 (100 kg K/ha and no earthing up) treatment combination. Proper levels of potassium and numbers of earthing up helps to increase the root length of carrot.

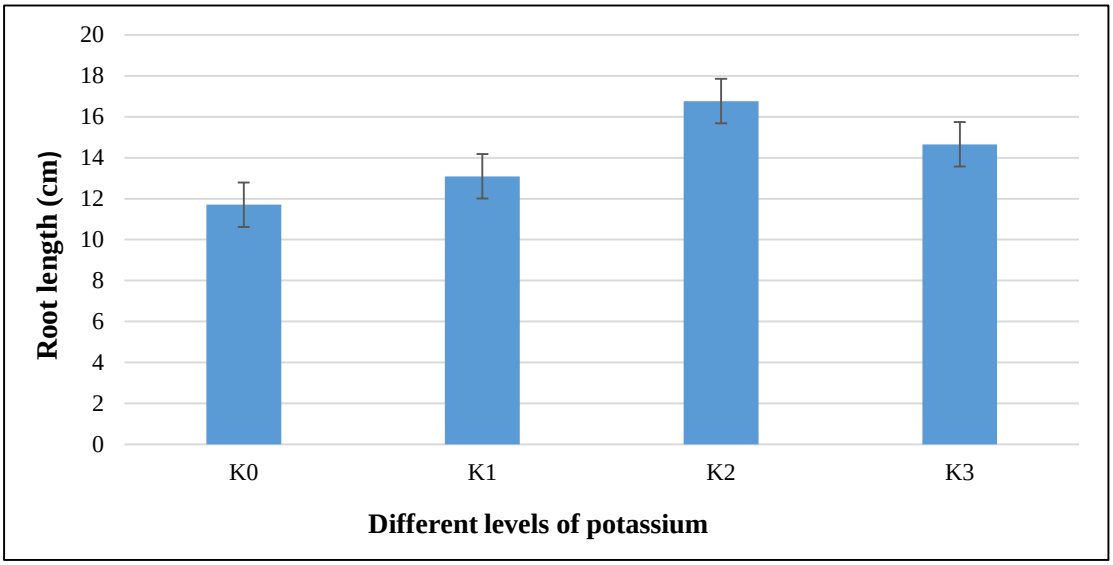


Figure 8. Effect of potassium on root length of carrot. Where, K_0= control, K_1= 100 kg K/ha, K_2= 120 kg K/ha, K_3= 140 kg K/ha.

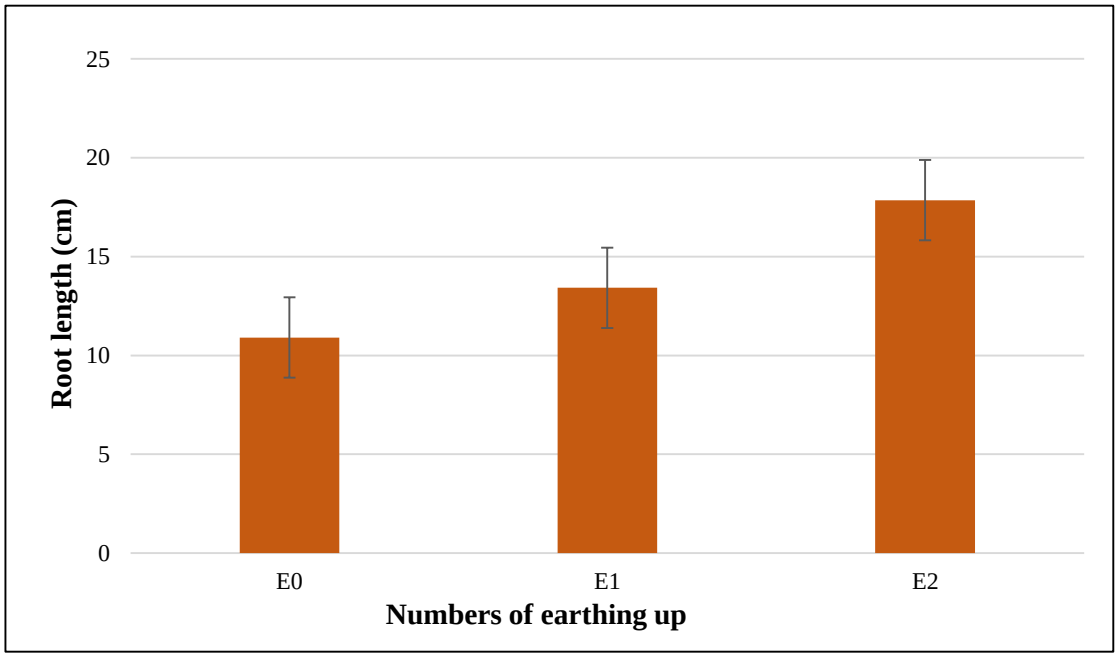


Figure 9. Effect of earthing up on root length of carrot. Where, E_0= no earthing up, E_1= two times earthing up, E_2= three times earthing up.

4.5 Root diameter

Root diameter of carrot was significantly influenced by different levels of potassium (Figure 10 and Appendix VIII, XIII). The maximum root diameter (4.40 cm) was obtained from K_2 (120 kg K/ha) treatment, while the lowest root diameter (2.89 cm) was produced from the K_0 (control) treatment. Sharangi and Paria (1996) showed similar trends of results in their study. They found from their study that the application of higher levels of potassium produced the wider roots of carrot than the lower levels of potassium application. Khatun (1999) also found her study that potassium increased the diameter of carrot root.

Root diameter varied significantly due to the effect of numbers of earthing up (Figure 11 and Appendix IX, XIII). The maximum diameter of carrot root (4.24 cm) was found from E_2 (three times earthing up) treatment. The minimum diameter of carrot root (3.29 cm) was found from E_0 (control) treatment. Booth (2007) found similar trend of results in his study. Earthing up increases the area around the root that helps to retain moisture, nutrients and temperature. This area helps to increase the root length. Photosynthesis increased that increase the root diameter and weight.

Root diameter of carrot varied significantly due to the combined effect of different levels of potassium and earthing up (Table 3 and Appendix XIII). The maximum root diameter of carrot (5.06 cm) was found from the treatment combination of K_2E_2 (120 kg K/ha and three times earthing up) and minimum root diameter of carrot (2.59 cm) was observed from control (K_0E_0) treatment combination. Proper levels of potassium and earthing up combination helps to carrot root for increasing the diameter of root by loosening the soil and dry matter accumulation.

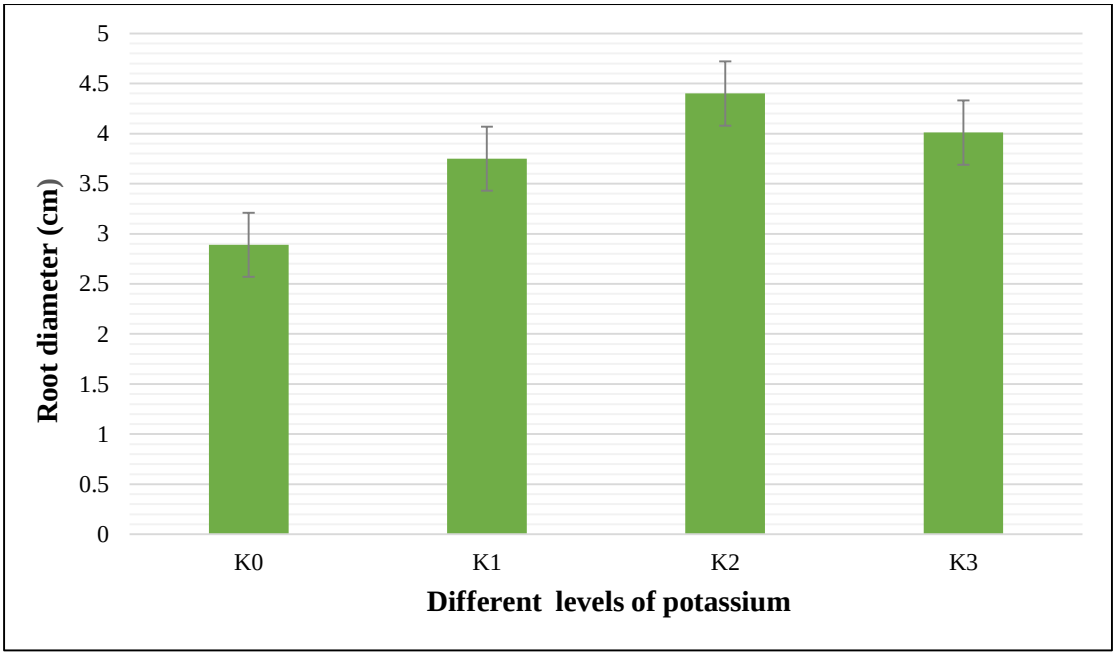


Figure 10. Effect of potassium on root diameter of carrot. Where, K_0= control, K_1= 100 kg K/ha, K_2= 120 kg K/ha, K_3= 140 kg K/ha.

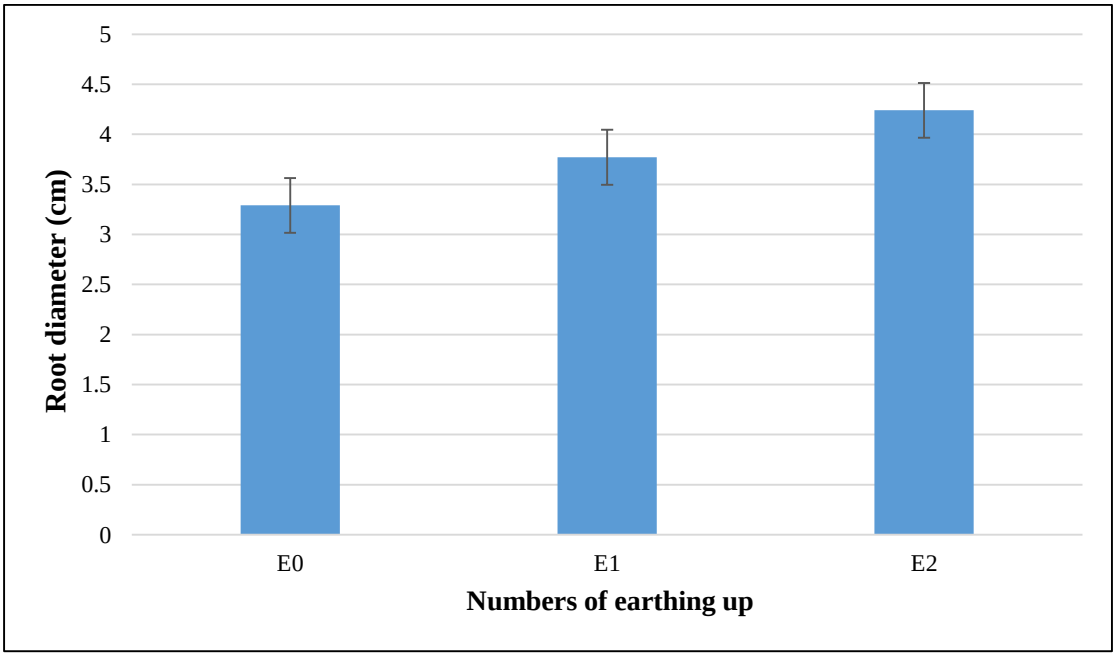


Figure 11. Effect of earthing up on root diameter of carrot. Where, E_0= no earthing up, E_1= two times earthing up, E_2= three times earthing up.

4.6 Fresh root weight of carrot

Fresh root weight of carrot per plant significantly differed with the application of different levels of potassium (Figure 12 and Appendix VIII, XIII). The maximum fresh root weight of carrot (191.73 g) was recorded from K_2 (120 kg K /ha) treatment. However, the control (K_0) treatment gave the lowest fresh root weight of carrot (119.50 g). The application of potassium significantly improved carrot growth, productivity and quality of roots. Sharangi and Paria (1996) observed the same kind of results. Potassium application produced the heavier roots. Abou El-Nasr *et al.* (2011) recorded that root weight increased with potassium fertilizer.

The fresh root weight of carrot per plant significantly differed due to different numbers of earthing up (Figure 13 and Appendix IX, XIII). The highest fresh root weight (178.55 g) was recorded from E_2 (three times earthing up) treatment and K_0 (control) treatment gave the lowest fresh root weight of carrot (138.53 g). The results showed that good soil coverage of the developing roots with the increases in earthing up frequency results in good root development. Increases in earthing up frequency ensured a well-drained cool environment being created from good crop that enables adequate amount of carbohydrate to translocate to root hence resulting in good fresh root weight. Qadir *et al*. (1999) also confirmed that earthing up after emergence resulted in better total biomass of plant. Tafi *et al.* (2010) reported that same trend of result.

The combined effect of potassium and earthing up showed significant variation on fresh root weight of carrot per plant (Table 3 and Appendix XIII). The maximum fresh root weight of carrot (217.55 g) was recorded when plant grown from the treatment combination of K_2E_2 (120 kg K/ha and three times earthing up) and the minimum fresh root weight of carrot (110.06 g) was observed from the K_0E_0 (control) treatment combination.

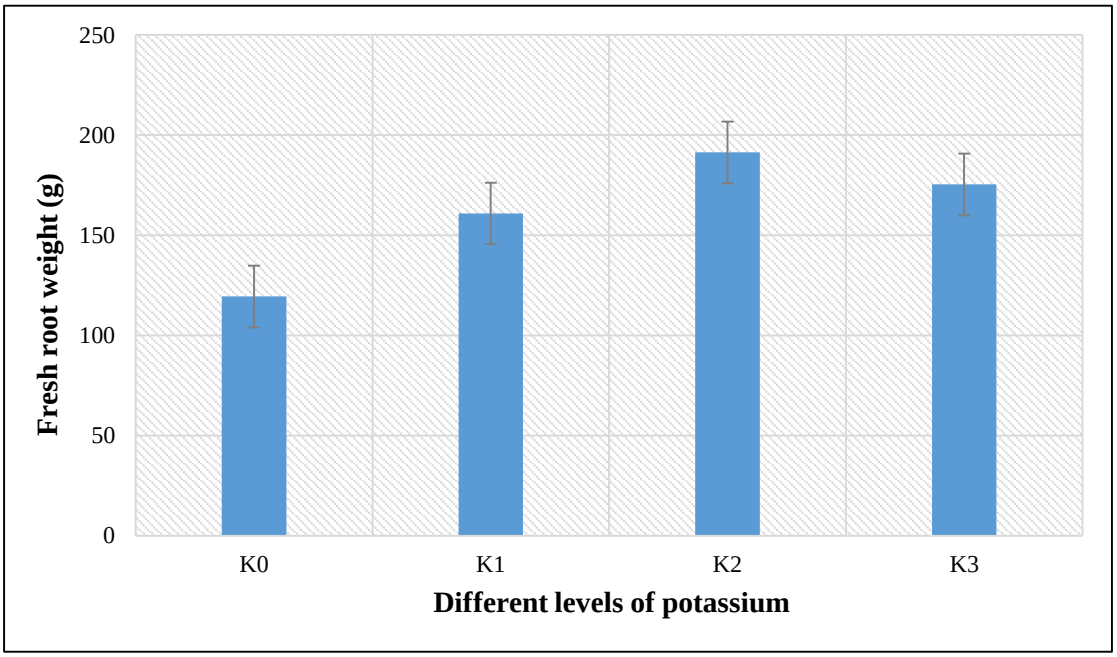


Figure 12. Effect of potassium on fresh root weight of carrot. Where, K_0= control, K_1= 100 kg K/ha, K_2= 120 kg K/ha, K_3= 140 kg K/ha.

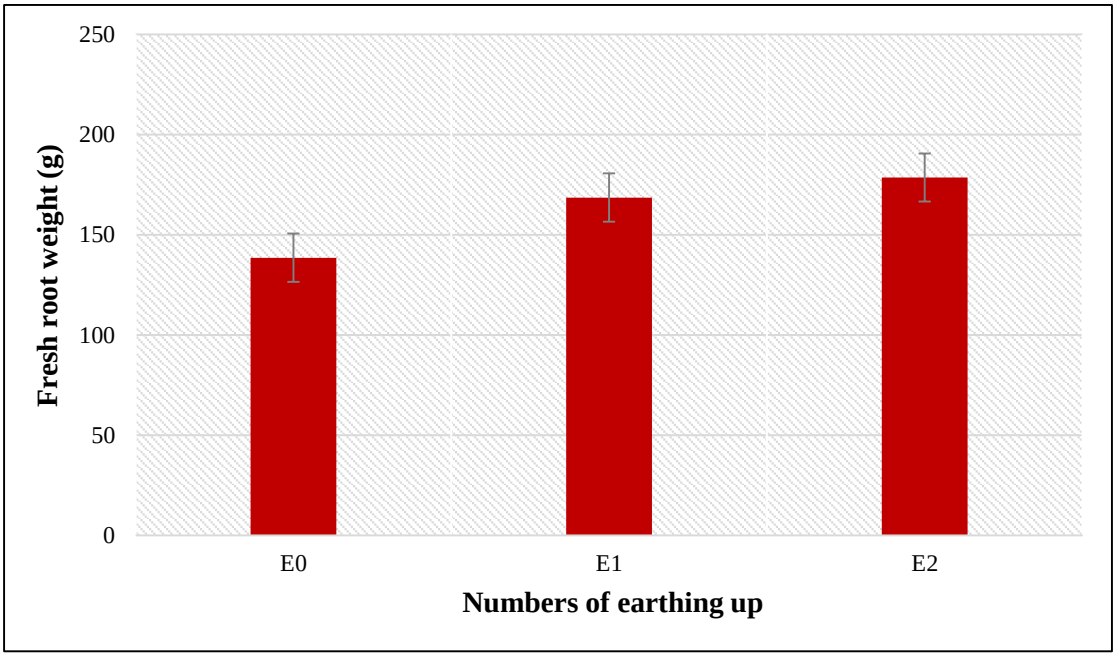


Figure 13. Effect of earthing up on fresh root weight of carrot. Where, E_0= no earthing up, E_1= two times earthing up, E_2= three times earthing up.

Table 3. Combined effect of potassium and earthing up on fresh weight of leaves, root length, root diameter and fresh root weight of carrot

Treatment combination	Fresh weight of leaves (g)	Root Length (cm)	Root Diameter (cm)	Fresh Root weight (g)
K_0 E_0	80.09 g	8.95 h	2.59 f	110.06 i
K_0 E_1	86.78 f	11.79 fg	3.01 e	122.78 h
K_0 E_2	89.53 f	14.38 de	3.05 e	125.65 h
K_1 E_0	94.67 e	10.36 gh	3.27 e	138.12 g
K_1 E_1	97.79 e	12.83 ef	3.82 d	166.06 e
K_1 E_2	101.73 d	16.07 c	4.18 cd	178.48 d
K_2 E_0	106.81 c	12.84 ef	3.91 cd	152.66 f
K_2 E_1	113.45 b	15.40 cd	4.23 c	204.98 b
K_2 E_2	121.46 a	22.06 a	5.06 a	217.55 a
K_3 E_0	103.82 cd	11.46 fg	3.36 e	153.29 f
K_3 E_1	107.05 c	13.64 e	4.02 cd	180.36 d
K_3 E_2	110.47 b	18.89 b	4.67 b	192.51 c
LSD (0.05)	3.2487	1.6250	0.3700	10.957
CV%	1.90	6.83	5.81	4.00

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, K_0 = Control, K_1 = 100 kg K/ha, K_2 = 120 kg K/ha, K_3 = 140 kg K/ha, E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up.

4.7 Dry matter of leaves

Dry matter percentage of leaves was significantly influenced by different levels of potassium of carrot (Table 4 and Appendix XIV). The highest dry matter of leaves (17.23%) was recorded from K_2 (120 kg K/ha) treatment and the lowest dry matter of leaves (11.62 %) was observed from K_0 (control) treatment condition. Krarup *et al.* (1984) stated that potassium increased the dry matter because of higher assimilation of various micro and macro elements. El-Tohamy *et al.* (2011) also recorded similar kind of result. Dry weight of leaves enhanced by the levels of potassium.

Earthing up had significant effect on dry matter of leaves per plant (Table 5 and Appendix XIV). The highest dry matter of leaves (16.40 %) was recorded from E_2 (three times earthing up) treatment, while the lowest dry matter of leaves (13.36 %) was recorded from E_0 (no earthing up) treatment condition. Tafi *et al.* (2010) reported that adding soil to the plant increased significantly and attributed the increased dry matter accumulation.

A significant variation was found due to combined effect of different levels of potassium and earthing up on percentage of dry matter of leaves (Table 6 and Appendix XIV). The highest dry matter of leaves (19.18 %) was obtained from the treatment combination of K_2E_2 (120 kg K/ha and three times earthing up) whereas, the treatment combination of K_0E_0 (control) produced the lowest (10.92 %) dry matter of leaves. Potassium and earthing up equally helps to increase the dry matter of leaves.

4.8 Dry matter of roots

Use of different levels of potassium showed significant effect on the percent dry matter of carrot root (Table 4 and Appendix XIV). The highest dry matter of carrot root (16.22 %) was found from K_2 (120 kg K/ha) treatment, while the lowest dry matter of carrot root (12.34 %) was from K_0 (control) treatment. Grigrov (1990) and Krarup *et al*. (1984) found similar trends of findings in their study. Potassium application increased the assimilation of various nutrient elements. Higher assimilation of nutrients increased the dry matter of roots.

Remarkable variation was identified on dry matter of root (%) due to the effect of different numbers of earthing up of carrot (Table 5 and Appendix XIV). The highest dry matter of root (15.71 %) was found from the treatment E_2 (three times earthing up), which was significantly different from all other treatments. On the other hand the lowest dry matter of root (13.65 %) was found from the treatment E_0 (control). Tafi *et al.* (2010) also similar kind of result. Earthing up to the carrot plant increased significantly and attributed the increased dry matter accumulation.

Variation on dry matter of root (%) was significantly influenced by the combined effect of potassium and earthing up (Table 6 and Appendix XIV). The highest dry matter of root (17.34 %) was found from the K_2E_2 (120 kg K/ha and three times earthing up) treatment combination. The lowest dry matter of root (11.49 %) was found from the treatment combination K_0E_0 (control), which was significantly different from all other treatment combinations.

4.9 Percentage of branched roots

The percentage of branched roots production of carrot was significantly influenced by the different levels of potassium (Table 4 and Appendix XIV). The highest percentage of branched roots (14.89 %) recorded from K_0 (control) treatment whereas, the lowest percentage of branched roots (4.67 %) was found from K_2 (120 kg K/ha) treatment. Hossain (2005) showed the same findings in his field trial. The increasing trend of branched root of carrot with the decreasing of potassium level. Potassium helps for proper growth and development of root. When plants get less amount of nutrients, they become in abnormal size and shape.

Due to application of numbers of earthing up showed significant differences on branched roots of carrot (Table 5 and Appendix XIV). The maximum branched roots of carrot (12.50 %) was observed from K_0 (no earthing up) treatment and the minimum branched roots of carrot (4.67 %) from K_2 (three times earthing up) treatment. Earthing up helps to loosening the soil and increasing the space around the carrot root. So, the roots get more space to grow but no earthing up cannot help to loosening the soil. For this reason, roots cannot grow properly.

Combined effect of potassium and earthing up showed significant differences for branched root of carrot (Table 6 and Appendix XIV). The maximum branched roots of carrot (18.67 %) was obtained from K_0E_0 (control) treatment combination, whereas the minimum branched roots of carrot (1.33 %) was found from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination.

4.10 Percentage of cracked roots

Different levels of potassium showed significant differences on cracked root of carrot (Table 4 and Appendix XIV). The maximum cracked roots of carrot (11.11 %) was recorded from K_0 (control) treatment and the minimum cracked roots of carrot (3.89 %) from K_2 (120 kg K/ha) treatment. Hossain (2005) found similar findings in his field trial. The cracked roots of carrot decreasing with the increasing application of potassium level and the increasing trend of cracked root of carrot with the decreasing of potassium levels. Potassium helps for proper growth and development of root. When plants get less amount of nutrients, they become in abnormal size and shape

Percentage of cracked roots of carrot showed statistically significant variation for the application of earthing up (Table 5 and Appendix XIV). The maximum cracked roots (11.25 %) was observed from E_0 (no earthing up) treatment while the minimum cracked roots (4.00 %) from K_2 (three times earthing up) treatment. Earthing up helps to plant for their proper growth and development by loosening the soil, maintaining moisture content and reducing soil temperature. Without earthing up cannot provide this properly. Frequency of earthing up helps to grow properly.

The variation was observed from combined effect of potassium and earthing up on cracked roots of carrot (Table 6 and Appendix XIV). The maximum cracked roots of carrot (16.00%) was found from K_0E_0 (control) treatment combination whereas the minimum cracked roots of carrot (1.33%) was obtained from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination.

Table 4. Effect of different levels of potassium on dry matter of leaves, dry matter of roots, percentage of branched roots, percentage of cracked roots of carrot

Treatments	Dry matter of leaves (%)	Dry matter of roots (%)	Branched roots (%)	Cracked roots (%)
K_0	11.62 d	12.34 d	14.89 a	11.11 a
K_1	14.61 c	15.01 c	8.11 b	7.56 b
K_2	17.23 a	16.22 a	4.67 d	3.89 d
K_3	15.87 b	15.52 b	6.89 c	6.22 c
LSD(0.05)	0.4117	0.2672	0.7595	0.8102
CV%	2.84	1.85	8.99	11.52

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, K_0 = Control, K_1 = 100 kg K/ha, K_2 = 120 kg K/ha, K_2 = 140 kg K/ha.

Table 5. Effect of different numbers of earthing up on dry matter of leaves, dry matter of roots, percentage of branched roots and percentage of cracked roots of carrot

Treatments	Dry matter of leaves (%)	Dry matter of roots (%)	Branched roots (%)	Cracked roots (%)
E_0	13.36 c	13.65 c	12.50 a	11.25 a
E_1	14.74 b	14.96 b	8.75 b	6.33 b
E_2	16.40 a	15.71 a	4.67 c	4.00 c
LSD(0.05)	0.3565	0.4628	0.6577	0.7017
CV%	2.84	1.85	8.99	11.52

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up.

Table 6. Combined effect of potassium and earthing up on dry matter of leaves, dry matter of roots, percentage of branched roots and percentage of cracked roots of carrot

Treatments	Dry matter of leaves (%)	Dry matter of roots (%)	Branched roots (%)	Cracked roots (%)
K_0 E_0	10.92 h	11.49 j	18.67 a	16.00 a
K_0 E_1	11.63 gh	12.40 i	15.33 b	10.67 c
K_0 E_2	12.30 g	13.14 h	10.67 d	6.67 d
K_1 E_0	13.19 f	13.67 g	12.67 c	13.33 b
K_1 E_1	14.25 e	15.19 de	7.67 e	5.33 de
K_1 E_2	16.38 c	16.16 c	4.00 g	4.00 e
K_2 E_0	15.17 d	14.50 f	7.33 e	6.33 d
K_2 E_1	17.35 b	16.81 b	5.33 f	4.00 e
K_2 E_2	19.18 a	17.34 a	1.33 i	1.33 f
K_3 E_0	14.17 e	14.93 ef	11.33 d	9.33 c
K_3 E_1	15.70 cd	15.45 d	6.67 e	5.33 de
K_3 E_2	17.74 b	16.19 c	2.67 h	4.00 e
LSD (0.05)	0.713	0.4628	1.3155	1.4034
CV%	2.84	1.85	8.99	11.52

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, K_0 = Control, K_1 = 100 kg K/ha, K_2 = 120 kg K/ha, K_3 = 140 kg K/ha, E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up.

4.11 Gross yield of roots per plot

Gross yield of roots per plot was found statistically significant due to the effect of different levels of potassium (Figure 14 and Appendix X, XV). The treatment K_2 (120 kg K/ha) produced the highest (4.79 kg) gross yield of carrot roots per plot. However, K_0 (control) treatment produced the lowest (2.98 kg) gross yield of roots per plot. The application of potassium significantly improved carrot growth, productivity and quality of roots. Bartaseviciene and Pekarskas (2007) indicated that potassium fertilizers increased the total harvest of carrot. Anjaiah and Padmaja (2006) also found similar findings in their study. They reported that the root yield and quality parameters increased with increasing levels of potassium.

Statistically significant variation was found due to the effect of different numbers of earthing up on gross yield of roots per plot (Figure 15 and Appendix XI, XV). The maximum gross yield of roots per plot (4.46 kg) was obtained from the E_2 (three times earthing up) treatment, while the E_0 (no earthing up) treatment produced the minimum (3.46 kg) gross yield of roots per plot. High gross yield of roots per plot recorded on earthed treatments indicated that earthing up several times improved and conserved soil moisture which also lowers the soil temperature hence creating favorable conditions for good yield levels. This concurred well with Kouwenhoven (1970) and Grany (2009), who pointed out that good soil moisture has a positive relationship with good yields.

The combined effect of different levels of potassium and earthing up showed significant differences on gross yield of root per plot (Table 7 and Appendix XV). The maximum gross yield of carrot root (5.44 kg) was found from the treatment combination K_2E_2 (120 kg K/ha and three times earthing up). On the other hand, the minimum gross yield of root (2.75 kg) was recorded from the treatment combination K_0E_0 (control).

4.12 Marketable yield of roots per plot

Marketable yield of roots per plot varied significantly due to the application of different levels of Potassium (Figure 14 and Appendix X, XV). The highest marketable yield of roots per plot (4.42 kg) was obtained from K_2 (120 kg K/ha) treatment and the lowest marketable yield of roots per plot (2.83 kg) was recorded from K_0 (control) treatment. Bartaseviciene and Pekarskas (2007) concurred well with this results. Potassium

application has great effects on carrot productivity and quality. They found that proper doses of potassium fertilizers increased the marketable harvest of carrots.

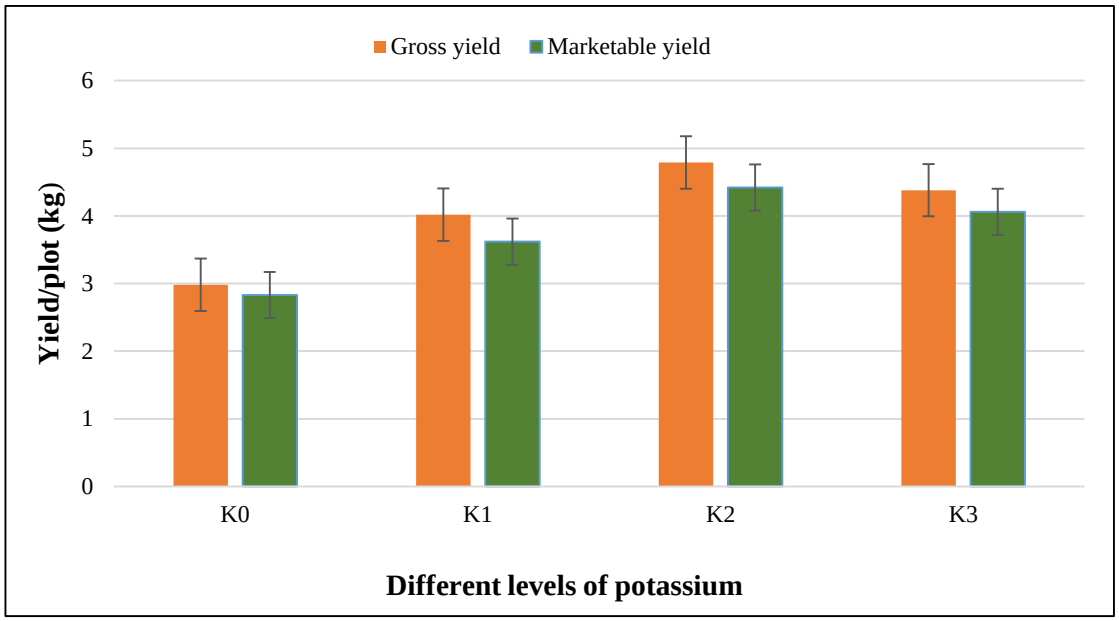


Figure 14. Effect of potassium on gross yield per plot and marketable yield per plot of carrot. Where, K_0= control, K_1= 100 kg K/ha, K_2= 120 kg K/ha and K_3= 140 kg K/ha.

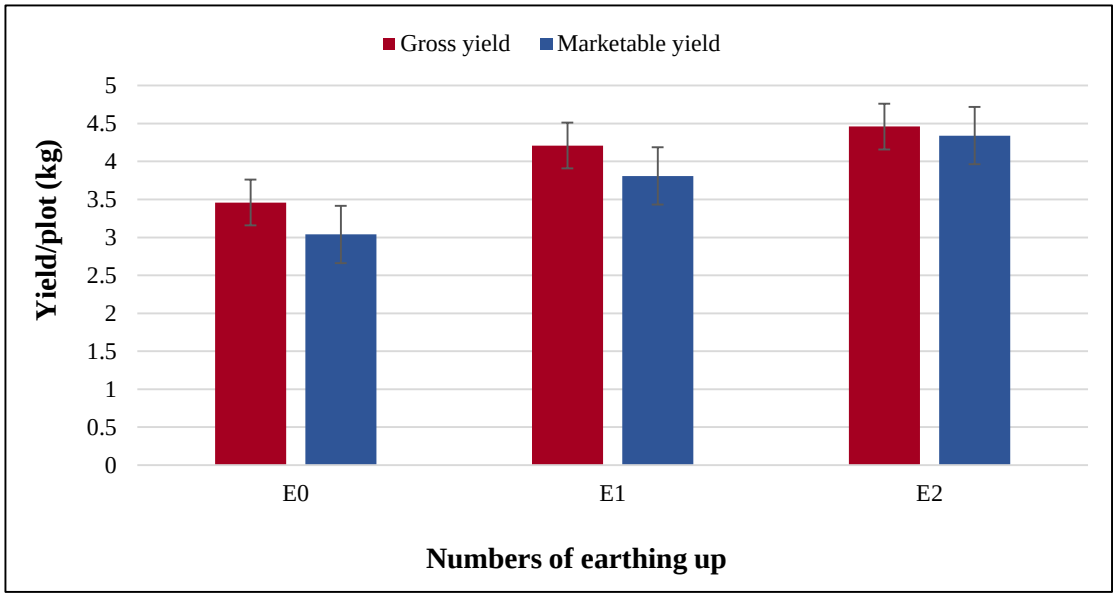


Figure 15. Effect of earthing up on gross yield per plot and marketable yield per plot of carrot. Where, E_0= no earthing up, E_1= two times earthing up and E_2= three times earthing up.

The marketable yield of roots per plot was found statistically significant due to the effect of earthing up (Figure 15 and Appendix XI, XV). The treatment E_2 (three times earthing up) produced the highest (4.34 kg) marketable yield of roots per plot. The lowest marketable yield of roots per plot (3.04 kg) was recorded from the E_0 (control) treatment. Kouwenhover (1970), Grany (2009) and Chitsinde (2018) reported the similar trends of the result. Earthing up brought an adequate accumulation of carbohydrate in the roots resulting in superior root weight at the final harvest. When roots are well covered by soil, the extent of mechanical, insect damage and greening disease is very low as soil cushions roots from damage thereby promoting development of good marketable roots.

The combined effect of marketable yield of roots per plot was significantly influenced by different levels of potassium and earthing up (Table 7 and Appendix XV). The highest marketable yield of roots per plot (5.29 kg) was observed from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination whereas, the lowest marketable yield of roots per plot (2.50 kg) was obtained from the treatment combination K_0E_0 (control).

4.13 Gross yield of roots per hectare

Gross yield of roots per hectare was significantly influenced by the different levels of potassium (Figure 16 and Appendix X, XV). The highest gross yield of roots per hectare (38.35 t) was obtained from K_2 (120 kg K/ha) treatment and the lowest gross yield of roots per hectare (23.90 t) was obtained from K_0 (control) treatment. Kadar (2004) and Bartaseviciene and Pekarskas (2007) concurred well with this results. Potassium application has great effects on carrot productivity and quality. They found that higher application of potassium fertilizers increased the gross yield of carrots.

Application of different numbers of earthing up significantly influenced on gross yield of roots per hectare (Figure 17 and Appendix XI, XV). The maximum gross yield of roots per hectare (35.71 t) was obtained from E_2 (three times earthing up) treatment and the treatment E_0 (control) gave the lowest (27.71 t) gross yield per hectare. Kouwenhoven (1970) and Grany (2009) pointed out the same kind of results. They opined that good soil moisture has a positive relationship with good yields. Bernik and Vucajnk (2008) who concluded that ridges with the highest cross sectional reduced the percentage of greening of roots and the yield of the root increased.

The combined effect of different levels of potassium and earthing up showed significant differences on the gross yield of carrot per hectare (Table 7 and Appendix XV). The highest gross yield of roots per hectare (43.51 t) was found from the treatment combination K_2E_2 (120 kg K/ha and three times earthing up). On the other hand, the lowest gross yield of carrot root per hectare (22.01 t) was recorded from K_0E_0 (control) treatment combination.

4.14 Marketable yield of roots per hectare

Marketable yield of roots varied significantly due to the application different levels of potassium (Figure 16 and Appendix X, XV). The maximum marketable yield of roots per hectare (35.32 t) was obtained from K_2 (120 kg K/ha) treatment, while the minimum yield of roots per hectare (22.69 t) was found from K_0 (control) treatment. Anjaiah and Padmaja (2006) also found similar findings in their study. They reported that increasing level of potassium increase root yield and quality parameters.

The marketable yield of carrot per hectare was found statistically significant due to the application of different numbers of earthing up (Figure 17 and Appendix XI, XV). The highest marketable yield of carrot per hectare (34.75 t) was obtained from E_2 (three times earthing up) treatment and the lowest marketable yield of carrot per hectare (24.34 t) from E_0 (no earthing up) treatment. When roots are well covered by soil, the extent of mechanical, insect damage and greening disease is very low as soil cushions roots from damage thereby promoting development of good marketable roots (Grany, 2009).

A significant variation was found due to combined effect of different levels of potassium and earthing up on marketable yield of carrot root per hectare (Table 7 and Appendix XV). The highest marketable yield of carrot per hectare (42.29 t) was recorded from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination, whereas the lowest marketable yield of carrot per hectare (20.03 t) was found from the treatment combination of K_0E_0 (control).

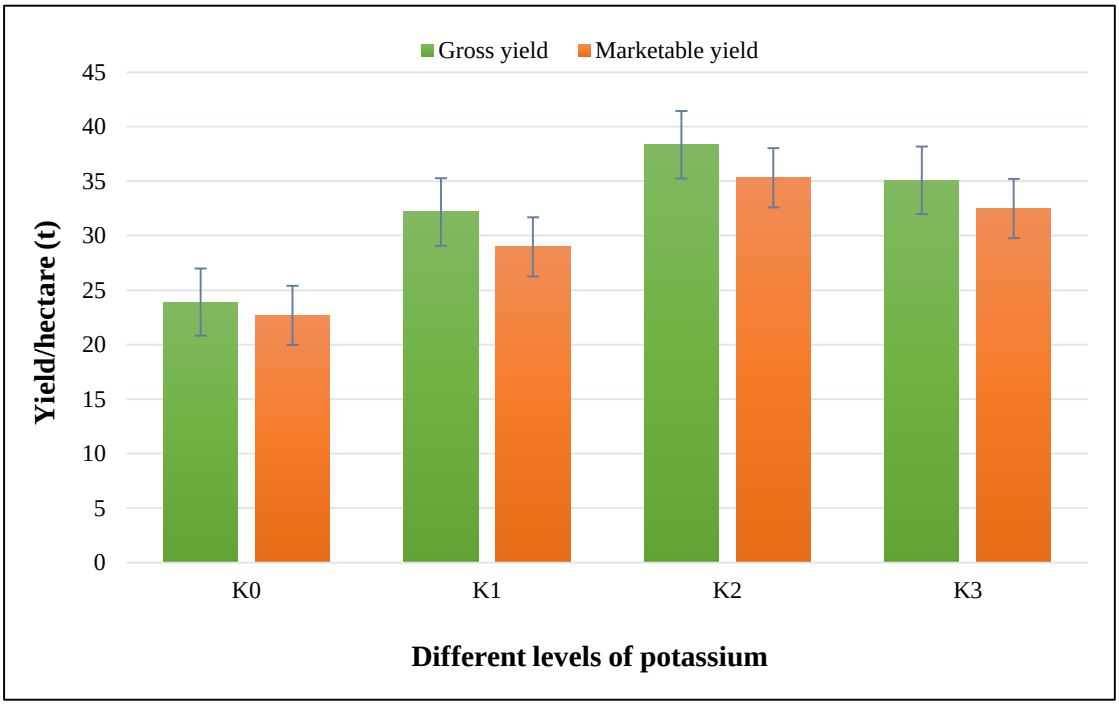


Figure 16. Effect of potassium on gross yield per hectare and marketable yield per hectare of carrot. Where, K_0= control, K_1= 100 kg K/ha, K_2= 120 kg K/ha and K_3= 140 kg K/ha.

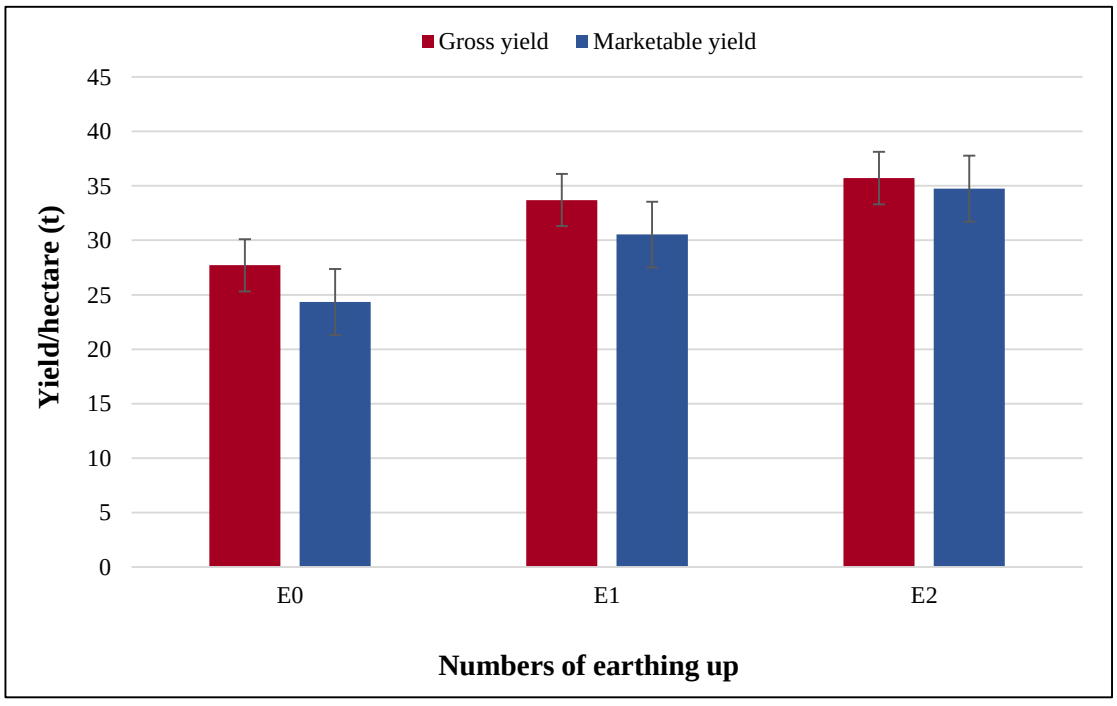


Figure 17. Effect of earthing up on gross yield per hectare and marketable yield per hectare of carrot. Where, E_0= no earthing up, E_1= two times earthing up and E_2= three times earthing up.

Table 7. Combined effect of potassium and earthing up on gross yield per plot, marketable yield per plot, gross yield per hectare and marketable yield per hectare of carrot

Treatment combination	Gross yield/plot (kg)	Marketable yield/plot (kg)	Gross yield/ha (t)	Marketable yield/ha (t)
K_0E_0	2.75 i	2.50 i	22.01 i	20.03 i
K_0E_1	3.07 h	2.82 h	24.56 h	22.59 h
K_0E_2	3.14 h	3.18 g	25.13 h	25.46 g
K_1E_0	3.45 g	2.89 h	27.62 g	23.12 h
K_1E_1	4.15 e	3.82 e	33.21 e	30.58 e
K_1E_2	4.46 d	4.15 d	35.69 d	33.23 d
K_2E_0	3.81 f	3.53 f	30.53 f	28.27 f
K_2E_1	5.12 b	4.43 c	40.99 b	35.41 c
K_2E_2	5.44 a	5.29 a	43.51 a	42.29 a
K_3E_0	3.83 f	3.24 g	30.66 f	25.93 g
K_3E_1	4.51 d	4.19 d	36.07 d	33.53 d
K_3E_2	4.81 c	4.75 b	38.50 c	38.03 b
LSD (0.05)	0.274	0.1997	2.1921	1.5932
CV%	4.00	3.16	4.00	3.15

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, K_0 = Control, K_1 = 100 kg K/ha, K_2 = 120 kg K/ha, K_3 = 140 kg K/ha, E0 = Control, E1 = Two times earthing up, E2 = Three times earthing up.

4.15 Economic analysis:

Economic analysis is the major criteria to evaluate the best treatments which were economically sound and that can be accepted by farming community. The cost of cultivation, gross and net returns in addition to benefit cost ratio of different treatment combinations studied in the present investigation is presented in (Table 8 and Appendix XVI).

4.15.1 Cost of cultivation

The total expenditure was observed to range from Tk. 156882 (K_0E_0) to Tk. 195114 (K_3E_2). Among all the inputs used in the present investigation, labor contributes more to the cost of cultivation (Table 8 and Appendix XVI).

4.15.2 Gross return

Gross returns for different treatment combinations in the present investigation ranged from Tk. 240360 to Tk. 507480. Among all the treatment combinations studied, K_2E_2 (120 kg K/ha and three times earthing up) treatment combination gave the highest gross returns of Tk. 507480 and the lowest gross returns of Tk. 240360 from K_0E_0 (control) treatment combination (Table 8 and Appendix XVI).

4.15.3 Net return

Highest net returns per hectare of Tk. 313782 in carrot cultivation under different treatment combinations of potassium and earthing up studied was obtained from the K_2E_2 (120 kg K/ha and three times earthing up) treatment combination, whereas lowest net returns of Tk. 83478 was obtained from K_0E_0 (control) treatment combination (Table 8 and Appendix XVI).

4.15.4 Benefit cost ratio (BCR)

From all the treatment combinations studied in the present investigation, K_2E_2 (120 kg K/ha and three times earthing up) treatment combination resulted in highest benefit cost ratio of 2.62 and the lowest benefit cost ratio 1.53 was obtained from K_0E_0 (control) treatment combination (Table 8 and Appendix XVI).

Table 8. Economic analysis of carrot influenced by potassium and earthing up

Treatment combination	Cost of cultivation (Tk./ha)	Yield (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio (BCR)
K_0E_0	156882	20.03	240360	83478	1.53
K_0E_1	176338	22.59	271080	94742	1.54
K_0E_2	185202	25.46	305520	120318	1.65
K_1E_0	163962	23.12	277440	113478	1.69
K_1E_1	183418	30.58	366960	183542	2.00
K_1E_2	192282	33.23	398760	206478	2.07
K_2E_0	165378	28.27	339240	173862	2.05
K_2E_1	184834	35.41	424920	240086	2.29
K_2E_2	193698	42.29	507480	313782	2.62
K_3E_0	166794	25.93	311160	144366	1.86
K_3E_1	186250	33.53	402360	216110	2.16
K_3E_2	195114	38.03	456360	261246	2.34

Here, K_0= control, E_0= No earthing up
K_1= 100 kg K/ha E_1= Two times earthing up
K_2 = 120 kg K/ha E_2= Three times earthing up
K_3 = 140 kg K/ha

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

Sale of marketable carrot @ TK. 12000/t.

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during the period from November, 2018 to February, 2019 to study the effect of potassium and earthing up on the growth, yield and economic benefit of carrot. The experiment consisted of two factors. Factor A: Four level of potassium, *viz*. K_0: control, K_1: 100 kg K/ha, K_2: 120 kg K/ha and K_3: 140 kg K/ha; Factor B: Different numbers of earthing up, *viz*. E_0 = Control, E_1 = Two times earthing up and E_2 = Three times earthing up. Levels of these two factors made 12 (4×3) treatment combinations and the numbers of plots were 36. The size of the unit plot was 1.25 m × 1.00 m following the spacing 25 cm ×20 cm. Data were collected on different growth and yield parameters.

The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on the following parameters such as plant height, number of leaves per plant, fresh weight of leaves, root length of carrot, diameter of carrot root, fresh root weight of carrot, dry matter content of leaves, dry matter content of root, percentage of branched roots per plot, percentage of cracked roots per plot, gross yield of roots per plot, gross yield of roots per hectare, marketable yield per plot and marketable yield per hectare. The recorded data on different parameters were statistically analyzed using Statistic 10 software.

Data on different growth parameters, yield contributing characters and yield of carrot were recorded. Considerable influence was found due to variation on potassium application. Results revealed that in terms of growth parameters, at harvest the highest plant height (43.89 cm), number of leaves per plant (18.18) were found from K_2 (120 kg K/ha) treatment, on the other hand the lowest plant height (36.99 cm), number of leaves per plant (13.18) were found from the treatment K_0 (control). Likewise, in terms of yield contributing parameters and yield, the maximum fresh weight of leaves (113.91 g), root length (16.77 cm), diameter of root (4.40 cm), fresh root weight of (191.73 g), dry matter of leaves (17.23 %) and dry matter of roots (16.22 %) were found from the K_2 (120 kg K/ha) treatment where the minimum fresh weight of leaves (85.47 g),root length (11.71 cm), diameter of root (2.89 cm), fresh root weight (119.50 g), dry matter of leaves (11.62 %) and dry matter of root (12.34 %) were found from the K_0 (control)

treatment. The highest percentage of branched roots (14.89 %) and cracked roots (11.11 %) were observed from the treatment K_0 (control), where the lowest percentage of branched roots (4.67 %) and cracked roots (3.89 %) were obtained from the treatment K_2 (120 kg K/ha). The highest gross yield of carrot per plot (4.79 kg), gross yield of carrot per hectare (38.35 t), marketable yield of carrot per plot (4.42 kg), marketable yield of carrot per hectare (35.32 t) were observed from K_2 (120 kg K/ha) treatment, when the lowest gross yield of carrot per plot (2.98 kg), gross yield of carrot per hectare (23.90 t), marketable yield of carrot per plot (2.83 kg) and marketable yield of carrot per hectare (22.69 t) were recorded from K_0 (control) treatment.

Considerable influence was found due to the effect of different numbers of earthing up application. Results obtained that in terms of growth parameters, maximum plant height (44.38 cm), number of leaves per plant (17.76) at harvest were recorded from E_2 (three times earthing up) treatment and minimum plant height (36.12 cm), number of leaves per plant (13.31) found from E_0 (control) treatment. In terms of yield contributing parameters and yield, the maximum fresh weight of leaves (105.80 g), root length (17.85 cm), diameter of root (4.24 cm), fresh root weight of carrot (178.55 g), dry matter of leaves (16.40 %) and dry matter of roots (15.71 %) were found from E_2 (three times earthing up) treatment, where the minimum fresh weight of leaves (96.35 g), root length (10.90 cm), diameter of root (3.29 cm), fresh root weight of carrot (138.53 g), dry matter of leaves (13.36 %) and dry matter of roots (13.65 %) were found from the treatment E_0 (control) . Highest percentage of branched roots (12.50 %) and cracked roots (11.25 %) were found from K_0 (control) treatment where the lowest percentage of branched roots (4.67 %) and cracked roots (4.00 %) were found from the treatment E_2 (three times earthing up). The highest gross yield of carrot per plot (4.46 kg), gross yield of carrot per hectare (35.71 t), marketable yield of carrot per plot (4.34 kg), marketable yield of carrot per hectare (34.75 t) were observed from E_2 (three times earthing up) treatment, when the lowest gross yield of carrot per plot (3.46 kg), gross yield of carrot per hectare (27.71 t), marketable yield of carrot per plot (3.04 kg), marketable yield of carrot per hectare (24.34 t) was observed from E_0 (control) treatment.

In case of combined effect of potassium and earthing up the highest plant height (47.40 cm), number of leaves per plant (21.11) at harvest were observed from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination, while shortest plant height

(31.45 cm), number of leaves (10.53) were recorded from K_0E_0 (control) treatment combination. Maximum fresh weight of leaves (121.46 g) was recorded from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination, where minimum fresh weight of leaves (80.09 g) was observed from K_0E_0 (control) treatment combination. The longest root of carrot (22.06 cm) was recorded from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination and the shortest root of carrot (8.95 cm) was observed from K_0E_0 (control) treatment combination which was statistically similar (10.36 cm) to K_1E_0 (100 kg K/ha and no earthing up) treatment combination. The highest diameter of root (5.06 cm), fresh root weight of carrot (217.55 g), dry matter of leaves (19.18%), dry matter of roots (17.34 %) were found from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination while the lowest diameter of root (2.59 cm), fresh root weight of carrot (110.06 g), dry matter of leaves (10.92 %), dry matter of roots (11.49 %) were found from K_0E_0 (control) treatment combination. The maximum branched roots (18.67 %) and cracked roots (16.00 %) were recorded from K_0E_0 (control) treatment combination, whereas the minimum branched roots (1.33 %) and cracked roots (1.33 %) from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination. The highest gross yield per plot (5.44 kg), gross yield per hectare (43.51 t), marketable yield per plot (5.29 kg), marketable yield per hectare (42.29 t) were obtained from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination, while the lowest gross yield per plot (2.75 kg), gross yield per hectare (22.01 t), marketable yield per plot (2.50 kg) and marketable yield per hectare (20.03 t) obtained from K_0E_0 (control) treatment combination.

The highest gross return (Tk. 507480) was obtained from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination and the lowest gross return (Tk. 240360) was recorded from K_0E_0 (control). The lowest net return (Tk. 83478) was recorded from K_0E_0 (control) treatment combination and the highest net return (Tk. 313782) was obtained from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination. The highest benefit cost ratio (2.62) estimated from K_2E_2 (120 kg K/ha and three times earthing up) treatment combination and the lowest benefit cost ratio (1.53) was obtained from K_0E_0 (control) treatment combination.

Conclusion:

Considering the above result of the present experiment, the following conclusion can be drawn:

- The potassium level K_2 (120 kg K/ha) was superior to others.
- Three times earhing up showed better performances
- The treatment combination of K_2E_2 (120 kg K/ha and three times earthing up) showed the best potentiality of 42.29 t/ha with Tk. 313782 net income and 2.62 BCR.

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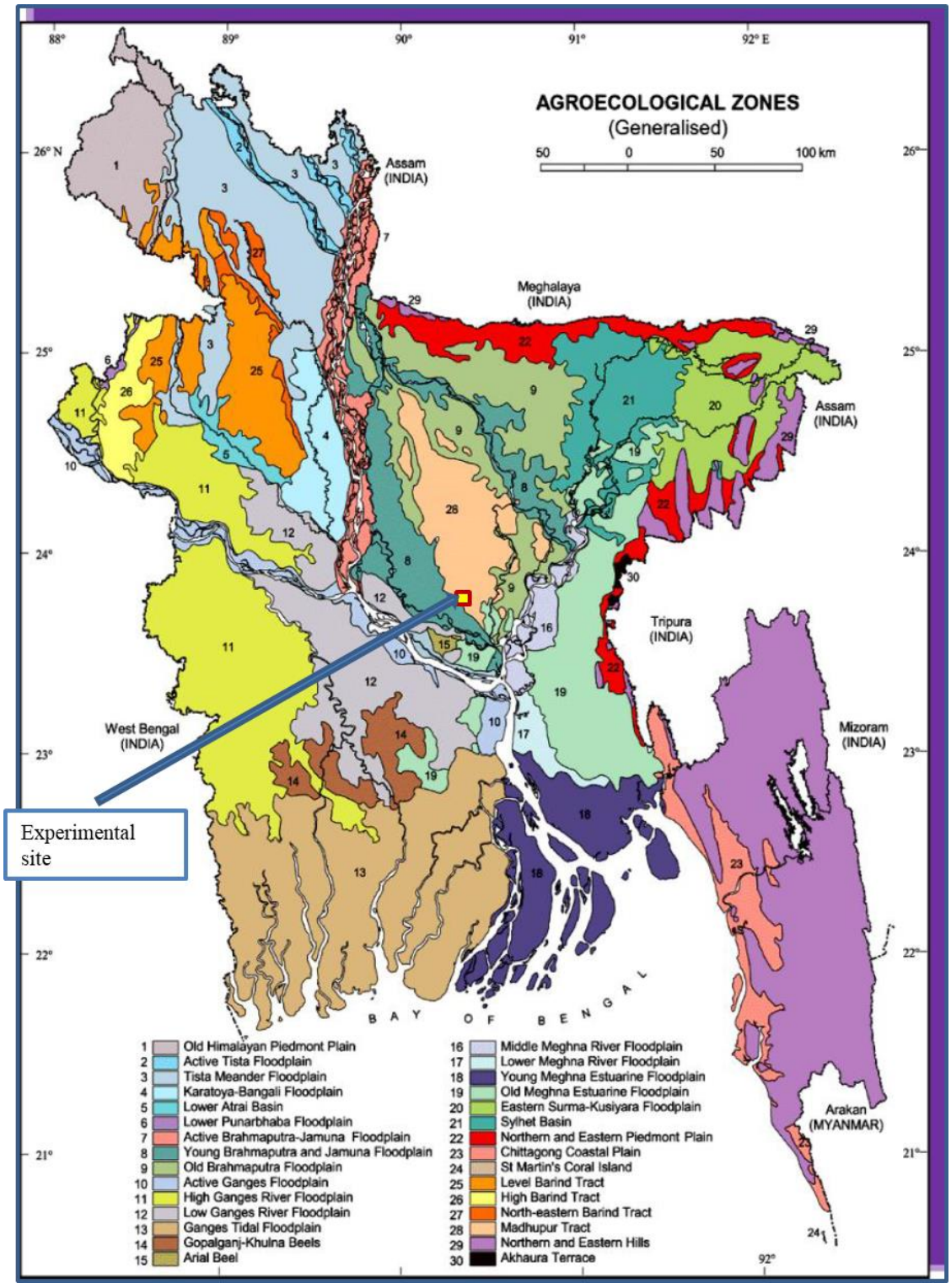
APPENDICES

Appendix I. Map showing the experimental site under the study



Appendix II: **Characteristics of Sher-e-Bangla Agricultural University soil is analyzed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka**

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural
AEZ	Madhupur Tract (28)
General soil type	Shallow Red Brown Terrace Soil
Land Type	High land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fellow-Tomato

B. Physical composition of the soil

Soil separates	**%**
Sand	27
Silt	43
Clay	30
Texture class	Sandy loam

C. Chemical composition of the soil

Soil characteristics	**Analytical data**
PH	5.47 – 5.63
Organic carbon (%)	0.46
Organic matter (%)	0.83
Total N (%)	0.05
Available P (ppm)	20.00
Available S (ppm)	46
Exchangeable K (me/ 100 gm soil)	0.12

Source: Soil Resources Development Institute (SRDI)

Appendix III. Monthly record of annual temperature, rainfall, relative humidity and sunshine of the experimental site during the period from November, 2018 to February, 2019 (site Dhaka)

Month	Air temperature (^{0}C)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum	Mean			
November 2018	29.85	18.50	24.17	70.12	00	235.2
December 2018	26.76	16.72	21.74	70.63	00	190.5
January 2019	24.05	13.82	18.93	62.04	00	197.6
February 2019	28.90	18.03	23.46	68.79	09	220.5

Appendix IV. Effect of potassium on plant height at different days after sowing (DAS) of carrot

Treatments	Plant height			
	35 DAS	55 DAS	75 DAS	At harvest
K_0	11.99 d	23.16 d	29.53 d	36.99 d
K_1	13.78 c	29.67 c	32.04 c	39.24 c
K_2	15.02 a	33.72 a	39.25 a	43.89 a
K_3	14.14 b	31.63 b	36.55 b	41.57 b
LSD (0.05)	0.2677	1.6908	2.4708	0.8607
CV%	1.99	5.85	7.36	2.18

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of significance. Where, K_0 = Control, K_1 = 100 kg K/ha, K_2 = 120 kg K/ha, K_3 = 140 kg K/ha.

Appendix V. Effect of earthing up on plant height at different days after sowing (DAS) of carrot

Treatments	Plant height			
	35 DAS	55 DAS	75 DAS	At harvest
E_0	13.61	25.88 b	27.38 b	36.12 c
E_1	13.77	30.80 a	36.77 a	40.78 b
E_2	13.83	31.96 a	38.88 a	44.38 a
LSD (0.05)	NS	1.4643	2.1398	0.7454
CV%	1.99	5.85	7.36	2.18

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of significance. Where, E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up.

Appendix VI. Effect of potassium on number of leaves per plant at different days after sowing (DAS) of carrot

Treatments	Number of leaves per plant			
	35 DAS	55 DAS	75 DAS	At harvest
K_0	4.51 d	6.36 d	10.42 d	13.18 d
K_1	6.24 c	7.79 c	11.34 c	14.78 c
K_2	7.51 a	10.03 a	14.18 a	18.18 a
K_3	6.74 b	8.86 b	12.29 b	16.05 b
LSD (0.05)	0.5034	0.6628	0.8583	1.1463
CV%	8.24	8.21	7.28	7.54

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of significance. Where, K_0 = Control, K_1 = 100 kg K/ha, K_2 = 120 kg K/ha, K_3 = 140 kg K/ha.

Appendix VII. Effect of earthing up on number of leaves per plant at different days after sowing (DAS) of carrot

Treatments	Number of leaves per plant			
	35 DAS	55 DAS	75 DAS	At harvest
E_0	6.08	6.45 b	9.52 b	13.31 c
E_1	6.19	8.88 a	13.05 a	15.58 b
E_2	6.48	9.45 a	13.60 a	17.76 a
LSD (0.05)	NS	0.5740	0.7433	0.9927
CV%	8.24	8.21	7.28	7.54

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up.

Appendix VIII. Effect of potassium on fresh weight of leaves, root length, root diameter and fresh root weight of carrot

Treatments	Fresh weight of leaves (g)	Root Length (cm)	Root Diameter (cm)	Fresh root weight (g)
K_0	85.47 d	11.71 d	2.89 d	119.50 d
K_1	98.06 c	13.09 c	3.75 c	160.89 c
K_2	113.91 a	16.77 a	4.40 a	191.73 a
K_3	107.11 b	14.66 b	4.01 b	175.39 b
LSD(0.05)	1.8756	0.9382	0.2136	6.3261
CV%	1.90	6.83	5.81	4.00

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, K_0 = Control, K_1 = 100 kg K/ha, K_2 = 120 kg K/ha, K_3 = 140 kg K/ha.

Appendix IX. Effect of earthing up on fresh weight of leaves, root length, root diameter and fresh root weight of carrot

Treatments	Fresh weight of leaves (g)	Root Length (cm)	Root Diameter (cm)	Fresh root weight (g)
E_0	96.35 c	10.90 c	3.29 c	138.53 c
E_1	101.27 b	13.42 b	3.77 b	168.55 b
E_2	105.80 a	17.85 a	4.24 a	178.55 a
LSD (0.05)	1.6243	0.8125	0.1850	5.4786
CV%	1.90	6.83	5.81	4.00

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up.

Appendix X. Effect of potassium on gross yield per plot, marketable yield per plot, gross yield per hectare and marketable yield per hectare of carrot

Treatments	Gross yield/plot (kg)	Marketable yield/plot (kg)	Gross yield/ha (t)	Marketable yield/ha (t)
K_0	2.98 d	2.83 d	23.90 d	22.69 d
K_1	4.02 c	3.62 c	32.18 c	28.98 c
K_2	4.79 a	4.42 a	38.35 a	35.32 a
K_3	4.38 b	4.06 b	35.08 b	32.49 b
LSD(0.05)	0.1582	0.1153	1.2656	0.9198
CV%	4.00	3.16	4.00	3.15

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, K_0 = Control, K_1 = 100 kg K/ha, K_2 = 120 kg K/ha, K_3 = 140 kg K/ha.

Appendix XI. Effect of earthing up on gross yield per plot, marketable yield per plot, gross yield per hectare and marketable yield per hectare of carrot

Treatments	Gross yield/plot (kg)	Marketable yield/plot (kg)	Gross yield/ha (t)	Marketable yield/ha (t)
E_0	3.46 c	3.04 c	27.71 c	24.34 c
E_1	4.21 b	3.81 b	33.71 b	30.53 b
E_2	4.46 a	4.34 a	35.71 a	34.75 a
LSD (0.05)	0.1370	0.0998	1.0960	0.7966
CV%	4.00	3.16	4.00	3.15

In a column means having similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up.

Appendix XII. Analysis of variance of the data on plant height and number of leaves at different days after sowing (DAS) of carrot as influenced by potassium and earthing up

Source of variation	Degrees of freedom (df)	Mean square of							
		Plant height				Number of leaves per plant			
		35 DAS	55 DAS	75 DAS	At Harvest	35 DAS	55 DAS	75 DAS	At Harvest
Replication	2	0.0301	46.344	11.433	8.283	0.6019	2.4204	7.9078	5.1762
Factor A (Potassium)	3	14.5394**	187.517**	172.275**	79.539**	14.5679**	21.9315**	23.1955**	40.0969**
Factor B (Earthing Up)	2	0.1515^{ns}	125.367**	450.151**	205.541**	0.5032^{ns}	30.6108**	58.7083**	59.5256**
Combination (A x B)	6	0.0415^{ns}	8.298*	18.880*	5.528**	0.1481^{ns}	3.7524**	2.0948*	3.9204*
Error	22	0.0750	2.991	6.387	0.775	0.2652	0.4597	0.7708	1.3748

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{ns}Non-significant

Appendix XIII. Analysis of variance of the data on fresh weight of leaves, root length, root diameter and fresh root weight of carrot as influenced by potassium and earthing up

Source of variation	Degrees of freedom (df)	Mean square of			
		Fresh weight of leaves (g)	Root length (cm)	Root diameter (cm)	Fresh root weight (g)
Replication	2	37.04	7.908	0.12109	95.62
Factor A (Potassium)	3	1361.11**	42.474**	3.72117**	8612.35**
Factor B (Earthing Up)	2	268.15**	148.505**	2.73142**	5204.33**
Combination (A x B)	6	11.58*	3.327**	0.13860*	348.94**
Error	22	3.68	0.921	0.04775	41.87

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{ns}Non-significant

Appendix XIV. Analysis of variance of the data on dry matter of leaves, dry matter of roots, percentage of branched roots, percentage of cracked roots of carrot as influenced by potassium and earthing up

Source of variation	Degrees of freedom (df)	Mean square of			
		Dry matter of leaves (%)	Dry matter of roots (%)	Branched roots (%)	Cracked roots (%)
Replication	2	3.1202	3.8968	0.028	0.111
Factor A (Potassium)	3	51.7189**	25.8360**	174.546**	82.028**
Factor B (Earthing Up)	2	27.7805**	13.0708**	184.194**	164.361**
Combination (A x B)	6	1.0995**	0.5857**	1.824*	6.583**
Error	22	0.1773	0.0747	0.604	0.687

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{ns}Non-significant

Appendix XV. Analysis of variance of the data on gross yield per plot, marketable yield per plot, gross yield per hectare and marketable yield per ha of carrot as influenced by potassium and earthing up

Source of variation	Degrees of freedom (df)	Mean square of			
		Gross yield/plot (kg)	Marketable yield/plot (kg)	Gross yield/ha (t)	Marketable yield/ha (t)
Replication	2	0.05983	0.03354	3.289	2.129
Factor A (Potassium)	3	5.38192**	4.18381**	344.443**	266.809**
Factor B (Earthing Up)	2	3.25317**	5.14493**	208.203**	329.347**
Combination (A x B)	6	0.21814**	0.18251**	13.961**	11.689**
Error	22	0.02619	0.01390	1.676	0.885

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{ns}Non-significant

Appendix XVI. Cost of production of carrot per hectare

A. Input Cost

Treatments	Cultivation with labour	Seed cost	Pesticides	Intercultural operation	Seed sowing cost	Earthing up (labour cost)	Manure and Fertilizer					Harvesting cost	Sub Total of A
							Cowdung	TSP	Urea	MoP	Gypsum		
K_0E_0	14000	20000	3000	10400	2500	0	25000	5400	5000	0	6600	8000	99900
K_0E_1	14000	20000	3000	10400	2500	16000	25000	5400	5000	0	6600	8000	115900
K_0E_2	14000	20000	3000	10400	2500	24000	25000	5400	5000	0	6600	8000	123900
K_1E_0	14000	20000	3000	10400	2500	0	25000	5400	5000	6000	6600	8000	105900
K_1E_1	14000	20000	3000	10400	2500	16000	25000	5400	5000	6000	6600	8000	121900
K_1E_2	14000	20000	3000	10400	2500	24000	25000	5400	5000	6000	6600	8000	129900
K_2E_0	14000	20000	3000	10400	2500	0	25000	5400	5000	7200	6600	8000	107100
K_2E_1	14000	20000	3000	10400	2500	16000	25000	5400	5000	7200	6600	8000	123100
K_2E_2	14000	20000	3000	10400	2500	24000	25000	5400	5000	7200	6600	8000	131100
K_3E_0	14000	20000	3000	10400	2500	0	25000	5400	5000	8400	6600	8000	108300
K_3E_1	14000	20000	3000	10400	2500	16000	25000	5400	5000	8400	6600	8000	124300
K_3E_2	14000	20000	3000	10400	2500	24000	25000	5400	5000	8400	6600	8000	132300

Here, K_0= control, K_1= 100 kg K/ha , K_2 = 120 kg K/ha, K_3 = 140 kg K/ha, E_0= No earthing up, E_1= Two times earthing up and E_2= Three times earthing up

B. Overhead cost (Tk./ha)

Treatments	Overhead cost (Tk./ha)				Sub total (A)	Total cost of production (A + B)	Yield (Ton/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	BCR
	Cost of leased land for 6 months (13% value of land tk-6,00000)	Miscellaneous cost (Tk-5% of the input cost)	Interest on running capital for 6 months (13% of cost per year)	Sub total (B)						
K_0E_0	39000	4995	12987	56982	99900	156882	20.03	240360	83478	1.53
K_0E_1	39000	5955	15483	60438	115900	176338	22.59	271080	94742	1.54
K_0E_2	39000	6195	16107	61302	123900	185202	25.46	305520	120318	1.65
K_1E_0	39000	5295	13767	58062	105900	163962	23.12	277440	113478	1.69
K_1E_1	39000	6255	16263	61518	121900	183418	30.58	366960	183542	2.00
K_1E_2	39000	6495	16887	62382	129900	192282	33.23	398760	206478	2.07
K_2E_0	39000	5355	13923	58278	107100	165378	28.27	339240	173862	2.05
K_2E_1	39000	6315	16419	61734	123100	184834	35.41	424920	240086	2.29
K_2E_2	39000	6555	17043	62598	131100	193698	42.29	507480	313782	2.62
K_3E_0	39000	5415	14079	58494	108300	166794	25.93	311160	144366	1.86
K_3E_1	39000	6375	16575	61950	124300	186250	33.53	402360	216110	2.16
K_3E_2	39000	6615	17199	62814	132300	195114	38.03	456360	261246	2.34