



Effect of Potassium and Earthing Up on Growth, Yield and Economic Benefit of Carrot

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Authors' contributions

This work was carried out in collaboration between all authors. Authors TM and KK planned the experiment and lead the research. Authors SSR, TM and KK designed and carried out the research. Authors SSR, MAS and MEH performed the statistical analysis. Authors SSR, MAS carried out the research on the field. Authors MA, ASAS and KF collected the data. Authors SSR and MEH wrote the manuscript. Authors MAS, MA, ASAS and KF managed the literature searches. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

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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 K₀= Control, K₁= 100 kg K/ha, K₂= 120 kg K/ha, K₃= 140 kg K/ha and Factor B: E₀= no earthing up, E₁= two times earthing up, E₂= 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 K₂ (120 kg K/ha) treatment compared to K₀ (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)

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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. 8,45,800), net return (Tk. 6,52,102) and BCR (4.37) were obtained from the treatment combination K_2E_2 (120 kg K/ha + three times earthing up) where the lowest gross return (Tk. 4,00,600), net return (Tk. 2,43,718) and BCR (2.55) 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 growth, yield and economic benefit.

Keywords: Benefit cost ratio; carrot, quality; vegetable and yield.

1. 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 [1] and extensively cultivated in North and South America, Europe, Asia, North Africa [2]. 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 [3]. It grows successfully in Bangladesh during Rabi season when temperature ranges from 11.17°C to 28.9°C [4] and mid November to early December is the best time for its cultivation to get satisfactory yield [5]. The carrot is one of the profitable crops in Bangladesh. The edible part of this crop is characterized by its high beta carotene content, a precursor of vitamin A and acts as an excellent source of iron, calcium, phosphorus, vitamin B, sugar and folic acid [6]. 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. 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 year [7]. 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 [8].

Carrot cultivation requires ample supply of plant nutrients. Carrot is a potassium demanding plant [9]. 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, stimulates root growth. It is necessary for the translocation of sugars and formation of carbohydrates. It is a highly mobile element in the plant and has a specific phenomenon, it is called luxury consumption [10]. 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.

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 [11]. Author [12] 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. Unfortunately, very limited researches have been carried out regarding the effect of potassium and earthing up on carrot for higher growth, yield and economic benefit of carrot. A detailed and systematic study is needed to find out the suitable levels, optimum number of earthing up and suitable combination of potassium and the number of earthing up for maximum growth, yield and economic benefit of carrot in Bangladesh.

2. MATERIALS AND METHODS

2.1 Experimental Site

The research was conducted during the period from November, 2018 to February, 2019 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. The soil was having a texture of sandy loam with pH and organic matter 5.47-5.63 and 0.83%, respectively.

2.2 Experiment Frame Work

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. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole experimental area was 18.5 m x 5.75 m which was divided into three blocks. Each block was again divided into 12 plots and hence there were 36 (12 x 3) unit plots. The treatments were assigned randomly in each block separately. The size of unit plot was 1.25 m x 1.0 m. The distance between two adjacent blocks and plots were 50cm.

2.3 Manure and Fertilizer Application

In the experimental plots total amount of cowdung (1% potash) (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. Fertilizers were used from Sher-e-Bangla Agricultural University (SAU) authorize Farm.

2.4 Earthing Up

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

2.5 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 [13]. The benefit-cost ratio (BCR) was calculated as follows:

$$\text{BCR} = \frac{\text{Gross returns (Tk./ha)}}{\text{Total cost of production}} \times 100$$

2.6 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 the least significant difference test (LSD) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 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 Table 1. 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. Author [14] 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. Significant influence was not found in terms of plant height of carrot at 35 days after sowing (DAS) but later at 55 DAS, 75 DAS and at harvest there was significant differences in plant height Table 2. Because first earthing up was done at 35 DAS. 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. Authors [15,16] 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 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 3. 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.

3.2 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, 55, 75 DAS and at harvest. 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 Table 4. Authors [17,18] 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. Significant variation was not found in terms of number of leaves per plant of carrot at 35 days after sowing (DAS) affected by different numbers of earthing up but later at 55 and 75 DAS and at harvest there was significant differences in number of leaves per plant Table 5. Because first earthing up was done at 35 DAS. At harvest the highest number of leaves per plant (17.76) was observed from E_2 (three times earthing up) treatment and lowest number of leaves per plant (13.31) was observed from E_0 (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 number of leaves per plant varied significantly at 55 and 75 DAS and at harvest Table 6. 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.

3.3 Fresh Weight of Leaves Per Plant

The maximum fresh weight of leaves per plant (113.91 g) was recorded from K_2 (120 kg K/ha) treatment and control (K_0) treatment showed the minimum fresh weight of leaves per plant (85.47 g) Table 7. Authors [14,19] also showed similar results in their study. Fresh weight of leaves increased by the application of proper doses of potassium. They also concluded that fresh weight of leaves per plant enhanced by the levels of potassium. In case of earthing up, 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 Table 8. Author [20] also found the similar trend of results in their experiment. Frequency of earthing up results in plants having a larger area from which to hold waters and nutrients for plant. Among the combination treatments 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 and minimum fresh weight of leaves per plant (80.09 g) was recorded from K_0E_0 (control) treatment combination Table 9.

Table 1. 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
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
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

Table 2. Effect of 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 ₀ E ₀	11.87	20.78 g	22.94 h	31.45 g
K ₀ E ₁	12.17	23.95 f	32.64 ef	37.66 e
K ₀ E ₂	11.94	24.76 ef	33.01 ef	41.88 cd
K ₁ E ₀	13.72	27.62 de	24.84 gh	33.54 f
K ₁ E ₁	13.79	30.85 c	34.44 de	40.56 d
K ₁ E ₂	13.83	30.55 c	36.84 cde	43.63 b
K ₂ E ₀	14.88	29.16 cd	28.91 fg	40.92 d
K ₂ E ₁	14.95	34.48 b	42.18 b	43.36 bc
K ₂ E ₂	15.24	37.53 a	46.66 a	47.40 a
K ₃ E ₀	13.97	25.94 ef	32.81 ef	38.58 e
K ₃ E ₁	14.17	33.93 b	37.82 cd	41.53 d
K ₃ E 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

Table 3. Combined effect of potassium and earthing up on plant height at different days after sowing (DAS) of carrot

Treatment combination	Number of leaves per plant			
	35 DAS	55 DAS	75 DAS	At Harvest
K ₀ E ₀	4.31	5.04 g	8.21 i	10.53 g
K ₀ E ₁	4.50	7.12 ef	11.78 def	12.63 f
K ₀ E ₂	4.72	6.92 ef	11.29 efg	16.38 cd
K ₁ E ₀	5.92	6.24 f	9.46 hi	14.01 ef
K ₁ E ₁	6.24	8.55 cd	12.15 de	14.81 de
K ₁ E ₂	6.56	8.61 cd	12.41 cde	15.53 de
K ₂ E ₀	7.15	6.62 f	10.45 fgh	14.80 de
K ₂ E ₁	7.57	10.55 b	15.23 b	18.62 b
K ₂ E ₂	7.81	12.91 a	16.85 a	21.11 a
K ₃ E ₀	6.94	7.88 de	9.98 gh	13.89 ef
K ₃ E ₁	6.47	9.31 c	13.04 cd	16.25 cd
K ₃ E ₂	6.82	9.37	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, K₀ = control, K₁ = 100 kg K/ha, K₂ = 120 kg K/ha, K₃ = 140 kg K/ha, E₀ = control, E₁ = two times earthing up, E₂ = three times earthing up

Table 4. 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

Table 5. 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

Table 6. Combined effect of potassium and earthing up on number of leaves per plant at different days after sowing (DAS) of carrot

Treatment combination	Cost of cultivation (Tk./ha)	Yield (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio (BCR)
K ₀ E ₀	156882	20.03	400600	243718	2.55
K ₀ E ₁	176338	22.59	451800	275462	2.56
K ₀ E ₂	185202	25.46	509200	323998	2.75
K ₁ E ₀	163962	23.12	462400	298438	2.82
K ₁ E ₁	183418	30.58	611600	428182	3.33
K ₁ E ₂	192282	33.23	664600	472318	3.45
K ₂ E ₀	165378	28.27	565400	400022	3.42
K ₂ E ₁	184834	35.41	708200	523366	3.83
K ₂ E ₂	193698	42.29	845800	652102	4.37
K ₃ E ₀	166794	25.93	518600	351806	3.11
K ₃ E ₁	186250	33.53	670600	484350	3.60
K ₃ E ₂	195114	38.03	760600	565486	3.89

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, K₀ = Control, K₁ = 100 kg K/ha, K₂ = 120 kg K/ha, K₃ = 140 kg K/ha, E₀ = Control, E₁ = two times earthing up, E₂ = three times earthing up

3.4 Root Length

The longest root of carrot (16.77 cm) was obtained from K₂ (120 kg K/ha) treatment and control (K₀) treatment showed the shortest root length of carrot (11.71 cm) Table 7. Root length was increased due to basipetal movement of potassium in the carrot roots which produced to enhance the longest root [21]. Application of higher levels of potassium produced the longer roots than the lower ones [19,22]. Effect of earthing up on root length of carrot was differed significantly. E₂ (three times earthing up) treatment showed the longest root length of carrot (17.85 cm) while the shortest root length (10.90 cm) recorded from E₀ (control) treatment Table 8. This is supported by [23] 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. Combined effect of different levels of potassium and earthing up showed significant differences on root length of

carrot. K₂E₂ (120 kg K/ha and three times earthing up) treatment combination gave the longest (22.06 cm) root of carrot and shortest (8.95 cm) length of root was obtained from the control (K₀E₀) treatment combination Table 9. Proper levels of potassium and numbers of earthing up helps to increase the root length of carrot.

3.5 Root Diameter

Root diameter of carrot was significantly influenced by different levels of potassium. The maximum root diameter (4.40 cm) was obtained from K₂ (120 kg K/ha) treatment, while the lowest root diameter (2.89 cm) was produced from the K₀(control) treatment Table 7. Authors [19,24] 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. Root diameter varied significantly due to the effect of numbers of earthing up. The maximum diameter of carrot root (4.24 cm) was

found from E₂ (three times earthing up) treatment and minimum diameter of carrot root (3.29 cm) was found from E₀ (control) treatment Table 8. Author [23] 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. Root diameter of carrot varied significantly due to the combined effect of different levels of potassium and earthing up. The maximum root diameter of carrot (5.06 cm) was found from the treatment combination of K₂E₂ (120 kg K/ha and three times earthing up) and minimum root diameter of carrot (2.59 cm) was observed from control (K₀E₀) treatment combination Table 9.

3.6 Fresh Root Weight (g)

The maximum fresh root weight of carrot (191.73 g) was recorded from K₂ (120 kg K /ha) treatment and the control (K₀) treatment gave the lowest fresh root weight of carrot (119.50 g) Table 7. The application of potassium significantly improved carrot growth, productivity and quality of roots. Authors [19,22] observed the same kind of results. Potassium application produced the heavier roots. The fresh root weight of carrot per plant significantly differed due to different numbers of earthing up Table 8. The highest fresh root weight of carrot (178.55 g) was recorded from E₂ (three times earthing up) treatment and K₀ (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. Authors [16,25] confirmed that earthing up after emergence resulted in better total biomass of plant. Combined effect of potassium and earthing

up showed significant variation on fresh root weight of carrot per plant Table 9. The maximum fresh root weight of carrot (217.55 g) was recorded when plant grown from the treatment combination of K₂E₂ (120 kg K/ha and three times earthing up) and the minimum fresh root weight of carrot (110.06 g) was observed from the K₀E₀ (control) treatment combination.

3.7 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 Fig. 1. K₂ (120 kg K/ha) treatment produced the highest (4.79 kg) gross yield of carrot roots/plot and K₀ (control) treatment produced the lowest (2.98 kg) gross yield of roots/plot. The application of potassium significantly improved carrot growth, productivity and quality of roots. Authors [26,27] indicated that potassium fertilizers increased the total harvest of carrot. 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 earthing up on gross yield of roots/plot Fig. 2. Maximum gross yield of roots/plot (4.46 kg) was obtained from the E₂ (three times earthing up) treatment, while the E₀ (no earthing up) treatment produced the minimum (3.46 kg) gross yield of roots/plot. High gross yield of roots/plot recorded on earthed treatments indicated that earthing up several times improved and conserved soil moisture which also lowers soil temperature hence creating favorable conditions for good yield levels. This concurred well with [28,29] who pointed out that good soil moisture has a positive relationship with good yields. Among combined effect the maximum gross yield of carrot root (5.44 kg) was found from the treatment combination K₂E₂ (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 K₀E₀ (control) Table 10.

Table 7. 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

Table 8. 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

Table 9. 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	8.89 b	4.67 b	192.51 c
LSD (0.05)	3.2487	1.625	0.37	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, K₀ = Control, K₁ = 100 kg K/ha, K₂ = 120 kg K/ha, K₃ = 140 kg K/ha, E₀ = Control, E₁ = Two times earthing up, E₂ = Three times earthing up

3.8 Marketable Yield of Roots Per Plot

Marketable yield of roots per plot varied significantly due to the application of different levels of Potassium Fig. 1. The highest marketable yield of roots/plot (4.42 kg) was obtained from K₂ (120 kg K/ha) treatment and the lowest marketable yield of roots/plot (2.83 kg) was recorded from K₀ (control) treatment. Author [26] concurred well with this results. Potassium application has great effects on carrot productivity and quality. The marketable yield of roots per plot was found statistically significant due to the effect of earthing up Fig. 2. E₂ (three times earthing up) treatment produced the highest (4.34 kg) marketable yield of roots/plot and lowest marketable yield/plot (3.04 kg) was recorded from the E₀ (control) treatment. Several authors [28,29] and [30] 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 10. The highest marketable yield of roots per plot (5.29 kg) was observed from K₂E₂ (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 K₀E₀ (control).

3.9 Gross Yield of Roots Per Hectare

Gross yield of roots per hectare was significantly influenced by the different levels of potassium Fig. 3. The highest gross yield of roots (38.35 t/ha) was obtained from K₂ (120 kg K/ha) treatment and the lowest gross yield of roots per hectare (23.90 t) was obtained from K₀(control) treatment. Authors [26,31] concurred well with this results. 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 Fig. 4. The maximum gross yield of roots (35.71 t/ha was obtained from E₂ (three times earthing up) treatment and E₀ (control) gave the lowest (27.71 t/ha) gross yield. Authors [28,29] pointed out the same kind of results. They opined that good soil moisture has a positive relationship with good yields. Another author [32] 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 10. The highest gross yield of roots (43.51 t/ha) was found from the treatment combination K₂E₂ (120 kg K/ha and three times earthing up) and lowest gross yield of carrot root (22.01 t/ha) was recorded from K₀E₀ (control) treatment combination.

3.10 Marketable Yield of Roots Per Hectare

Marketable yield of roots varied significantly due to the application of different levels of potassium Fig. 3. The maximum marketable yield of roots (35.32 t/ha) was obtained from K₂ (120 kg K/ha) treatment, while the minimum yield of roots (22.69 t/ha) was found from K₀ (control) treatment. Similar findings found from the study of [27]. They reported that increasing level of potassium increase root yield and quality parameters. Marketable yield of carrot per hectare was found statistically significant due to the application of different numbers of earthing up Fig. 4. Highest marketable yield of carrot (34.75 t/ha) was obtained from E₂ (three times

earthing up) treatment and the lowest marketable yield of carrot (24.34 t/ha) from E₀ (no earthing up) treatment. Authors [28,29,30] reported the similar trends of the result. Among the combination, highest marketable yield of carrot (42.29 t/ha) was recorded from K₂E₂ (120 kg K/ha and three times earthing up) treatment combination, whereas the lowest marketable yield of carrot (20.03 t/ha) was found from the treatment combination of K₀E₀ (control) Table 10.

3.11 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 11.

3.11.1 Cost of cultivation

The total expenditure was observed to range from Tk.1,56,882 (K₀E₀) to Tk. 1,95,114 (K₃E₂) Table 11.

3.11.2 Gross return

Gross returns for different treatment combinations in the present investigation ranged from Tk. 4,00,600 to Tk. 8,45,800. Among all the treatment combinations studied, K₂E₂ (120 kg K/ha and three times earthing up) treatment combination gave the highest gross returns of Tk. 8,45,800 and the lowest gross returns of Tk. 4,00,600 from K₀E₀ (control) treatment combination Table 11.

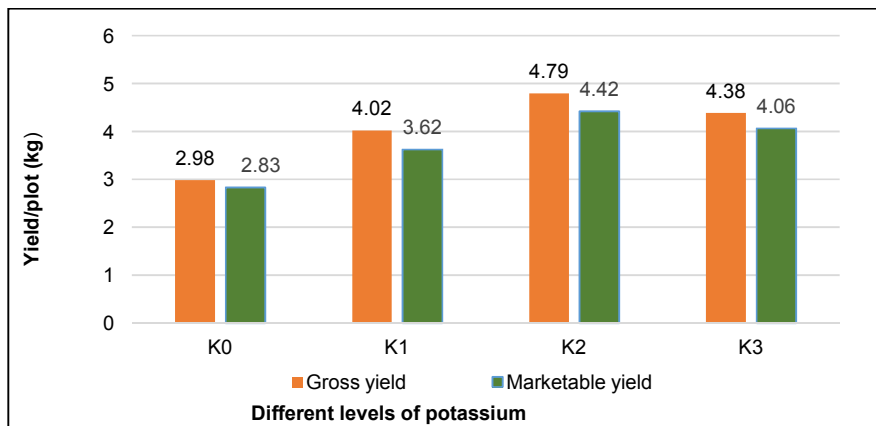


Fig. 1. Effect of potassium on gross yield/plot and marketable yield/plot of carrot. Where, K₀= control, K₁= 100 kg K/ha, K₂= 120 kg K/ha and K₃= 140 kg K/ha

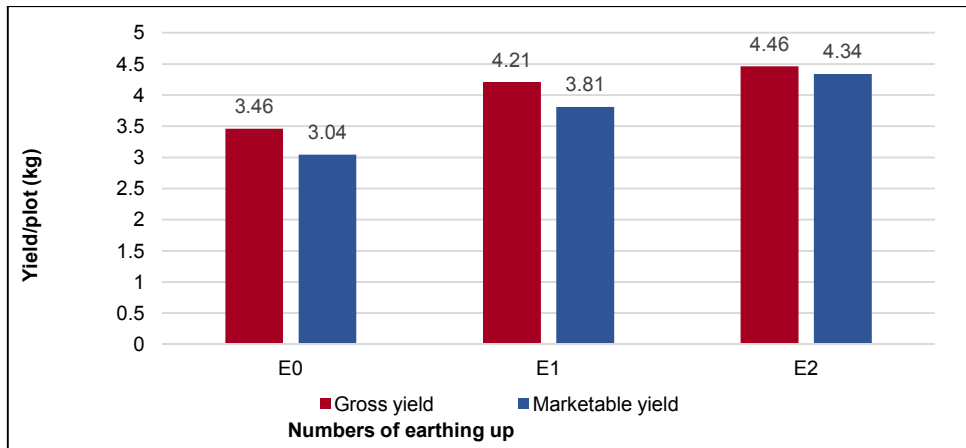


Fig. 2. Effect of earthing up on gross yield/plot and marketable yield/plot of carrot. Where, E₀= no earthing up, E₁= two times earthing up and E₂= three times earthing up

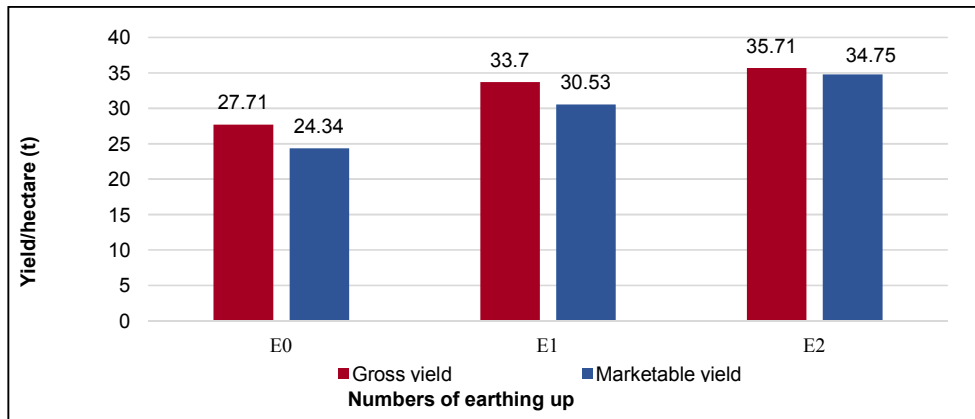


Fig. 3. Effect of potassium on gross yield/hectare and marketable yield/hectare of carrot. Where, K₀= control, K₁= 100 kg K/ha, K₂= 120 kg K/ha and K₃= 140 kg K/ha

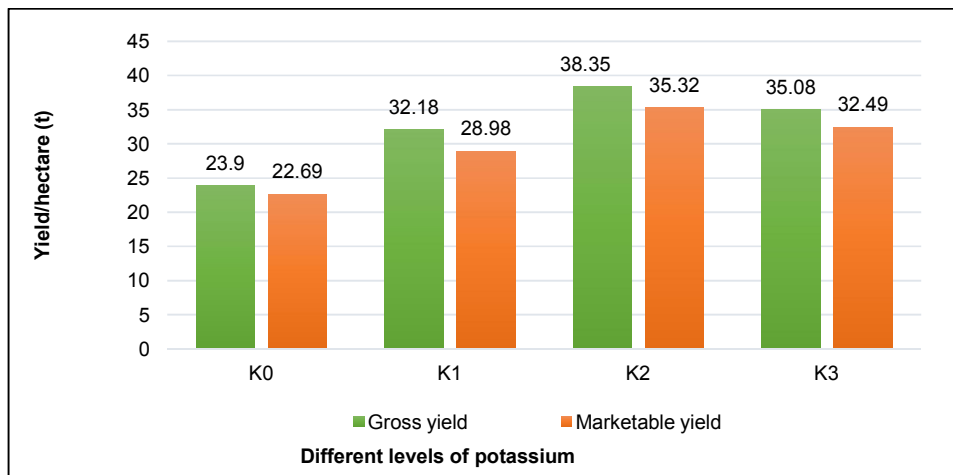


Fig. 4. Effect of earthing up on gross yield/hectare and marketable yield/hectare of carrot. Where, E₀= no earthing up, E₁= two times earthing up and E₂= three times earthing up

Table 10. Combined effect of potassium and earthing up on gross yield/plot, marketable yield/plot, gross yield/hectare and marketable yield/hectare of carrot

Treatment combination	Gross yield/plot (kg)	Marketable yield/plot (kg)	Gross yield/ha (t)	Marketable yield/ha (t)
K ₀ E ₀	2.75 i	2.50 i	22.01 i	20.03 i
K ₀ E ₁	3.07 h	2.82 h	24.56 h	22.59 h
K ₀ E ₂	3.14 h	3.18 g	25.13 h	25.46 g
K ₁ E ₀	3.45 g	2.89 h	27.62 g	23.12 h
K ₁ E ₁	4.15 e	3.82 e	33.21 e	30.58 e
K ₁ E ₂	4.46 d	4.15 d	35.69 d	33.23 d
K ₂ E ₀	3.81 f	3.53 f	30.53 f	28.27 f
K ₂ E ₁	5.12 b	4.43 c	40.99 b	35.41 c
K ₂ E ₂	5.44 a	5.29 a	43.51 a	42.29 a
K ₃ E ₀	3.83 f	3.24 g	30.66 f	25.93 g
K ₃ E ₁	4.51 d	4.19 d	36.07 d	33.53 d
K ₃ E 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, K₀ = Control, K₁ = 100 kg K/ha, K₂ = 120 kg K/ha, K₃ = 140 kg K/ha, E₀ = Control, E₁ = Two times earthing up, E₂ = Three times earthing up

Table 11. Effect of potassium and earthing up on economic analysis of carrot

Treatment combination	Cost of cultivation (Tk./ha)	Yield (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio (BCR)
K ₀ E ₀	156882	20.03	400600	243718	2.55
K ₀ E ₁	176338	22.59	451800	275462	2.56
K ₀ E ₂	185202	25.46	509200	323998	2.75
K ₁ E ₀	163962	23.12	462400	298438	2.82
K ₁ E ₁	183418	30.58	611600	428182	3.33
K ₁ E ₂	192282	33.23	664600	472318	3.45
K ₂ E ₀	165378	28.27	565400	400022	3.42
K ₂ E ₁	184834	35.41	708200	523366	3.83
K ₂ E ₂	193698	42.29	845800	652102	4.37
K ₃ E ₀	166794	25.93	518600	351806	3.11
K ₃ E ₁	186250	33.53	670600	484350	3.60
K ₃ E ₂	195114	38.03	760600	565486	3.89

Here, K₀ = Control, K₁ = 100 kg K/ha, K₂ = 120 kg K/ha, K₃ = 140 kg K/ha, E₀ = Control, E₁ = Two times earthing up, E₂ = Three times earthing up. Sale of marketable carrot @ TK. 20,000/t

3.11.3 Net return

Highest net returns per hectare of Tk. 6,52,102 in carrot cultivation under different treatment combinations of potassium and earthing up studied was obtained from the K₂E₂ (120 kg K/ha and three times earthing up) treatment combination, whereas lowest net returns of Tk. 2,43,718 was obtained from K₀E₀ (control) treatment combination Table 11.

3.11.4 Benefit cost ratio (BCR)

From all the treatment combinations studied in the present investigation, K₂E₂ (120 kg K/ha and three times earthing up) treatment combination

resulted in highest benefit cost ratio of 4.37 and the lowest benefit cost ratio 2.55 was obtained from K₀E₀ (control) treatment combination Table 11.

4. CONCLUSION

Considering the above result it was concluded that the application of potassium significantly affected the production and the yield of carrot. Among the treatment K₂ (120 kg K/ha) was superior to others. Numbers of earthing up was played an important role on the growth and yield of carrot. In respect of all, three times earthing up showed better performance than others. The

treatment combination of K₂E₂ (120 kg K/ha and three times earthing up) provide maximum growth, yield and economic benefit of carrot and therefore, we recommend 120 kg K/ha with three times earthing up for maximizing the carrot growth, yield and economic benefit.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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