EFFECT OF MULCHING AND POTASSIUM ON GROWTH AND YIELD OF CARROT (*Daucus carota* L.)

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TO

MY BELOVED PARENTS

DEPARTMENT OF HORTICULTURE

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CERTIFICATE

This is to certify that the thesis entitled ***"EFFECT OF MULCHING AND POTASSIUM ON GROWTH AND YIELD OF CARROT (Daucus carota L.)"*** *submitted to the Department of Horticulture, 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 authentic research work carried out by* ***MD.SHAHADOT HOSSAIN,*** *Registration No.* ***19-10304*** *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.

Dated: December, 2021
Dhaka, Bangladesh

Prof. Md. Hasanuzzaman Akand
Supervisor

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~The Author

EFFECT OF MULCHING AND POTASSIUM ON GROWTH AND YIELD OF CARROT (*Daucus carota* L.)

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ABSTRACT

An experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2019 to February 2020. The experiment consisted of two factors, Factor A: four different mulch materials, M_0: No mulching, M_1: Water hyacinth, M_2: Saw dust and M_3: Straw and Factor B: four different levels of potassium, K_0: No potassium, K_1: 75 kg k/ha, K_2: 85 kg k/ha and K_3: 95 kg k/ha, respectively. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Mulching and potassium influenced significantly all the studied parameters. In case of mulching the maximum plant height (45.89 cm) root length (15.85 cm), root diameter (5.02 cm), marketable root yield (31.07 t/ha) were recorded from M_1 treatment. In case of potassium, the maximum plant height (46.46 cm), root length (16.01 cm), root diameter (6.80 cm), marketable root yield (30.04 t/ha) were found in K_2 treatment. Due to combined effect of the highest marketable root yield (35.60 t/ha) was obtained from M_1K_2 and the lowest (21.69 t/ha) was from M_0K_0 (control). The highest BCR (2.18) was obtained from the treatment combination of M_1K_2 where the lowest BCR (1.71) was from M_0K_0. So, it can be concluded that K_2 (85 kg k/ha) with M_1 (water hyacinth) was the best for carrot cultivation.

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ABBREVIATION AND ACRONYM

ABBREVIATION		FULL WORD
Abst.	=	Abstract
AEZ	=	Agro-Ecological Zone
ANOVA	=	Analysis of variance
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CV%	=	Percentage of Coefficient of Variance
DAS	=	Days After Sowing
Df	=	Degrees of Freedom
Ecol.	=	Ecology
Env.	=	Environment
et al	=	And others
FAO	=	Food and Agriculture Organization of United Nations
LSD	=	Least of Significant Difference
M. Sc.	=	Master of Science
MoP	=	Muriate of Potash
MS	=	Mean Square
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University

CHAPTER I

INTRODUCTION

One of the most widely grown vegetables worldwide is the carrot (*Daucus carota* L.), a plant in the apiaceous family (previously Umbclliferae). It is said to have originated in the Mediterranean area. It is widely farmed in Europe, Asia, North Africa, and North and South America and is widely dispersed across the temperate, tropical, and subtropical regions of the planet (Bose and Som, 1990). (Thompson and Kelly, 1998). The optimal period to cultivate carrots for an acceptable yield is from mid-November to early December in Bangladesh during the Rabi season. Rashid (2004). November to early December is the best time for its cultivation to get satisfactory yield. Rashid (1986).

In certain nations, notably those in Asia that depend heavily on rice, a deficit is a public health concern (Woolfe, 1988). Therefore, carrots, which are high in vitamin A, may provide a significant amount of vitamin A to help Bangladeshi people. Carrots are becoming more and more popular in Bangladesh, particularly with the one of the most crucial ingredients in human nutrition; vegetables including vitamins, minerals, proteins, carbs, and lipids. Bangladesh produces less vegetables production per capita than it demands. A source of carbohydrates, protein, fat, minerals, vitamin C, and calories, carrots have greater concentrations of carotene (100 mg/100 g), thiamin (0.04 mg/100 g), and riboflavin (0.05 mg/100 g) (Yawalkcr, 1985).

The two main ingredients of carrot flavor are sugar and volatile terpenoids; glucose, fructose, and sucrose account for more than 95% of the free sugars and 40% to 60% of the stored carbs in the carrot root. When a root reaches maturity, the ratio of sucrose to reducing sugar rises; however, it falls after harvest and during cold storage (Freman and Simon, 1983). Carrots can be consumed fresh or used to make the Bangladeshi sweet dish halua.

Additionally, carrot roots are used as a vegetable in soups and curries, and shredded roots are used in salads.

According to reports, Bangladesh produced 16306 metric tons of carrots on just 4533 acres in the 2016–2017 growing season (BBS, 2017). In Bangladesh, the average output of carrots is roughly 25 t/ha, which is quite low compared to other major nations that produce carrots (FAO, 2004). It grows effectively in Bangladesh during the Rabi season, when temperatures vary from 11.17°C to 28.9°C (Alim, 1974).

Carrot production demands a plentiful supply of plant nutrients. Use of fertilizer is necessary for its healthy development and growth. For the plant's growth and root development, potassium fertilizer must be used. Potassium is a fertilizer that benefits all root crops. Potassium is important for photosynthesis, starch synthesis, and the movement of starch from the top to the bottom of the root system. It also aids in root growth. Additionally, it is required for carrot quality (Dyachenko and Kurumli, 1978). Application of the right potassium dosages is one of the variables that helps increase yield.

In Bangladesh, carrots are produced in the winter when there is little rainfall. In order to cultivate, irrigation is necessary. However, it drives up the price of farming. Mulching could help in this situation to lessen the need for irrigation. Water hyacinth, wood ash, and straw can all be utilized as mulching materials to achieve this goal. The rate at which soil moisture evaporates can be effectively controlled by mulching.

Mulching prevents soil moisture loss from wind-induced soil evaporation and lowers the need for irrigation. It boosts the effectiveness of irrigation and N fertilizer applications (Rhee *et al.,* 1990). Various mulches control the temperature and moisture of the soil, eliminate weeds, and promote germination and emergence (Frazier, 1957). Mulches also boost the soil's microbial activity. The benefits of mulching include enhanced quality and productivity, less insect and disease infestation, early harvest, a longer growing season, more nutritious content, and improved storability (Ahmed, 1999). Mulches help to some extent prevent the spread of illness and insects (Brown *et al.*, 1989).

However, potassium overdose or underdoes might have an impact on crop development and output. Only the ideal potassium dosage is required to provide the most carrots of high grade. Due to its greatest potassium availability and lower cost than any potassium fertilizer, muriate of potash (MP) is a common source of potassium. Mulching is also important for carrot growth and development.

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

Objectives:

1. To determine the optimum dose of potassium for ensuring the growth and higher yield of carrot.
2. To find out the suitable mulch in order to get maximum growth and yield of carrot.
3. To find out the suitable combination of mulching and potassium for growth and yield of carrot.

CHAPTER II
REVIEW OF LITERATURE

Daucus carota L., or carrot, is a significant carotene-rich root vegetable grown around the world, including in Bangladesh. From a nutritional standpoint, carrot is particularly interesting to academics who are working to advance production methods. Carrots are known to be heavy moisture absorbers, thus it is important to control soil moisture appropriately through practices like mulching and irrigation. Mulching and the use of potassium fertilizer are both crucial for maximizing crop output. Similar to many other root and tuber crops, these two elements have a significant impact on carrot development and productivity. These parameters are intimately connected to emergence, soil temperature and moisture, plant growth, and crop yields. To provide the best economic return on the crop, the ideal potassium dose and suitable mulch materials are required. The literature on studies on potassium level mulching materials in Bangladeshi circumstances is sadly lacking, despite the fact that numerous research projects have been conducted on various cultural features of carrots in other nations. This chapter reviews the material that is currently accessible on carrots and other root crops that is pertinent to the current study.

1.1 LITERATURE OF MULCHING

Olfati *et al.* (2008) conducted an experiment on mulching affect in soils. The objectives of this study were to characterize the possibility of using organic based mulches to modify carrot (*Daucus carota* L.), cv. Forto Royal, plant growth and 14 determine effects on yield and quality. Mulch treatments included rice (Oriza sativa L.) hulls, sawdust (Populus deltoids Bartram ex *Marshall* var. *deltoides*), and chopped rice straw. Total yield, root weight, root length, and total soluble solids for plants grown with organic mulches were better than the bare soil control. No significant differences were found in plant height, root diameter, inner and outer core diameter, root color, dry matter, and ash percentage due to treatment. Mulching with organic materials provided some benefit to root development, yield, and total soluble solids content and its use is recommended to promote the carrot root development.

Rani *et al.* (2016) conducted experiment comprised of two factors such as - organic manures viz. F_0 (control), F_1 (cowdung), F_2 (vermi-compost), F_3 (poultry manure), and mulches viz. M_0 (control), M_1 (rice straw), M_2 (water hyacinth) respectively. It was laid out in Randomized Complete Block Design (RCBD) with three replications. The results of the experiment shown that different organic manures and mulches had significant influences of all the parameters studied.

The fresh weight of root (121.31 g), and dry matter of root (17.49 %) were found the highest from cowdung treatment and the lowest 103.62 g, 13.86 % from control. Again, the highest fresh weight of root (122.34 g), dry matter of root (17.06 %) was found from water hyacinth mulch treatment and the lowest 109.29 g and 15.78 % were found from control. For combined effect, maximum fresh weight of root (134.51 g) and dry matter of root (18.87 %) were found from application of cowdung with water hyacinth mulch and minimum 103.27 g and 13.82 % from control treatment. In addition, the highest total yield (57.93 t/ha) and marketable yield (49.11 ton/ha) were recorded from cowdung treatment and the lowest 51.78 t/ha and 41.44 ton/ha were obtained from control. In case of mulching, the highest total yield (57.69 t/ha) and marketable yield (47.14 ton/ha) were found from water hyacinth mulch and the lowest 54.61 t/ha and 45.12 ton/ha were from control treatment. For combined effect, maximum total yield (59.83 t/ha) and marketable yield 49.80 ton/ha were observed from the treatment of cowdung with water hyacinth mulch and minimum total yield (51.61 t/ha) and marketable yield (41.30 ton/ha) were from control treatment. It may be concluded that the combination of cowdung with water hyacinth mulch can be used to obtain higher growth and yield of carrot.

Daniel *et al.* (2018) was carried out an experiment to evaluate the contributions to the optimization of water use in a carrot crop under different forms of mulch using (*Gliricidia sepium)*, fertilization with castor bean cakes and irrigation water depths. The experiment was conducted in Seropédica, RJ, Brazil (22º 46ʿʿ S and

43° 41'' W), from June to September 2010. The experiment was conducted using a split-split-plot scheme (5 x 3 x 2), with four replicates.

The five plots had irrigation depths corresponding to 0, 43, 72, 100 and 120 % of crop evapotranspiration (ETc); the three subplots contained the different forms of mulch (whole leaves (WL) and chopped leaves and branches (CLB) and the absence of mulch (AM); and the two sub-subplots contained either the presence (PF) or absence of fertilization (AF). Using time domain reflectometry (TDR) in the irrigation management, water depths ranging from 67.8 to 285.5 mm were applied.

The use of mulch in association with fertilization led to higher yields and water-use efficiency (WUE) of the carrot plants, and the mulch composed of WL performed best. The application of irrigation depths corresponding to 97 % of ETc promoted the highest carrot yields, although the highest values of WUE were observed, with irrigation depths corresponding to a range from 51 to 68 % of ETc.

Jaysawl *et al.* (2018) conducted research work at Research field, Department of Horticulture, School of Agriculture, ITM University, Gwalior (M.P.) during the winter season of 2016-17 of carrot. The experiment comprises of eight treatment viz.T_1-Control, T_2-Sugarcane straw mulch, T_3-Black polythene mulch, T_4-Leaves mulch (*Dalbergia sissoo*) T_5-Blue polythene mulch, T_6-Paddy straw mulch, T_7-Grass mulch (*Cynodon dactylon*) and T_8-White polythene mulch. The experiment was laid out in Randomized Block Design with three replications. The results revealed that the treatment T_3-Black polythene mulch was found to be the best among the various treatment and recorded maximum plant height (61.70 cm), Length of leaf (26.78 cm), 16 number of leaves (9.84 plant^{-1}), Fresh weight of leaves (39.38 plant^{-1}), Dry weight of leaves plant^{-1} (5.83 plant^{-1}), Fresh weight of root plant^{-1} (225.33 plant^{-1}), Dry weight of roots plant^{-1} (17.88 plant^{-1}), Fresh weight of plant (264.72 g), Dry weight of plant (23.71 g), Total root length (23.45), Total root diameter (5.54 cm). The treatment T_3 also recorded the maximum yield (1.43 kg/m and 54.69 t/ha) which was followed by T_5- Blue polythene mulch for these parameters.

Hasan *et al.* (2018) were conducted an experiment to determine the effects of vermicompost and organic mulching on growth yield and profitability of carrot (*Daucus carota* L.). Vermicompost was processed from waste and it was applied to field plots in the three different concentrations viz., 2 t/ha (V_1), 4 t/ha (V_2) and 6 t/ha (V_3) with control (V_0), and four levels of mulching viz., control (M_0), rice straw (M_1), water hyacinth (M_2), and sawdust (M_3), respectively. Plant height, number of leaves, leaves fresh weight, root length, leaves dry matter content, root fresh weight, root dry matter content and root diameter, significantly differed among the vermicompost doses and mulching at different levels.

Among the different level of vermicompost, the highest marketable yield and gross yield (27.68 t/ha) of the root (26.35 t/ha) were recorded from V_2 while the lowest (18.71 t/ha) and (20.18 t/ha) from control (V_0). The highest marketable yield (27.89 t/ha) and the gross yield (29.48 t/ha) of root observed from M_2 while the lowest (15.81 t/ha) and (17.12 t/ha) from control (M_0) under mulching treatment. Similarly, the highest marketable yield (33.24 t/ha) and gross yield (34.45 t/ha) of root were marked from V_2M_2 and the lowest (17.46 t/ha) and (18.65 t/ha), respectively from V_0M_0 under combined treatment. The highest (3.64) benefit-cost ratio was recorded from V_2M_2 while the lowest (1.68) from V_3M_0 and it was indicated that vermicompost @ 4 t/ha with water hyacinth mulching was found suitable for carrot cultivation.

Rahman *et al.* (2000) conducted an experiment at the Horticulture Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur.

Bangladesh to find out the effects of mulch and different manures and fertilizers on the yield components and quality of carrot (*Daucus carota* L.). Twelve treatment combinations were evaluated in two factors Randomized Complete Block Design (RCBD) with three replications. Different doses of manures and fertilizers viz. F_0 = Control, F_1 = Cowdung (CD) @ 10 t ha^{-1}, F_2 = Mustard Oil

Cake (MOC) @ 0.25 t ha^{-1}, F_3 = Cowdung (CD) @ 5.0 t ha^{-1} +Mustard Oil Cake (MOC) @ 0.125 t ha^{-1}, F_4 = Urea @ 326.08 kg ha^{-1} + Triple Super Phosphate (TSP) @ 93.75 kg ha^{-1} + Muriate of Potash (MoP) @ 200 kg ha^{-1} and F_5 = Cowdung (CD) @ 5 t ha^{-1} + Urea @ 163.04 kg ha^{-1} + Triple Super Phosphate (TSP) @ 46.87 kg ha^{-1} + Muriate of Potash (MoP) @ 100 kg ha^{-1} were applied under mulched (M_1) and non-mulched (M_0) conditions. Results from our study revealed that maximum fresh weight (3.57 kg plot^{-1}), individual root weight (101.90 g), root length (14.64 cm), root diameter (3.27 cm), total yield (23.78 t ha-1), marketable yield (20.53 t ha^{-1}) and beta-carotene content (8.78 mg 100-1 g) were recorded from F_5 treatment.

The mulching also had a significantly positive effect on maximizing the root yield components as well as beta-carotene contents over non-mulched treatment. On the other hand, the interaction effect of M_1F_5 performed superior in producing yield components and beta-carotene content of root compared to other combinations. The highest marketable yield (25.10 t ha^{-1}) along with best economic gross return (TK. 247167 ha^{-1}) and the benefit-cost ratio (2.91) were also noted from M_1F_5. It was concluded that organic and inorganic sources of nutrients along with mulch effectively increase the carrot yield than the sole application of higher doses of manures and fertilizers.

1.2 LITERATURE OF POTASSIUM

Zdravkovicet *el al*. (2007) conducted an experiment in different types of fertilizer on some control cultivars were applied. The cultivars were fertilized in three ways: (1) using manure at 50 t/ha; (2) NPK (15:15:15) at 670 kg/ha; and (3) calcium ammonium nitrate (CAN) at 670 kg/ha. 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.

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

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

Carrots were grown in three plantings during the winter of 1994-95 in Gainesville, Fa. To test the effect of K fertilization on carrot yield and quality on a sandy soil testing medium (38 ppm) in Mehlich-1 soil test K. Large-size carrot yield was increased linearly with K fertilization. Yield of U>S. No.1 grade carrots and total marketable carrots were not affected by K fertilization. K fertilizer was no required on this soil even though the University Florida Cooperative Extension Service Recommendation was 84 lb/c acre K. Neither soluble sugar nor carotenoid concentrations in carrots roots were affected by K fertilization. The current K recommendation for carrot grown on sandy soils testing 38 ppm Mehlich -1 K could be reduced and still maintain maximum carrot yield and root quality.

Selvi *et al*. (2005) a field study were conducted in India to investigate the effects of different N, P and K levels on carrot. Difference combinations of N, P and K at 100, 135 and 170 kg/ha were used. Full rates of P and K and half rate of N were applied at sowing. The remaining N was applied at 30 days after sowing. The highest yield (21.21 t/ha) was obtained under N, P, K rate of 135, 135,170, followed by 20.25 and 20.21 t/ha obtained from treatments with 170,100,170 and 17,135,170 kg/ha, respectively. A rate of 170, 170, 170 kg/ha did not significantly increase the yield which was low at 18.67 t/ha. Total N content was in the range 1.62-1.98 %. N at 135 kg/ha resulted in high total N values (1.90-198 %), while N at 170 kg/ha resulted in higher total N values (1.80-1.86 %).

Zalewska (2005) a pot experiment was carried out to study the effect of various Ca, Mg, K and H saturations of soil CEC on the yield mineral composition of carrot. A decrease in Kg saturations of CEC to the level approximately 5.7 % and simultaneous increase in the saturation of K to the level 13.5 % resulted in a significant decrease in carrot yield. A decrease in K saturation of CEC below 5 % also caused significant decrease in the yield of carrot roots. An increase in K saturation of CEC from 2.3 to 13 % and a simultaneous decrease in Mg saturation from 13.3 to 4.7 % caused an increase an in the concentration and uptake of potassium and a decrease in the uptake and content of magnesium in carrot roots and leaves. The result was that the value of K: (Ca=Mg) ratio in carrot roots increased from 0.96 to 2.68 mol.

Kancheva *et al.* (2004) cv. were supplied with 0.8, 16 and 24 kg N, P and K/ha in a field experiment conducted in Bulgaria. Results are present on the optimum combinations of fertilizer in Bulgaria. Results are presented on the optimum combinations of fertilizers that will give high carrot yield an quality for processing and direct consumption.

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

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

Akhilesh-Sharma *et al.* (2003) a field experiment was conducted to study the effects of integrated use of farmyard manure, and N, P and K fertilizers on the yield and root yield of carrot (*Daucas carota* cv. Nantes). Three levels of N, P and K (50, 100 and 150 % of the recommended rates of 50:40:35 kg N: P205: K_2O/ha) and 3 levels of farmyard manure (0, 10 and 20 t/ha) were evaluated in split-plot design with 3 replication. The application of 20 t/ha farmyard manure resulted in a significant increase in root yield and other characters over the control in both years. The application of 100 % NPK was superior over the other fertilizer combinations in terms of foot yield, whereas 100 and 150 % of the recommended rate were equally effective and significantly better than the 50 % level with regard to the other characters.

The interaction between farmyard Manure and NPK fertilizers was also significant. The highest net return (155000 rupees/ha) and a benefit cost ratio of 4.37 were obtained with 10 t farmyard manure/ha + 100 % of the recommended NPK rate. The application of 10 t farmyard manure/ha reduced the required N, P_2O_5 and K_2O rates by 25, 20 and 15 kg/ha, respectively.

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

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

At harvest, cabbage yields and nutrients uptakes were similar between the treatments. Cabbage yields averaged to over 90 t/ha in both years. At harvest, total nutrient uptakes were 213-243 kg N/ha, 36-40 kg P/ha and 302-345 kg k/ha. Carrot yielded according to the samplings close to 90 t/ha and nutrient uptake in roots and leaves was 180-190 kg N/ha, 23-30 P/ha and 325-444 kg K/ha. Onion yielded 40-50 t/ha, with uptakes of 117-166 kg N/ha, 18-28 kg P/ha and 117-136 kg K/ha. Fertilizer application did not increase nutrient use efficiency in these experimental conditions. Soil was not prone to leaching and adequate moisture in rooting layer created good conditions for nutrient uptake throughout the season in all treatments.

Subrahmanyam *et al*. (2000) field experiments were conducted to determine the effect of foliar feeding with 0.1 and 0.5% water-soluble fertilizers (Multi K, PF 19-19-19 + micro elements (ME), PF 19-09-19+Mgo + ME an POF 17-10-27 + ME) on carrot (*Daucas capitata* L.) in Bangalore, Karnataka India, during 1998-

99. Five sprays at 10 day intervals were administered with the first foliar spray applied 30 days after transplanting and 40 days after sowing. All the crops responded well to all the fertilizers. All the treatments increased yields substantially compared to the control although yield improvement varied marginally among the fertilizers applied. On average, Multi-K (13-0-46) alone increased yield by 25, 24.4 and 25.9 % in brinjal, cabbage and carrot, respectively. The highest and lowest additional yields were 12.5 and .5 t/ha, respectively, with 1.0 % Multi K and PF 17-10-27 + ME, in cabbage and brinjal, respectively. An increase in cabbage yield was observed when the spry concentration was increased from 0.5 to 1.0% for both Multi-K and PF 19-19-19 + ME. However, carrot yield decreased with increased spray concentration of both Multi –K and PF 19-09-19 + ME. Both cabbage and carrot yields increased when the concentration of PF 19-21-09-19+2MgO+ME was increased. A decrease in the yields of all 3 crops was observed with the increased in concentration of PF 17-10-27 + ME.

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

Flick *et al.* (1988) results of a field trial with carrot cv. Panther, grown on sandy loam, to determine the effects of applying 24 kg P/ha and 83 kg K/ha and sensory quality are briefly discussed and tabulated.

Lazar *et al.* (1997) an experiment was conducted in Romania, during 1995-97 on carrot cultivars Nantes and Chantenay to study the effect of sowing date and fertilizer application on the yield and quality of carrot roots. The treatments comprised: late March and early-June sowing, 110 kg KCI + 150 kg NH4NO3/ha and 150 kg KNO3 + 100 kg NH4NO3/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 (1996) the effect of N (50, 100 or 150 kg/ha) and K (20, 40, 60 or 80 kg/ha) on carrot (cv. *Pusa kesar*) seed yield were investigated in the field during winter seasons of 1992-93 and 1993-94. Pant height, number of umbels/plants and seed yield increased with increasing rates of N. Maximum plant height (mean of 148.95 cm), number of umbles/plant (46.27) and seed yield (9.84 q/ha) were recorded following application of 150 kg N/ha. The number of umbles/plant and seed yield also increasing rates of K, the highest seed yield (mean 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.

Konopinski (1995) carried out field trials near Lubin, Poland, with carrot cv. Perfection. The plants received N:P:K at150:150:300 kg/ha (control) or Super Fertilizer of French manufacture containing 1 % organic matter, 14 % Ca, 3.5 % Mg, 4 % P_2O_5, 2.5 % SO_3 plus all essential microelements. Super Fertilizer was applied at 50 or 100 kg/ha. Using the 100 kg/ha Using the 100 kg/ha rate gave the best yield increase in carrot viz, 70 and 30 % over the control respectively. Crops quality was also best in the variant.

Sharangi and Paria (1995) carried out an experiment where carrots (cv. *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 Feb 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 was3, 6, 9, 12 or15 cm. The highest yield at harvest (95.6 t/ha) was obtained with 150 kg P_2O_5 + 225 kg K_2O) + 10 t poultry manure/ha and a distance of 123 cm between plants, but the results were not statistically significant.

Roa (1994) conducted a field experiment on red sandy loam soil, the effects of K at 0, 50, 100, 150 and 200 kg K_2O/ha as KCI or K_2SO_4 on growth yield and quality of carrot. Mean root weight and yield were highs at 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 due to increase root size and weight.

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

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

Grigrov (1990) on medium or heavy loamy soil in the between the rivers Volga and Don, the soil moisture content during germination to start of root development should be maintained at not less than 80-85 and thereafter at 70 %. For this, 15 irrigation application (4400 m water/ha) were required in dry years and 8 applying N: P: K at 60:130: 20 kg/ha and 40-50 t/ha yield of ecologically clean produce could be expected.

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

Sarker (1989) conducted an experiment with different levels of nitrogen, phosphorus and potassium on yield and components of carrot and reported that the highest yield of 31.99 t/ha of carrot was obtained from the plants fertilized with the highest of nitrogen (120 kg N/ha). The highest yield of 34.27 t/ha was recorded when nitrogen and potash each at 120 kg/ha were applied. Application of nitrogen significantly affected the root length and individual root weight. K and significant effect on root diameter and fresh weight and had no significant effect on root length. In a two-years trial Evers (1988) found that the shoots reached their maximum weight 3 months after sowing, whereas root growth considerably more during both the 3 and 4 month. The roots and shoot DM were positively correlated and the yield was also increased by the application of K and N.

Bruckner (1986) conducted an experiment over3 years and reported that increasing the N supply (0-200 kg N/ha) produced a relatively small increases in yield. N at 100 kg/ha gave the best yield without increasing the content of carrots.

Cultivars Flakkeer RZ and 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.

Krarup *et al.* (1984) conducted an experiment where chant nay carrot were fertilized with K_2O (0,100 0r 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.

Farazi (1993) while conducting as experiment on spacing and application of fertilizer concluded that the highest yield of carrot (454 t/ha) was obtained from the crop fertilized with the highest of N (112 kg N/ha), and potash had no significant effect on then yield of carrot. Both nitrogen and potash had significant effect of diameter of root, but little effect on the length of root. The weight of leaves per plant was increased with the increasing level of nitrogen and potash and no considerable effect on the weight of leaves per plant.

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

Singh and Singh (1996) conducted the effects of N (50, 100 or 150 kg/ha) and K (20, 40, 60 or 80 kg/ha) on carrot (cv. *Pusa kesar*) seed yield were investigated in the field during winter seasons of 1992-93 a 1993-94. Plant height (46.27 cm) and seed yield (9.84 q/ha) were recorded following application of 150 kg N/ha. The number of umbels/plant and seed yield also increased with increasing rates of K; the highest seed yield (mean of 9.35 q/ha) was observed at the highest rate of K. obtained with fertilizer rate (2) + 3 drills/bed(32.7 t/feddan) an no fertilizer + broadcast sowing (19.7 t/feddn), resp. (1 feddan 0.42).

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

Roa (1994) conducted a field experiment on red sandy loam soils, the effect of K at 0, 50, 100 and 0, 50, and 200 kg K_2O/ha 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. In a two years trial Evers (1988) found that the shoots reached their maximum weight 3 months after sowing, whereas roots grew considerably more during both the 3rd and 4th month. The roots and shoot DM were positively correlated and the yield was also increased by the application of K and N.

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

CHAPTER III
MATERIALS AND METHODS

3.1 Experimental site

The experiment was conducted at the Horticulture Farm of the Sher-e-Bangla Agricultural University, Dhaka during November, 2019 to February, 2020. Laboratory works were done at Horticulture Laboratory in Sher-e-Bangla Agricultural University, Dhaka-1207.

3.2 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix VII.

3.3 Soil

The experiment area was belonged to the Modhupur Tract and AEZ 28. The soil was sandy loam with a pH value 6.6. Soil samples were collected randomly from a depth up to 30 cm of the experimental plot and analyses were done and showed nitrogen 0.075%, phosphorus 13 ppm, exchangeable potassium 0.20 me/ 100 g soil and organic carbon 0.82%.

3.4 Planting materials

The carrot variety "*New Kuroda*" was used as experimental materials. The seeds of this variety were collected from Siddique Bazar, Dhaka.

3.5 Treatments of the experiment

The experiment was conducted to study the effect of four levels of Potassium and four levels of mulches. Different levels of two factors were as follows:

Factor A: Different types of Mulches

M_0 = No Mulch (Control)

M_1 = Water hyacinth

M_2= Saw dust

M_3 = Straw

Factor B: Different type of Potassium

K_0 = Control

K_1 = 75 kg k/ha

K_2 = 85 kg k/ha

K_3 = 95 kg k/ha

There were altogether 16 treatments.

Table1. Two factors consist of sixteen (4×4=16) treatments combination. There are as follows:

Treatments	Description	
	Mulches	Potassium
M_0K_0	No mulch	No potassium
M_0K_1	No mulch	75 kg k/ha
M_0K_2	No mulch	85 kg k/ha
M_0K_3	No mulch	95 kg k/ha
M_1K_0	Water hyacinth	No potassium
M_1K_1	Water hyacinth	75 kg k/ha
M_1K_2	Water hyacinth	85 kg k/ha
M_1K_3	Water hyacinth	95 kg k/ha
M_2K_0	Saw dust	No potassium
M_2K_1	Saw dust	75 kg k/ha
M_2K_2	Saw dust	85 kg k/ha
M_2K_3	Saw dust	95 kg k/ha
M_3K_0	Straw	No potassium
M_3K_1	Straw	75 kg k/ha
M_3K_2	Straw	85 kg k/ha
M_3K_3	Straw	95 kg k/ha

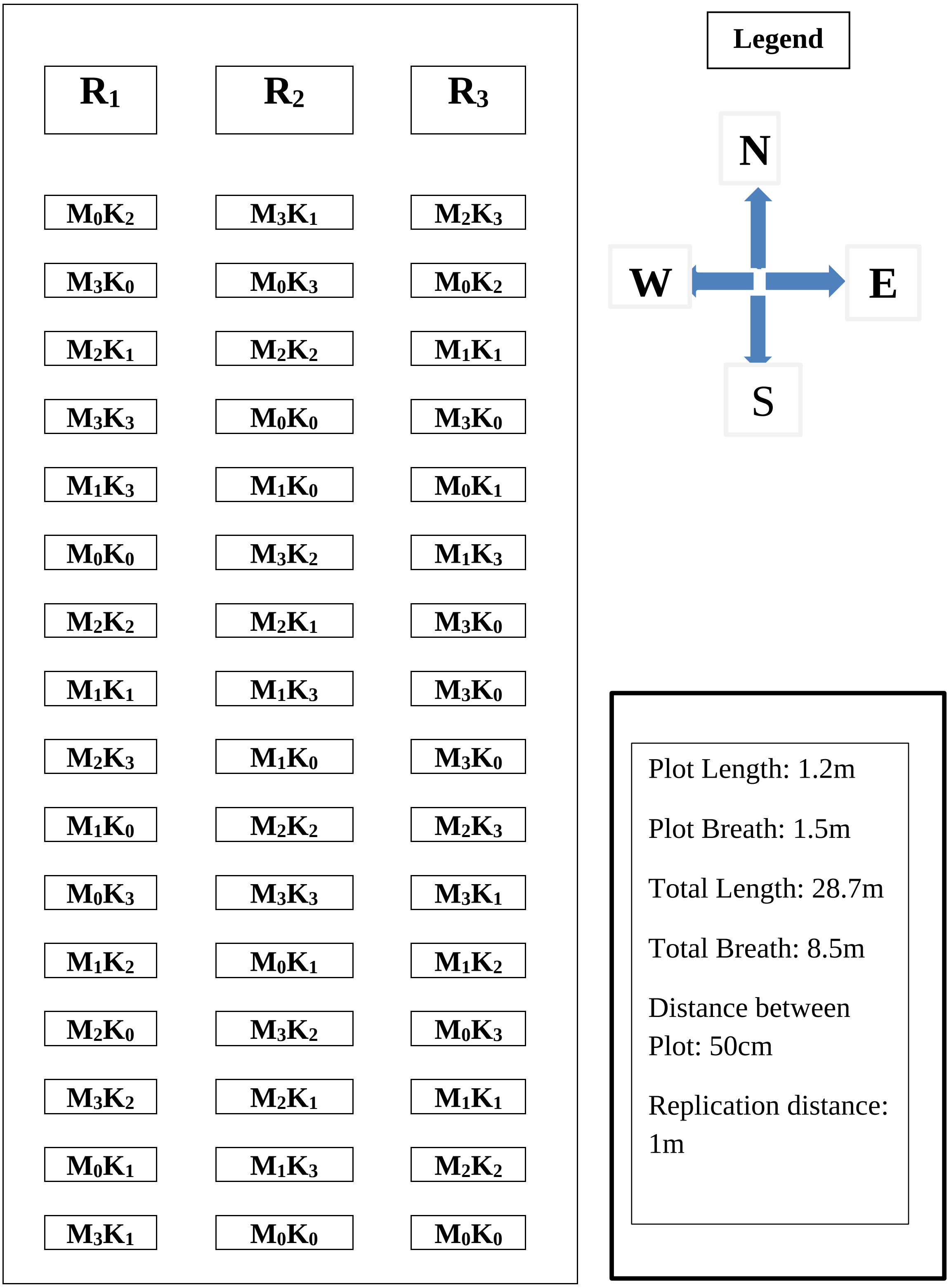

Figure 1. Layout of the experiment plot.

3.6 Design of the experiment

The two factor experiment was laid out in a RCBD design with three replications. The whole experimental area was 28.7m x 8.5 m which was divided into three blocks. Each block was again divided into 16 plots and hence there were 48 (16 x 3) unit plots. The treatments were assigned randomly in each block separately. The size of unit plot was 1.2m x 1.5m. The distance between two adjacent blocks and plots were 1.0 m and 0.5 m respectively. The spacing of each plot was 20×25 cm.

3.7 Seed soaking and treatment

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

3.8 Land preparation

The selected land for the experiment was first opened on November, 2019 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.

3.9 Manure and fertilizer application

The sources of applied N, P_2O_5, K_2O were as cowdung, vermicompost. The entire amounts of cowdung and vermicompost were applied during the final land preparation as per treatments.

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

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.

3.10 Application of mulching:

Before sowing of seeds mulching was done with water hyacinth, saw dust and straw as per treatments. Fresh water hyacinth as chopped into small pieces (8-10cm) and then placed over the plots with a thickness of 12cm and straw were cutting small pieces then placed on the plot. Saw dust was placed on another plot approximately.

3.11 Seed rate and seed sowing

Seeds were sown at the rate of 3 Kg/ha as narrated by Rashid (1994), consequently 75 g of seeds were used for the experimental area. Seeds were sown on different times as per treatments. The seeds were sown at a distance of 20 cm × 25 cm by making a shallow furrow at a depth 1.5 cm in each plot.

3.12 Intercultural operation

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.

3.12.1 Thinning

Emergence of seedlings started about six days after sowing. Different number of plants per plot was found due to different sowing. Thinning was done at two stages like 15 and 30 days after sowing in order to keep a healthy plant in each hill.

3.12.2 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.

3.12.3 Insects and diseases management

Precautionary measure against Fusarium rot was taken by spraying Dithane M 45 @ 2g /litter water. The crop was ingested by cutworms (*Agrotis ipsilon*) during the early 23 stage of growth of seedlings in the month of February. This insect was controlled initially by beating and hooking, afterwards by spraying Dieldrin 20 EC @ 0.1%.

3.13 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 crop was harvested after 90 days from seed 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. The soil and lateral roots adhering to the suberized conical roots were properly cleaned.

3.14 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

3.15 Collection of data

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.

3.15.1 Plant height (cm)

The 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 30, 50,70 and harvest days after sowing.

3.15.2 Number of leaves per plant

Number of leaves was counted 20 days interval and was started from 30 days after sowing and continued to harvest, i.e. 50, 70 and harvest DAS. Ten plants in each plot were used to count number of leaves per plant.

3.15.3 Length of root (cm)

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

3.15.4 Diameter of root (cm)

Ten selected plants are used to determine root diameter. Root diameter was measured at the time of harvesting with slide calipers and recorded in centimeter.

3.15.5 Fresh weight of leaves per plant (gm)

Leaves of ten fresh plants in each plot were detached by sharp knife and fresh weight was taken by using a balance and recorded in gram (g).

3.15.6 Weight of root per plant (g)

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

3.15.7 Dry matter percentage of root (%)

Ten selected carrot roots were used to determine root dry weight. Immediate after harvesting roots were weighed initially, then chopped and kept it in an oven at 70-80 ^{0}C for 48 hours in order to get constant weight. (AOAC, 2965). The dry weight of root was measured by electric balance and was considered as dry weight and recorded in gram (g).

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

3.15.8 Dry matter percentage leaves (%)

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

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

3.15.9 Yield per plot (kg)

Root weight per plot was calculated by using the following formula.

Root weight (kg/plot) = $\frac{\text{Area of single plot(m)} \times \text{Averag yield per plant}}{\text{Spacing} \times 100}$

3.15.10 Yield per hectare (ton)

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

Gross yield = $\frac{\text{Yield per plot (kg)}\times 10000\text{m}^2}{\text{Area of plot in squre meter}\times 1000\text{kg}}$

3.15.11 Marketable yield per plot (kg)

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 crack root and branched root)

3.15.12 Marketable yield per hectare (ton)

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

3.15.13 Branched root per plot (%)

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

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

3.15.14 Cracked root per plot (%)

After harvest the cracked roots are counted and the percentage was calculated by the following formula

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

3.16 Statistical analysis

The recorded data on different growth and yield parameters were calculated for statistical analysis. Analyses of variances (ANOVA) for most of the characters under consideration were performed with the help of MSTAT program. Treatment means were separated by Duncane‟s Multiple Range Test (DMRT) at 5% level of significance for interpretation of the results.

3.17 Economic analysis

In computing economics, the varying levels of manure and different types of mulches were taken into consideration apart from other costs common to all the treatments as per package of practices.

3.17.1 Cost of cultivation

The prices of all the inputs and the labour cost prevailed at the time of their use were taken into consideration while working out the cost of cultivation and expressed as taka per hectare.

3.17.2 Gross returns

Gross returns were calculated on the basis of the prevailing market price and the yield produced per hectare.

3.17.3 Net returns

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

3.17.4 Benefit cost ratio

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

$$\text{Benefit Cost Ratio} = \frac{\text{Gross returns}(\text{tk.ha}^{-1})}{\text{Cost of cultivation}(\text{tk.ha}^{-1})}$$

CHAPTER IV
RESULTS AND DISCUSSTIONS

The goal of the experiment was to investigate how varying mulching and potassium levels affect the growth, yield, and economic benefit of carrots (*Daucus carota* L.). Data were gathered on the various growth, yield, and economic benefits of carrots. The appendix section contains the analyses of variance (ANOVA) results for the data on various parameters. Possible interpretations of the results are provided under the following topics, which have been used to show the data using graphs and tables.

4.1 VEGETATIVE GROWTH

4.1.1 Plant height

Due to the effect of different mulch materials showed significant differences on plant height (Figure 2 Appendix IV). At 30, 50, 70 DAS, and at harvest, the tallest plant was generated by the M_1 (Water hyacinth) mulch treatment (14.00 cm, 28.97 cm, 39.69 cm, and 45.89 cm) respectively. For the treatment M_0, the shortest plant was noted by (control) treatment (12.35 cm, 23.16 cm, 35.26 cm, 40.02 cm) respectively at (30, 50, 70 DAS and at harvest) (Table 2 and Appendix IV). It was demonstrated practically that Water hyacinth was the best mulch for increasing plant height, due to contributes the higher nutrient with soil compare to other mulch material after decomposition during growth period.

This is because water hyacinth acts as a soil insulation system and prevents soil water evaporation, which eventually improves soil quality and allows the carrot plant to absorb more nutrients for growth and development. According to Hasan *et al.* (2018), they were found the highest result by using water hyacinth (mulch material) and noted on abstract highest marketable yield (27.89 t/ha) by using water hyacinth.

At several phases of carrot growth ie, 30 DAS, 50 DAS, 70 DAS and at harvest. Different levels of potassium varied significantly on plant height of carrot. The longest plant height (14.58 cm) was observed in K_2 (85 kg K/ha) at 30 DAS and shortest (11.4 cm) in K_0 (control) (Figure 3 and Appendix V).

At 50 DAS, K_2 (85 kg K/ha) treatment provided the maximum plant height of carrot (29.28 cm), whereas K_0 (control) treatment showed the lowest plant height of carrot (22.36 cm). At 70 DAS, the K_2 (85 kg K/ha) treatment produced the longest plant (40.55 cm), whereas the K_0 (control) treatment produced the smallest plant (35.09 cm). At harvest K_2 (85 kg K/ha) treatment had the tallest plants (46.46cm), while the K_0 (control) treatment had the shortest plant (40.24 cm). Others result were intermediate.

Carrot growth was greatly enhanced by the potassium treatment. Similar trends of findings were discovered in Haque *et al. (*2019)'s study. They discovered that potassium levels, especially when they were at the right levels, considerably boosted vegetative development; such as plant height, whereas control plants had the lowest readings.

Due to combined effect of different types of mulches and levels of potassium showed significant variation on plant height of carrot at different days after showing. However the longest plant (18.14 cm) was produced by the treatment combination of M_1K_2 (Water hyacinth and 85 kg K/ha) and shortest plant (11.04 cm) was found from M_0K_0 treatment combination at 30 DAS (Table 2 and Appendix XIV).

At 50 DAS, the M_1K_2 treatment combination (Water hyacinth and 85kg K/ha) provided the maximum plant height of carrot (36.63cm), whereas the M_0K_0 treatment combination (control) produced the lowest plant height of carrot (18.60 cm).

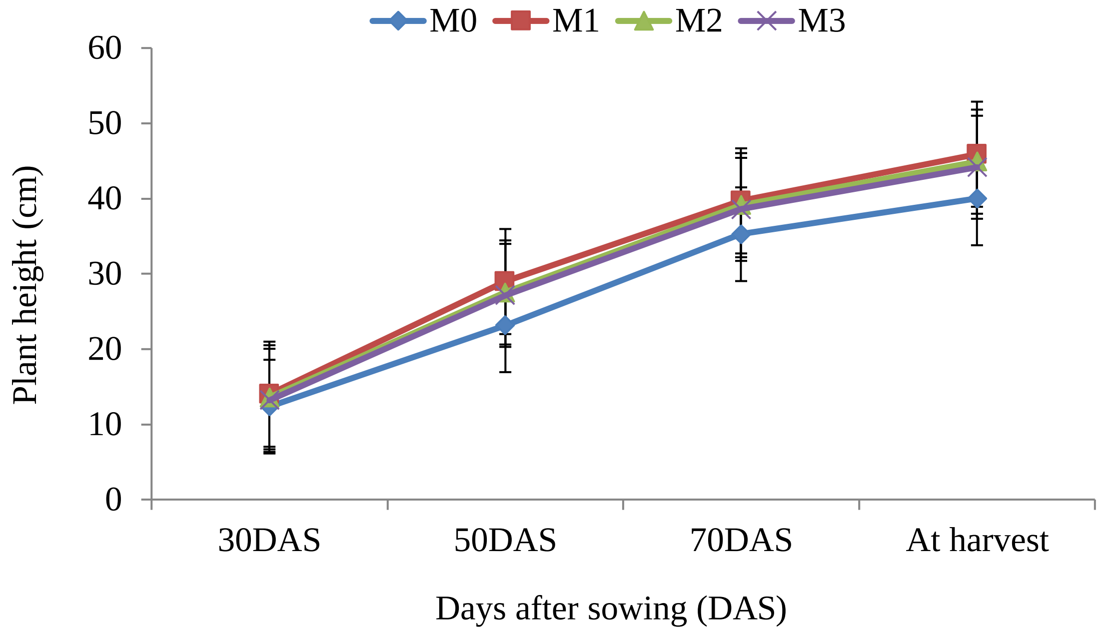

Fig. 2. Effect of mulching on plant height at different days after sowing (DAS).

Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw.

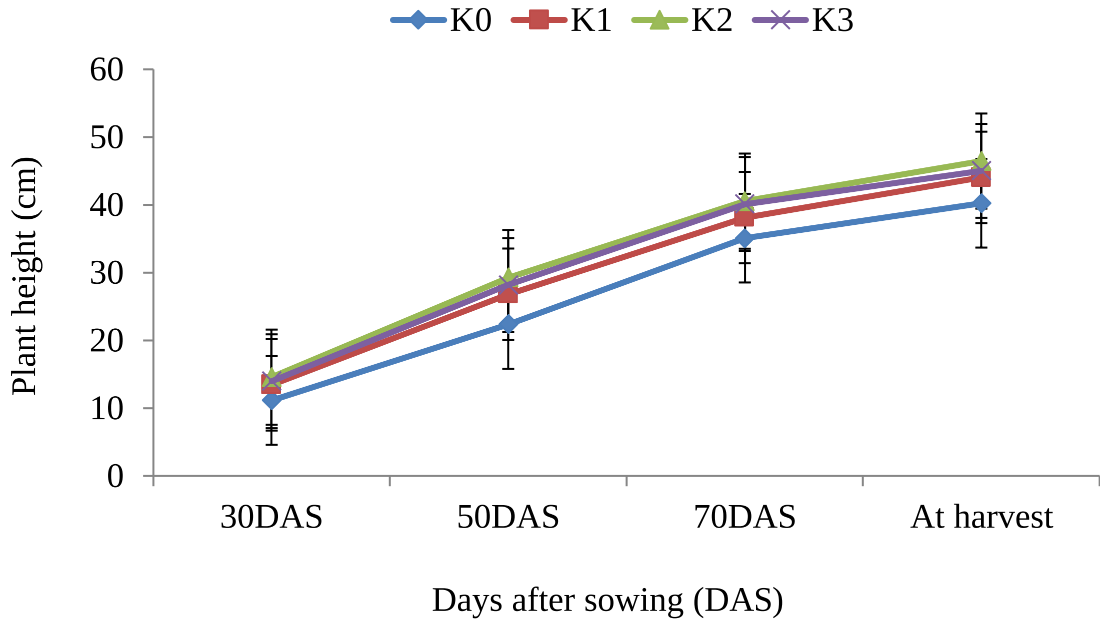

Fig. 3. Effect of potassium on plant height at different days after sowing (DAS).

Where, K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

Table 2. Combined effect of potassium and mulching on plant height (cm) at different days after sowing (DAS) of carrot.

Treatment combination	Plant height(cm)			
	30DAS	50DAS	70DAS	At harvest
M_0 K_0	11.04g	18.60j	32.24g	36.78g
M_0 K_1	13.21def	24.40gh	35.10f	39.30f
M_0 K_2	12.63f	25.27fg	36.67cde	42.70de
M_0 K_3	12.53f	24.37gh	37.04cde	41.31ef
M_1 K_0	11.54g	22.37i	35.00f	39.54f
M_1 K_1	12.78ef	24.76g	36.40ef	42.33de
M_1 K_2	18.14a	36.63a	48.72a	54.33a
M_1 K_3	13.54cde	25.95fg	38.64cd	43.37cde
M_2 K_0	10.77g	23.08hi	35.63ef	42.53de
M_2 K_1	13.67cd	25.92fg	36.74cde	45.33c
M_2 K_2	13.78cd	28.58d	38.74c	44.50cd
M_2 K_3	16.143b	34.29b	46.26b	51.23b
M_3 K_0	11.21g	25.39fg	37.48cde	42.10de
M_3 K_1	14.12c	32.15c	44.23b	49.26b
M_3 K_2	13.78cd	26.65ef	36.48def	44.31cd
M_3 K_3	13.68cd	28.04de	38.64cd	44.16cd
$LSD_{(0.05)}$	0.78	1.61	2.22	2.45
CV%	8.25	7.82	6.93	6.23

In a column means similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw and K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

At 70 DAS, the M_1K_2 treatment combination (Water hyacinth and 85kg K/ha) generated the maximum plant height of carrot (48.72cm), whereas the M_0K_0 treatment combination (control) produced the minimum plant height of carrot (32.24cm). At harvest, the M_1K_2 treatment combination (Water hyacinth and 85 kg K/ha) gave the highest plant height (54.33cm), whereas the M_0K_0 (control) treatment combination produced carrot plants with the lowest plant height (36.7cm) (Table 2 & Appendix XIV).

4.1.2 Number of Leaves

Different types of mulch materials caused a noticeable difference in the quantity of carrot plants' leaves at 30, 50, 70 DAS, and harvest (Figure 4). At 30, 50, 70 DAS, and at harvest, M_1 (Water hyacinth) treatment produced the highest number of leaves per plant (5.98, 8.97, 11.99 and 13.97), which was significantly different from M_2 (saw dust), M_3 (Straw) and M_0 (No Mulch) treatment was shown to result in the fewest leaves per plant (4.46, 7.12, 9.69, and 11.98) at the same days of observation (Appendix VI). According to Hasan *et al.* (2018), the Water hyacinth mulch treatment was the most effective among the different mulch treatments in terms of maximum number of leaves per plant.

A significant difference was observed on number of leaves due to application of different levels of potassium (Figure 5). The maximum number of leaves per plant (5.89, 9.38, 12.17, and 14.92) was observed in K_2 (85 kg k/ha) treatment at 30, 50, 70 DAS, and at harvest, respectively. For the same DAS, K_0 (control) treatment produced the lowest leaf numbers (4.53, 7.11, 9.31, and 11.42 respectively) (Fig 5 & Appendix VII).

Due to application of 85 kg potassium per hectare improved growth conditions by supplying sufficient plant nutrients, which led to the maximum number of leaves per plant and control treatment gave the minimum leaves per plant. It can be inferred from the findings of the current study. 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 plant growth, number of leaves etc.

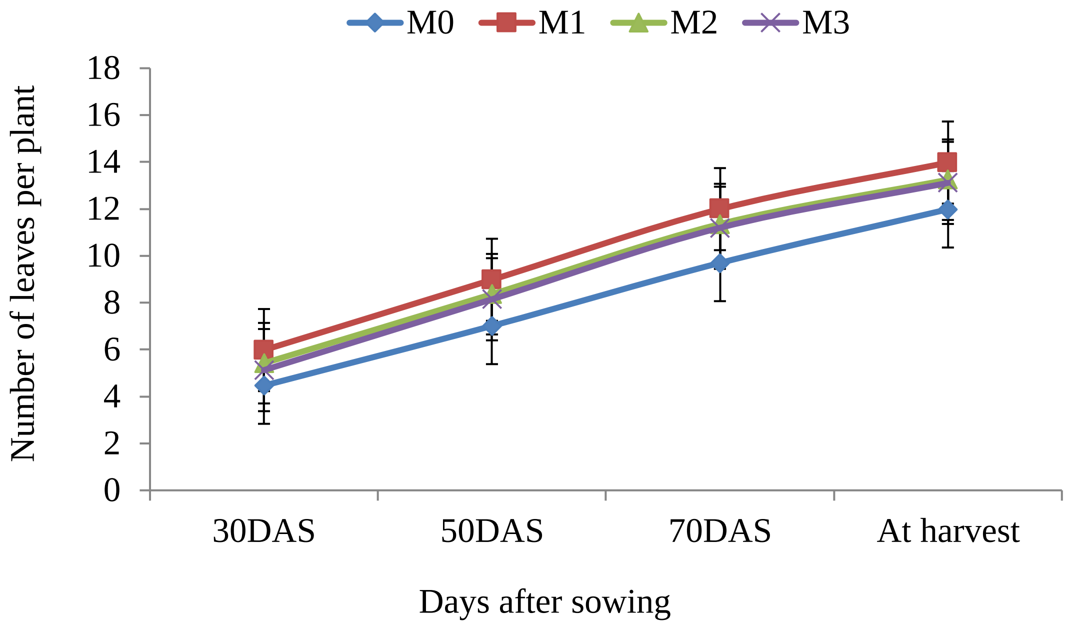

Fig. 4. Effect of mulching on number of leaves per plant at different days after sowing (DAS).

Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw.

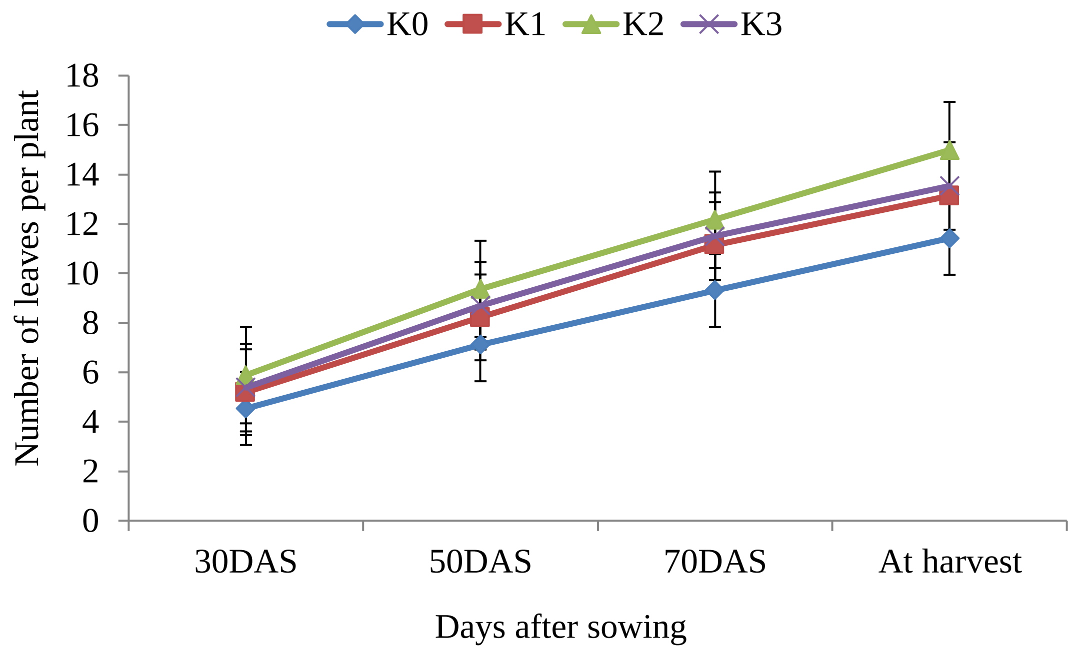

Fig. 5. Effect of potassium on number of leaves per plant at different days after sowing (DAS).

Where, K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

Table 3. Combined effect of mulching and potassium on number of leaves per plant at different days after sowing (DAS) of carrot.

Treatment combination	Number of leaves per plant			
	30DAS	50DAS	70DAS	At harvest
M_0 K_0	4.08f	6.53i	8.39i	10.41g
M_0 K_1	4.34ef	7.19ghi	10.25fg	12.49ef
M_0 K_2	4.64def	7.33fghi	9.76gh	12.10f
M_0 K_3	4.79def	6.99hi	10.36fg	12.93def
M_1 K_0	4.60def	7.13hi	9.40h	10.92g
M_1 K_1	5.36cd	8.13def	10.91ef	12.23f
M_1 K_2	8.52a	12.61a	15.43a	17.87a
M_1 K_3	5.43cd	8.03defg	11.42de	13.68d
M_2 K_0	4.66def	7.60efgh	9.55gh	12.20f
M_2 K_1	5.30cd	8.33de	11.83d	13.76d
M_2 K_2	4.99de	8.65d	11.83d	12.45ef
M_2 K_3	7.52b	11.27b	14.19b	16.16b
M_3 K_0	4.80def	7.20ghi	9.89gh	12.16f
M_3 K_1	6.17c	10.03c	13.19c	14.87c
M_3 K_2	5.36cd	8.90d	11.66de	13.53de
M_3 K_3	4.97def	8.46de	11.62de	13.76d
$LSD_{(0.05)}$	0.91	0.90	0.83	1.11
CV%	10.14	6.35	7.65	8.17

In a column means similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw and K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

Due to the application, the combined effects of various types of mulching and different levels of potassium showed significant variation on the number of leaves per plant of carrot at 30, 50, 70 DAS, and at harvest (Table 3). The maximum number of leaves was recorded from the treatment combination of M1K2 at 30, 50, 70 DAS, and at harvest which were 8.52, 12.61, 15.42, and

13.68 respectively, whereas the M_0K_0 treatment combination (no potassium + no mulch) recorded 4.08, 6.53, 8.39, 10.41 respectively (Table 3 and Appendix XIV).

4.2 AFTER HARVEST

4.2.1 Fresh weight of leaves per plant

Different types of mulching showed significant difference on fresh weight of leaves per plant (Figure 6 and Appendix IX). The highest fresh leaves weight per plant (89.47 g) was counted from M_1 (water hyacinth mulch) whereas the M_0 (control) treatment produced the lowest fresh leaf weight per. On the other hand, the lowest weight (77.14 g) of leaves per plant was provided by M_0 (c0ntrol treatment). According to Bhowmik *et al.* (2019), similar trends of result were found with their study.

Significantly increased by different levels of potassium on the fresh weight of the leaves per plant greatly varied (Figure 7 and Appendix VIII). Due to K_2 (85 kg K/ha) treatment, the highest fresh leaves weight per plant was measured to be 88.85 g which was the nearest value of K_3 (83.35 g). The control treatment, however, revealed the plant's minimal fresh leaves weight (76.32 g). K_2 (85 kg K/ha) was more availability compare to other potassium levels which leads to increase the weight of leaves of carrot .The present result supported to the findings of El-Tohamy *et al.* (2011).

Significantly difference was found due to the combined effect of various types of mulch materials and different levels of potassium (Table 4 and Appendix XV). M_1K_2 treatment (Water hyacinth and 85 kg K/ha) combination showed the maximum fresh leaves weight per plant (99.39g). The M_0K_0 (control) treatment combination showed the minimum fresh leaves weight (73.24 g) per plant.

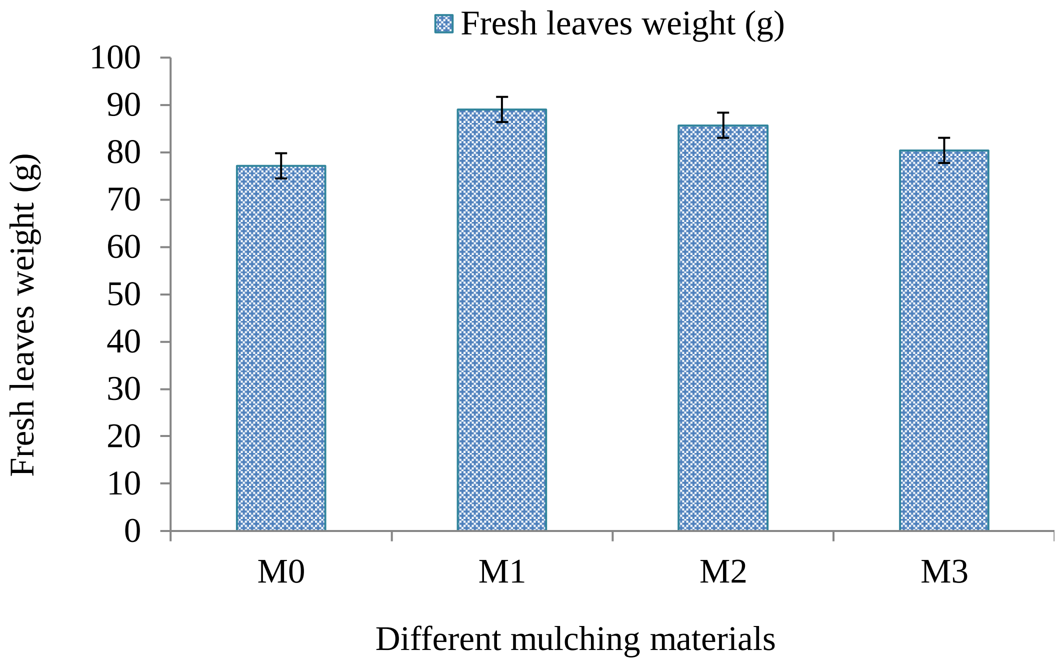

Fig. 6. Effect of mulching on fresh leaves weight (g) after harvest.

Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw.

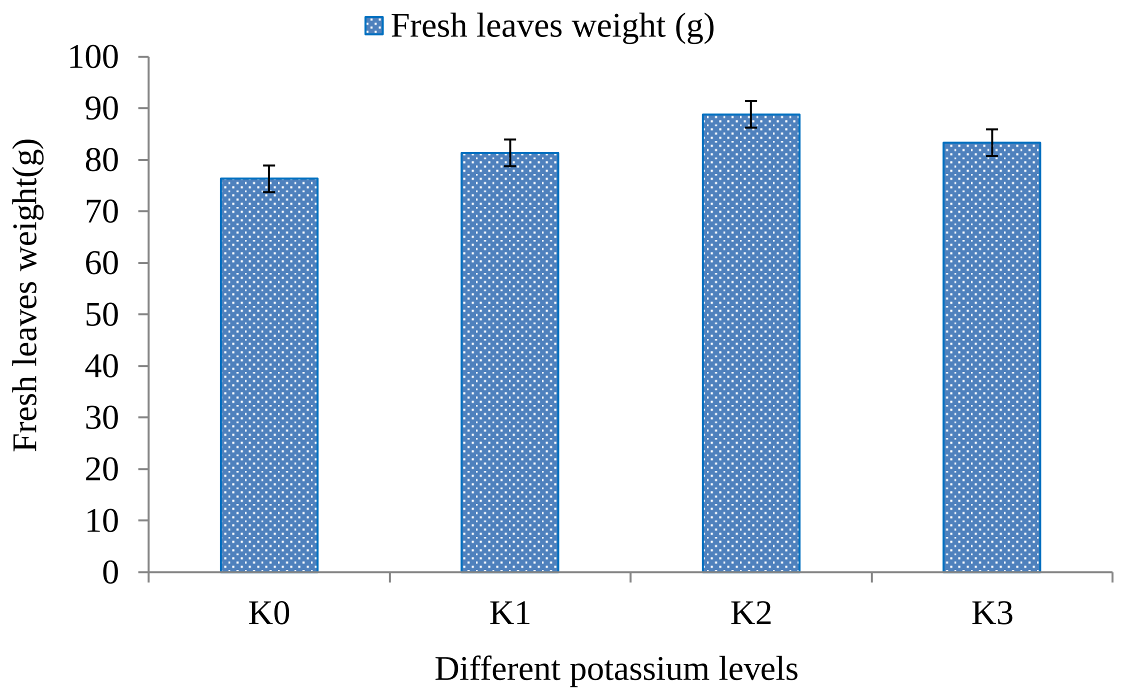

Fig. 7. Effect of potassium on fresh leaves weight (g) after harvest.

Where, K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

4.2.2 Root weight per plant

The root weight per plant of carrots varied significantly across different types of mulches (Fig 8). The water hyacinth treatment, M_1, had the maximum root weight per plant (164.41 g), which was statistically different from the other treatments. The control treatment had the minimum root weight per plant (125.79 g), according to the data (Fig 8 & Appendix IX). The availability of moisture and plant nutrients to the plant, which aided in fast cell division and cell elongation and eventually led to the creation of thicker carrot roots, may have contributed to the increase in root weight following the application of various mulching treatments. According to Rani *et al.* (2016), the water hyacinth mulch treatment produced the best results for maximum plant height.

The usage of various potassium levels resulted in a considerable difference in root weight per plant. The K_2 treatment (85 kg k/ha) had the highest root weight per plant, which was (158.01 g) and was statistically different from other treatments. Despite the fact that control plots gave the lowest root weight (130.38 g) (Fig 9 & Appendix VIII). Sharangi and Paria (1996) observed the same kind of result. Potassium application produced the heavier roots. Abou El-Nasr *et al.* (2011) recorded that root weight increased with potassium fertilizer.

Significant variation on root weight per plant was identified due to the combination of mulch materials and different levels of potassium. However, the combination of M_1K_2 (Water hyacinth and 85 kg k/ha) produced the largest combination of M_1K_2 (Water hyacinth and 85 kg k/ha) produced the largest root weight per plant (145.33 g), which was statistically distinct from other treatments. The control treatment M_0K_0 (No mulch + no potassium) gave the lowest root weight per plant (117.07g) (Table 4 and Appendix XV).

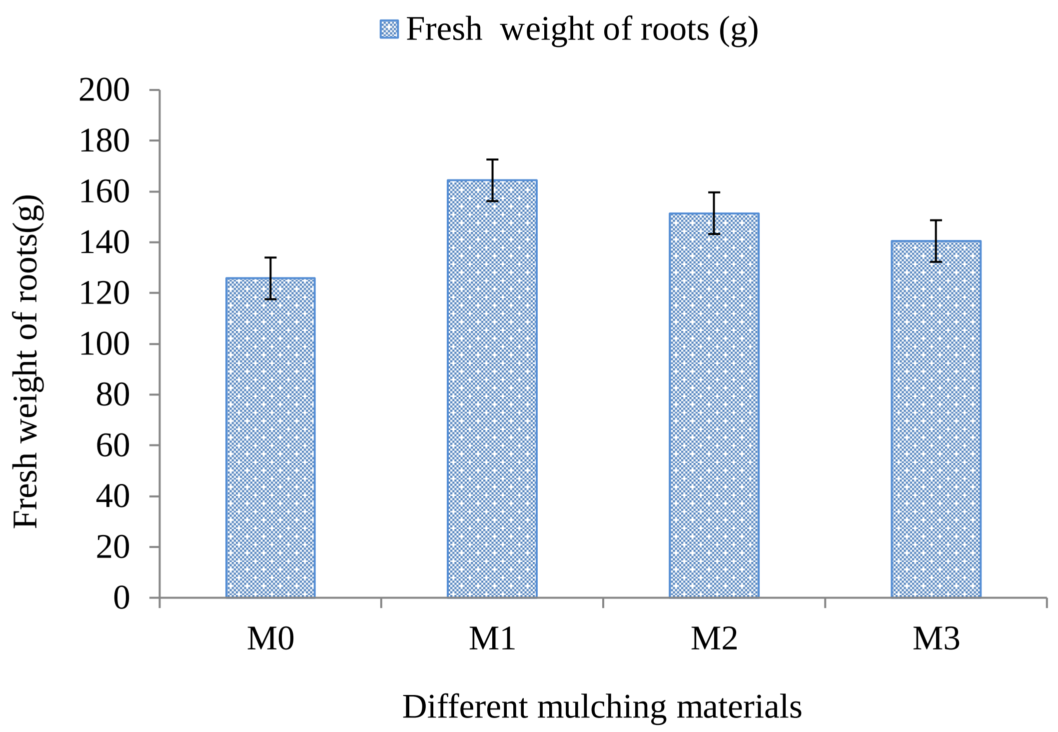

Fig. 8. Effect of mulching on fresh weight of roots (g) after harvest.

Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw

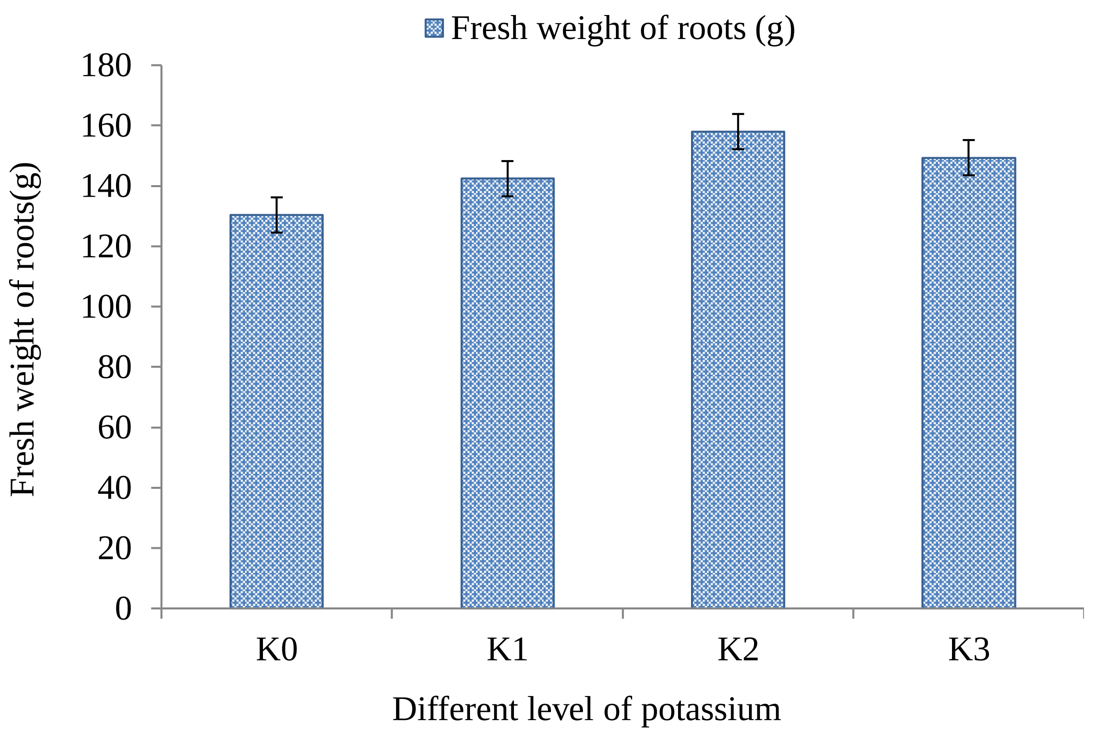

Fig. 9. Effect of potassium on fresh weight of roots (g) after harvest.

Where, K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

4.2.3 Root length

Application of different types of mulching on root length revealed a significant variation. In comparison to the M_0 and M_1 (Control and water hyacinth) treatment, the control treatment had the shortest roots (11.66 cm) and the longest roots (15.85 cm) was found in the treatment (Fig 10 & Appendix IX). Water hyacinth mulching provided the maximum root length by improving the nutrient-rich conditions in the soil and supplying the nutrients to the plants for optimal growth and development. Kayum *et al*.(2008), they were concluded from their study that water hyacinth and straw mulches have potentiality to increase the yield of tomato under Bangladesh content, which involves minimum cost of production.

The effect of various levels of potassium showed significant difference on root length and the control treatment gave the shortest roots length (cm). The K_2 (85 kg k/ha) treatment had the longest root length (16.01 cm) (Fig 11 & Appendix VIII). Potassium helps to prolong the maximum root length by enhancing the soil's favorable conditions and giving the nutrients needed by plants for better growth and development. According to Bonetti *et al.* (2017) were observed that the yield increased linearly with potassium adding, and 448 kg ha^{-1} K_{2O} showed the highest yield, and high correlation with increasing root length. Selvi *et al.* (2005) stated that root length was increased due to basipodial movement of potassium in the carrot roots which produced to enhance the longest root.

The combined effect of mulch materials and potassium revealed a considerable difference in the carrot's root length. The treatment combination M_1K_2 (Water hyacinth + 85 kg k/ha) produced the longest root (22.97 cm) and the shortest roots length (10.61 cm) obtained from the treatment combination M_0K_0 (Table 4 and appendix XV).

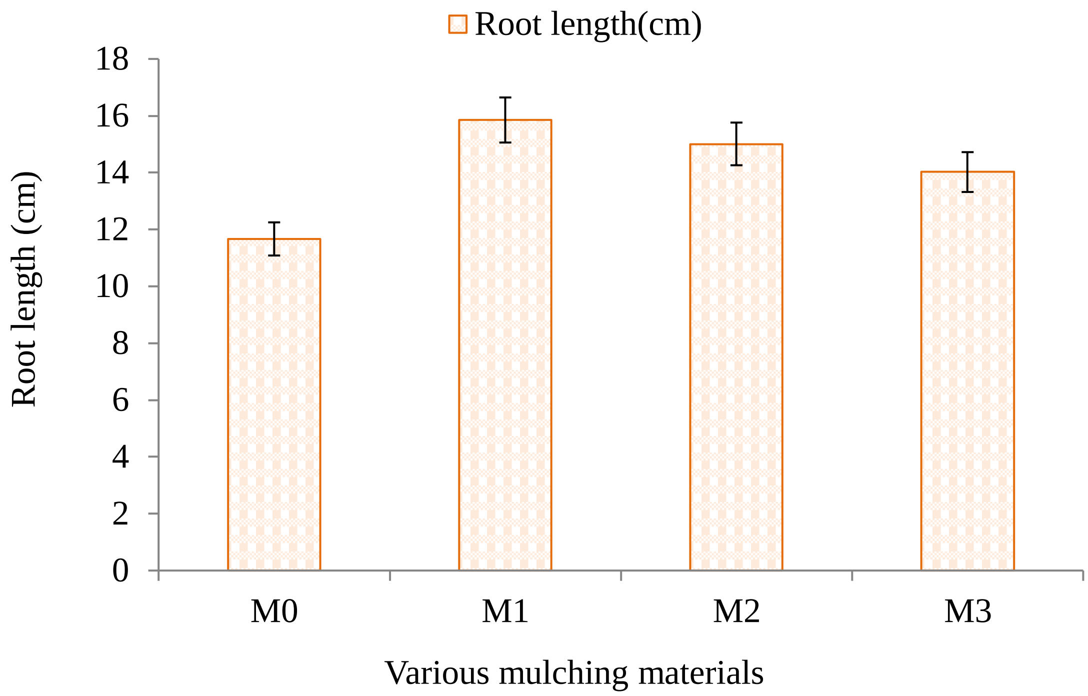

Fig. 10. Effect of mulching on root length (cm) after harvest.

Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw.

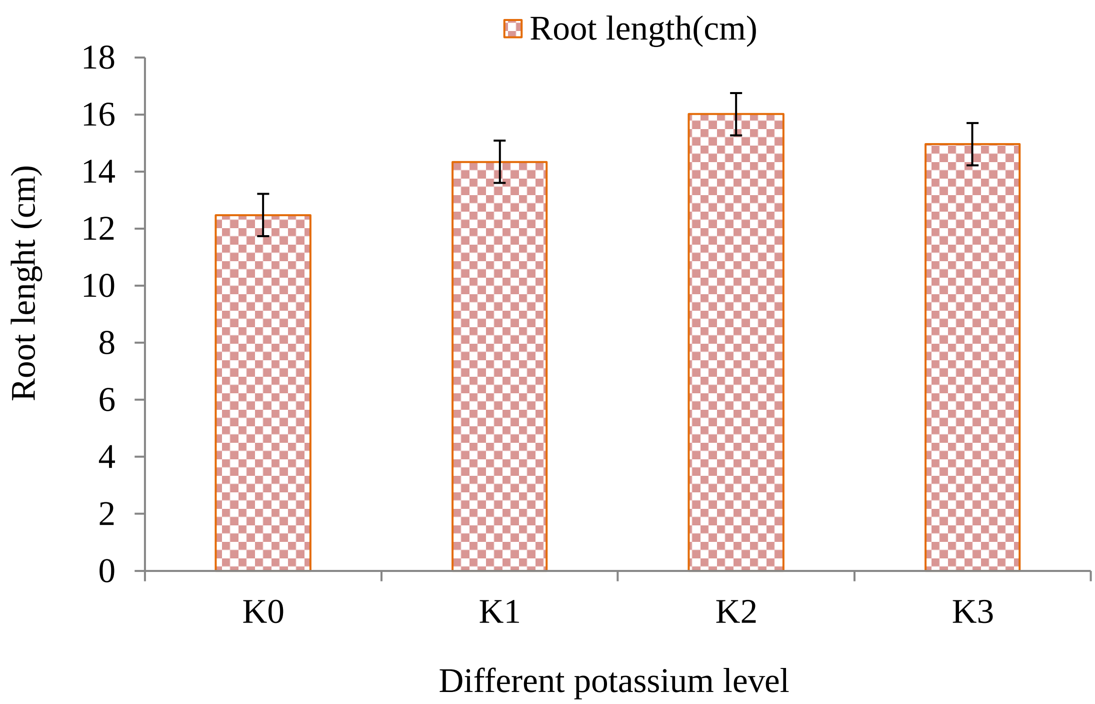

Fig. 11. Effect of potassium on root length (cm) after harvest.

Where, K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

Table 4. Combined effect of mulching and potassium on fresh weight of leaves (g), fresh weight of roots (g) and root length (cm) of carrot.

Treatment combination	Fresh weight of leaves(g)	Fresh weight of roots(g)	Root length(cm)
M_0 K_0	73.24f	117.07m	10.61g
M_0 K_1	81.23de	125.4l	14.77def
M_0 K_2	82.32cd	129.32k	13.87ef
M_0 K_3	83.77cd	131.34k	13.36f
M_1 K_0	77.12ef	135.58j	14.09def
M_1 K_1	85.45cd	165.33e	15.40def
M_1 K_2	99.39a	185.80a	22.97a
M_1 K_3	86.23c	170.93d	15.54def
M_2 K_0	77.39ef	131.33k	14.08def
M_2 K_1	82.56cd	161.42f	16.04cde
M_2 K_2	83.24cd	155.41g	16.44bcd
M_2 K_3	95.64ab	181.70b	18.94b
M_3 K_0	77.55ef	137.53j	15.32def
M_3 K_1	92.24b	177.40c	18.12bc
M_3 K_2	86.45c	141.52i	16.62bcd
M_3 K_3	85.34cd	145.50h	15.50def
LSD $_{(0.05)}$	4.43	2.97	2.56
CV %	6.49	6.93	7.72

In a column means similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw and K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

4.2.4 Root diameter

Root diameter varied significantly due to the effect of various mulch materials (Table 5 and Appendix IX). The M_1 (water hyacinth) treatment gave that the carrot root's maximum diameter (5.02 cm) and the minimum (1.77 cm) diameter was obtained from the M_0 (control). Mulching aids in maintaining temperature, nutrients, and moisture. The length of the root is aided by this region. The weight and diameter of the roots rose as photosynthesis increased. According to Rani *et al.* (2016), the water hyacinth mulch treatment produced the maximum diameter of roots.

Different potassium levels dramatically impacted the carrot's root diameter (Table 5 and Appendix VIII). The K_2 (85 kg K/ha) treatment generated roots with the maximum diameter of 6.80 cm, while the K0 (control) treatment produced roots with a minimum diameter of 2.15 cm. 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.

The combined effects of various potassium levels and mulch materials caused a considerable variation in the root diameter of carrots (Table 6 and Appendix XV). The treatment combination of M_1K_2 (Water hyacinth and 85 kg K/ha) produced the largest carrot root diameter (5.80 cm), whereas the control (M_0K_0) treatment combination produced the smallest carrot root diameter (1.86 cm).

4.2.5 Dry matter of leaves

The dry matter of leaves per plant was significantly influenced by the different mulching (Table 5 and Appendix X). While M_1 (water hyacinth) treatment condition had the highest dry matter of leaves (14.88 %), M_0 (no mulching) treatment gave the lowest dry matter of leaves (10.90 %). V.P. Indulekha and C. George and Thomas (2018) were observed that water hyacinth had positive effects on most morphological and physiological parameters like plant height, number of leaves, leaf area index, leaf area ratio, and dry matter production of turmeric.

There was a significant variation of dry matter (%) of leaves due to the effect of different levels of potassium (Table 5 and Appendix XI). Treatment K_2 (85 kg K/ha) was performed the highest (14.03%) dry matter of leaves, whereas the K_0 (control) treatment condition gave the lowest dry matter of leaves (10.10 %). Krarup *et al.* (1984) and El-Tohamy *et al.* (2011)reported that they are also found similar trends of result.

Combined effect of different types of mulch materials and different levels of potassium significantly influenced on dry matter (%) of leaves. However, the treatment combination of M_1K_2 (Water hyacinth and 85 kg K/ha) performed the highest dry matter of leaves (17.76 %), whereas M_0K_0 (control) produced the lowest (6.98 %) (Table 6 and Appendix XVI).

4.2.6 Dry matter of roots

Due to the effect of various types of mulch materials significant variation on dry matter of roots (%) (Table 5 and Appendix X). In contrast to all other treatments, the treatment M_1 (Water hyacinth) had the greatest dry matter of root (17.49 %). However, it was revealed that the treatment M_0 had the lowest dry matter of roots (1418 %) control. Islam and Noor (1982) were investigated that water hyacinth was great impact on garlic dry matter production.

The percentage of carrot root dry matter was significantly affected by the application of various levels of potassium (Fig 5 and Appendix XI). The K_2 (85 kg K/ha) treatment produced the highest dry matter of carrot roots (17.05 %), whereas the K_0 (control) treatment produced the lowest dry matter of carrot roots (10.13 %). Grigrov (1990) and Krarup *et al.* (1984) found similar trends of findings in their study. Application of potassium improved the digestion of numerous nutritional components. The dry matter of roots rose as nutrient absorption improved.

The combined effects of mulch materials and potassium had a substantial influence on variation on dry matter of roots (%) was found (Table 6 and Appendix XVI). The M_1K_2 treatment combination (water hyacinth and 85 kg K/ha) produced the maximum dry matter of root (22.97 %). The treatment combination M_0K_0 (control) had the minimum dry matter of roots (10.61 %), which was noticeably different from the other treatment combinations.

4.2.7 Cracking percentage of roots

A significant variation was observed on cracking percentage of roots due to the effect of different mulch materials. However, the maximum (11.39 %) cracked root percentage of root was obtained by control condition, whereas the minimum (3.01%) was recorded from M_1 (water hyacinth) (Table 5 and Appendix X).

The amount of root breaking was significantly impacted by potassium. The K_2 treatment provided the minimum cracking root percentage which was 4.01 percent. Whereas the maximum (18.00%) cracking root percentage was obtained by K_0 treatment (Table 5 and Appendix XI).

Due to the combined effects of various types of mulch materials and levels of potassium significantly influenced on cracked root percent. The treatment M_0K_0 combination of showed the maximum (18.88 %) cracked root. Other hand, the minimum (3.51%) was obtained from the treatment combination of M_1K_2 (water hyacinth and 85 kg k/ha) (Table 6 & Appendix XVI).

Table 5. Effect of mulching and potassium on root diameter (cm), dry matter of leaves (%), dry matter of roots (%), after harvest cracked root (%) and branched root (%) of carrot.

Treatment	Root diameter(cm)	Dry matter of leaves (%)	Dry matter of roots (%)	Cracked root (%)	Branched root (%)
Effect of mulch materials					
M0	1.77d	10.90d	14.18d	11.39a	26.22a
M1	5.02a	14.88a	17.49a	3.01d	1.02d
M2	4.01b	13.04c	15.77c	8.051c	10.24c
M3	3.0c	13.61b	16.16b	9.95b	12.08b
LSD (0.05)	0.23	0.382	1.0613	1.654	1.875
Effect of potassium					
K0	2.15d	10.10d	10.13d	18.00a	28.40a
K1	4.92c	12.34c	12.79c	16.18b	22.05b
K2	6.80a	14.03a	17.05a	4.01d	1.98a
K3	5.10a	13.02b	13.89b	15.02c	12.3c
LSD (0.05)	1.03	0.892	1.692	1.053	2.72
CV (%)	8.82	8.74	9.76	6.49	5.52

In a column means similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw and K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

4.2.8 Percentage of branched roots

Application of various mulch materials showed significant variations on percent of branched root (Table 5 and Appendix X). The highest percentage of carrot roots with branches (26.22 %) was seen in the M_0 (no mulching) treatment, while the lowest percentage (1.02 %) was seen in the M_1 (water hyacinth) treatment.

Different potassium levels had a major impact on how many branching roots carrot plants produced (Table 5 and Appendix XI). The K_0 (control) treatment had the largest proportion of branching roots (28.40 %), whereas the K_2 (85 kg K/ha) treatment had the lowest percentage (1.98 %). Hossain *et al.* (2005) showed the same findings in his field trial. The increasing trend of branched root of carrot with the decreasing of potassium levels. Potassium supports healthy root growth and development. Low nutrition levels cause plants to grow abnormally large and shaped.

Combined effects of various types of mulch materials and levels of potassium significantly influenced on branched root percent. The treatment M_0K_0 combination of showed the maximum (27.31 %) branched root percent. Other hand, the minimum (1.95 %) was obtained from the treatment combination of M_1K_2 (water hyacinth and 85 kg k/ha) (Table 6 and Appendix XVI).

Table 6. Combined effect of mulching and potassium on root diameter (cm), dry matter of leaves (%), dry matter of roots (%), branched roots (%) and cracked roots (%) after analysis.

Treatment combination	Root diameter (cm)	Dry matter of leaves (%)	Dry matter of roots (%)	Branched root (%)	Cracked root (%)
M_0 K_0	1.96h	6.98f	10.61g	27.31a	18.88a
M_0 K_1	3.53efg	10.07e	14.77def	23.60c	16.16c
M_0 K_2	3.50cdef	10.40e	13.87ef	21.45d	8.33f
M_0 K_3	3.61def	10.95de	13.36f	18.74e	10.20e
M_1 K_0	2.62gh	10.08e	14.09def	25.06b	18.74a
M_1 K_1	3.50def	11.59cde	15.40def	12.78g	11.15e
M_1 K_2	5.91a	17.76a	22.97a	1.95l	3.51h
M_1 K_3	3.71cdef	13.06bc	15.54def	11.76gh	12.76d
M_2 K_0	3.86cde	10.09e	14.08def	17.66e	16.67bc
M_2 K_1	4.07cd	12.28cd	16.04cde	10.13i	11.24e
M_2 K_2	3.66def	12.57cd	16.44bcd	12.77g	13.37d
M_2 K_3	4.96b	14.60b	18.94b	6.27k	6.73g
M_3 K_0	3.01fg	10.08e	15.32def	23.08c	17.70ab
M_3 K_1	4.18c	13.08bc	18.12bc	8.37j	7.68fg
M_3 K_2	3.31efg	12.63cd	16.62bcd	14.28f	8.30f
M_3 K_3	3.43def	12.12cd	15.50def	11.11hi	11.27e
$LSD_{(0.05)}$	0.713	1.72	2.56	1.41	1.30
CV%	8.82	8.74	9.79	5.52	6.49

In a column means similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw and K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

4.2.9 Total yield per plot

Different mulch materials' effects on the gross production of roots per plot led to statistically significant variance being discovered (Table 7 and Appendix XII). Water hyacinth treatment M_1 had the highest gross output of roots per plot (3.51 kg), whereas M_0 (no mulching) had the lowest gross yield of roots per plot (2.49 kg). Kayum *et al.*(2008), they were concluded from their study that water hyacinth and straw mulches have potentiality to increase the yield of tomato under Bangladesh content, which involves minimum cost of production

The influence of varied amounts of potassium was showed to have a statistically significant impact on the total yield of roots per plot (Table 8 and Appendix XIII). The maximum gross yield of carrot roots per plot (3.47 kg) was achieved by the treatment K_2 (85 kg K/ha). However, the lowest gross yield of roots per plot (2.53 kg) was obtained by the K_0 (control) treatment. The growth, output, and root quality of carrots were all greatly enhanced by the administration of potassium. 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. When potassium levels and mulch materials were mixed, the resulting effects on the gross root production per plot were noticeably different.

. From the treatment combination M_1K_2 (Water hyacinth and 85 kg K/ha), the greatest gross yield of carrot root (5.03 kg) was discovered. However, the treatment combination M_1K_2 produced a minimum gross yield of root of 2.08 kg (control) (Table 9 and Appendix XVII)

4.2.10 Marketable yield per plot

Due to the effect of mulching, the marketable output of roots per plot was determined to be statistically significant (Table 7 and Appendix XII). The maximum yield of roots per plot (3.25 kg) came from the water hyacinth treatment M_1 and 2.24 kg was observed as the lowest yield of roots per plot from the M_0 (control) treatment. According to Hasan *et al.* (2018), they were found the highest result by using water hyacinth (mulch material) and noted on abstract highest marketable yield (27.89 t/ha) by using water hyacinth. Mulching effectively protects soil, which reduces soil moisture, insect damage, and greening disease while encouraging the growth of strong, marketable roots by protecting roots from injury.

The treatment of various quantities of potassium resulted in a considerable variation in the marketable yield of roots per plot (Table 8 and Appendix XIII). The K_2 (85 kg K/ha) treatment produced the maximum commercial yield of roots per plot (3.22 kg), whereas the K_0 (control) treatment produced the lowest marketable yield (2.26 kg). Bartaseviciene and Pekarskas (2007) concurred well with this result. The quality and output of carrots are significantly impacted by potassium application. They discovered that using potassium fertilizers in the right amounts enhanced carrot harvests fit for market.

Different types of mulch materials and different levels of potassium had a combined effect on marketable yield of roots per plot (Table 9 and Appendix XVII). The treatment combination M_1K_2 (Water hyacinth and 85 kg K/ha) produced the highest yield of roots per plot (4.60 kg), whereas the treatment combination M_0K_0 produced the lowest marketable yield of roots per plot (1.80 kg) (control).

Table 7. Effect of different types of mulching on yield of carrot.

Treatment combination	Total yield per plot (kg/plot)	Marketable yield per plot (kg/plot)	Total yield per hectare (t/ha)	Marketable yield per hectare (t/ha)
M0	2.49d	2.24d	25.62c	24.18d
M1	3.51a	3.25a	31.13a	31.07a
M2	3.29b	3.05b	31.10a	29.78b
M3	3.13c	2.88c	29.44b	28.86c
$LSD_{(0.05)}$	0.11	0.10	0.87	0.67
CV (%)	4.16	3.9	3.51	4.82

In a column means similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw.

Table 8. Effect of different doses of potassium on yield of carrot.

Treatment combination	Total yield per plot (kg/plot)	Marketable yield per plot (kg/plot)	Total yield per hectare (t/ha)	Marketable yield per hectare (t/ha)
K0	2.53d	2.26d	26.61c	25.11c
K1	3.15c	2.53c	29.10b	29.21b
K2	3.47a	3.22a	30.70a	30.04a
K3	3.27b	3.01b	30.57a	29.53ab
$LSD_{(0.05)}$	0.11	0.10	0.87	0.67
CV (%)	4.16	3.9	3.51	4.82

In a column means similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha

4.2.11 Total yield per hectare

The total yield of roots per hectare was greatly influenced by the use of different mulch materials (Table 7 and Appendix XII). The treatment M_1 (Water hyacinth) produced the highest total yield of roots per hectare (31.13 t), whereas the control treatment M_0 produced the lowest gross yield per hectare (25.62 t). The table also showed that M_1 and M_2 were statistically similar but yield was different. Similar findings were discovered in Haque *et al. (*2019)'s study.

The several potassium levels greatly affected the total output of roots per hectare (Table 8 and Appendix XIII). The K_2 (85 kg K/ha) treatment produced the highest gross root yield per hectare (30.70 t), whereas the K_0 (control) treatment produced the lowest gross root yield per hectare (26.61 t). The table also showed that K_2 and K_3 were statistically similar but yield was different. Kadar (2004), Bartaseviciene and Pekarskas (2007) concurred well with this result. Carrot quality and production are greatly impacted by potassium treatment. They discovered that a greater application of potassium fertilizers boosted the carrot crop's gross output.

With regard to the total output of carrots per hectare, the combined effects of various mulch materials and different levels of potassium revealed notable variations (Table 9 and Appendix XVII). From the treatment combination M_1K_2 (Water hyacinth and 85 kg K/ha) provided the maximum total yield of roots per hectare (36.03 t). The M_0K_0 (control) treatment combination gave the lowest total yield of carrot roots per hectare (23.61 t).

4.2.12 Marketable yield per hectare

Due to the use of various mulch materials, the statistical significance of the marketable yield of carrots per hectare was discovered (Table 7 and Appendix XII). The M_1 (Water hyacinth) treatment gave the best commercial yield of carrots per hectare (31.07 t), whereas the M_0 (no mulching) treatment gave the lowest marketable yield (24.18 t).

Marketable yield of roots varied significantly due to the application different levels of potassium (Table 8 and Appendix XIII). The K_2 (85 kg K/ha) treatment gave the highest marketable root production per hectare (30.04 t), while the K_0 (control) treatment produced the lowest yield (25.11 t). Anjaiah and Padmaja (2006) also found similar findings in their study. They reported that increasing level of potassium increase root yield and quality parameters.

When roots are adequately covered by mulch, soil moisture, insect damage, and greening disease are extremely little because the soil protects the roots from harm and encourages the growth of strong, marketable roots. Hasan *et al.* (2018), they were found the highest result by using water hyacinth (mulch material) and noted on abstract highest marketable yield (27.89 t/ha) by using water hyacinth.

The combined impact of various potassium levels and mulch materials on the commercial yield of carrot root per hectare led to a large difference being discovered (Table 9 and Appendix XVII).

Table 9. Combined effect of mulching and potassium on yield of carrot.

Treatment combination	Total yield per plot (kg/plot)	Marketable yield per plot (kg/plot)	Total yield per hectare (t/ha)	Marketable yield per hectare (t/ha)
M_0 K_0	2.08h	1.80i	23.61h	21.69k
M_0 K_1	2.61g	2.33h	26.12g	25.30ij
M_0 K_2	2.56g	2.36gh	26.42g	24.43j
M_0 K_3	2.70fg	2.46gh	26.35g	25.33ij
M_1 K_0	2.52g	2.36gh	27.06fg	26.23hi
M_1 K_1	3.20de	2.99de	30.46cd	31.63c
M_1 K_2	5.03a	4.60a	36.03a	35.60a
M_1 K_3	3.29cde	3.06d	30.86cd	30.83cd
M_2 K_0	2.65fg	2.33h	27.46fg	26.06hi
M_2 K_1	3.30cd	3.04d	31.53c	30.20de
M_2 K_2	3.23de	3.11d	31.08c	29.43ef
M_2 K_3	4.00b	3.72b	34.44ab	33.44b
M_3 K_0	2.86f	2.54g	28.30ef	26.46hi
M_3 K_1	3.50c	3.37c	33.52b	33.04b
M_3 K_2	3.07e	2.82ef	29.29de	27.40gh
M_3 K_3	3.11de	2.80f	30.64cd	28.53fg
$LSD_{(0.05)}$	0.19	0.22	1.74	1.34
CV (%)	4.16	3.9	3.51	4.82

In a column means similar letter (s) are statistically similar and those dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw and K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha.

The treatment combination M_1K_2 (Water hyacinth and 85 kg K/ha) produced the best marketable yield of carrots per hectare (35.60 t), whereas M_0K_0 produced the lowest marketable yield of carrots per hectare (21.69 t) (control).

4.3 Economic Analysis

Economic analysis is a key criterion for selecting the best agricultural community-acceptable remedies that were also economically viable. The cost of cultivation, gross and net returns, as well as the benefit cost ratio of the various treatment combinations examined in the current study are shown in (Table 10 and Appendix XVIII).

4.3.1 Cost of Cultivation

The most effective agricultural community-acceptable solutions that were also economically viable were chosen using economic analysis as a major factor. The cost of cultivation, gross and net returns, and benefit cost ratio of the several treatment combinations looked at in the current study are displayed in (Table 10 and Appendix XVIII).The maximum cost of cultivation was recorded from M_1K_3 (TK. 330754/-) and the minimum cost was recorded from M_0K_0 (TK. 252560/-) treatment.

4.3.2 Gross Return

Gross returns in the current inquiry varied from Tk. 433800 to Tk. 712000 for various treatment combinations. Out of all the treatment combinations examined, M_1K_2 (Water hyacinth and 85 kg K/ha) provided the greatest gross returns of Tk. 712000 while M_0K_0 (control) provided the lowest gross returns of Tk. 433800 (Table 10 and Appendix XVIII).

4.3.3 Net Return

The M_1K_2 treatment combination (Water hyacinth and 85 kg K/ha) produced the highest net returns per hectare of Tk.386346 in carrot cultivation when various mulching and potassium treatment combinations were studied, while the M_0K_0 (control) treatment combination produced the lowest net returns of Tk. 181240 (Table 10 and Appendix XVIII).

4.3.4 Benefit Cost Ratio (BCR)

From all the treatment combinations examined in this experiment, M_1K_2 (Water hyacinth and 85 kg K/ha) produced the greatest benefit-cost ratio of

2.18, while M_0K_0 (Control) produced the lowest benefit-cost ratio of 1.71 (Table 10 and Appendix XVIII).

Table 10. Economic analysis of carrot influenced by mulching and potassium.

Treatment combination	Cost of cultivation (Tk/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio(BCR)
M_0K_0	252560	433800	181240	1.71
M_0K_1	279567	506000	226433	1.80
M_0K_2	280870	488600	207730	1.73
M_0K_3	283075	506600	223525	1.78
M_1K_0	284876	524600	239724	1.84
M_1K_1	319587	632600	313013	1.97
M_1K_2	325654	712000	386346	2.18
M_1K_3	330754	616600	305846	1.98
M_2K_0	298870	521200	222330	1.74
M_2K_1	212067	604000	304933	2.01
M_2K_2	299860	588600	288740	1.96
M_2K_3	314543	668800	354257	2.12
M_3K_0	297754	529200	231446	1.77
M_3K_1	313080	660800	347720	2.11
M_3K_2	300765	548000	247235	1.82
M_3K_3	312244	570600	258356	1.83

Where, M_0=no mulching, M_1=Water hyacinth, M_2=saw dust, M_3=straw. K_0=no potassium, K_1=75 kg k/ha, K_2=85 kg k/ha, K_3=95 kg k/ha,

Total cost of production was done in details according to the procedure of Krishitattik Fasaler Utpadan O Unnayan (In Bengali), (2014) Khan *et al.*

Sale of marketable carrot price @ TK 20000/t.

CHAPTER V
SUMMARY AND CONCLUTION

5.1 SUMMARY

An experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of mulching and potassium on growth and yield of carrot during November, 2019 to February, 2020. The experiment comprised of two different factors like as (i) four mulch materials Viz. M_0 (no mulching), M_1 (water hyacinth), M_2 (saw dust), M_3 (straw) and (ii) four different potassium levels viz. K_0 (no potassium), K_1 (75 kg k/ha), K_2 (85 kg k/ha), K_3 (95 kg k/ha) respectively. There was significant variation was noted among the different mulching and potassium levels in respect of all characters studied.

Three replications of the two-factor experiment were used in the Randomized Complete Block Design (RCBD) setup. There were 16 various treatment combinations in all. Each block's treatments were distributed at random inside a unit plot that measured 1.5 m x 1.2 m. Plot to plot distance 50 cm and plant to plant distance 20 cm, row to row distance 25 cm. In addition to potassium, the experimental plot obtained fertilization at the rates of 10 t/ha cow dung, 200 kg TSP/ha, gypsum 100 kg/ha and half of MoP (as per treatment) was used as basal dose and rest of MoP (as per treatment) was used after 30 DAS. Urea 250 kg/ha was applied equal three splits according to experimental design. On November 2^{nd}, 2019, the seeds for the carrots were seeded. The crop was collected on February 5^{th}, 2020. From each plot, ten plants were randomly selected to gather information. Statistics were employed to evaluate the yield and production parameter data. Using the Duncan's Multiple Range Test (DMRT) test, the disparities were investigated.

All the variables were considerably modified by mulching. The highest plant height (45.89 cm) was achieved with M_1 (water hyacinth), and the lowest (12.35 cm) from treatment (M_0). M_1 produced the most leaves (13.97/plant), whereas the control treatment produced the fewest (4.46/plant). The highest fresh weight of leaves (89.04 g) and lowest percent dry matter of leaves (80.14 %) were found in M_1, and M_0, respectively. The longest root length (15.85 cm) was identified in M_1 (water hyacinth), while the shortest length (11.66 cm) was discovered in M_0.

The largest root diameter (5.02 cm) was discovered in M_1 (water hyacinth), and the smallest root diameter (1.77 cm) was discovered in M_0. The highest fresh weight of roots (164.41 g) and dry matter percent of roots (17.49 %) were obtained from M_1 (water hyacinth), while the lowest fresh weight and dry matter percent of roots per plant were discovered in treatment (125.79 g and 14.18 %, respectively) (M_0). The control condition (M_0) had the most root cracking (11.39 %), whereas M_1 (water hyacinth) had the lowest root cracking (3.01%).

The M_0 treatment showed the most branching root (26.22 %) while the M_1 treatment showed the lowest (1.02 %). The M_1 treatment (water hyacinth) produced the largest gross yield of roots (3.51 kg per plot, 31.13 t/ha), whereas the M_0 treatment produced the lowest (2.49 kg per plot, 25.62 t/ha). The M_1 treatment (water hyacinth) produced the highest marketable root yield (3.05 kg/plot, 31.07 t/ha), whereas the control treatment produced the lowest (2.24 kg/plot, 24.18 t/ha).

In case of potassium, at harvest or after 90 days planting, K_2 (85 kg k/ha) generated the plant with the highest height (46.46 cm) but growth rate was high between 30 DAS and 50 DAS, and also growth rate was high in 70 DAS. Every 20 days the plant height was increasing 18 cm and 12 cm. Last 20 days (70 DAS to at harvest) was very slow growth rate, only 6 cm height was obtain in last 20 days and lowest plant height K_0 (11.14 cm), the greatest number of leaves (14.99/plant) from K_2 and lowest number of leaves K_0 (14.53). The K_2 treatment provided the fresh weight of leaves per plant (88.85 g), whereas the control treatment produced the fewest (76.32 g) fresh leaves weight per plant. The highest dry matter percentage of leaves (14.03 %) was recorded from the

K_2 (85 kg k/ha) treatment, while the lowest (10.10 %) was identified from the K_0 control condition. Maximum root length (16.01 cm), root diameter (6.80 cm), fresh weight of roots (158.01 g/plant), dry matter root (17.05 %), gross yield (3.47 kg/plot) and marketable yield (3.22 kg/plot) per plots, gross yield (30.70 t/ha) and marketable yield (30.04 t/ha) of roots per hectare (85 kg k/ha) were measured from K_2 treatment, which was massively better than all other treatments, but the lowest cracking.

Potassium dramatically impacted the height of the plant, the number of leaves, the fresh weight of leaves per plant, the dry matter percentage of leaves, the length of the root, the diameter of the root, the fresh weight of the root, the dry matter percentage of the root, the gross yield of the root per plot, the marketable yield of the root per plot, the gross yield of the root per hectare, and the marketable yield of the root per hectare. All parameters were the greatest finding from K_2 (85 kg k/ha. The control treatment (K_0), which contained no potassium, had the greatest root fracture and branching root percentage.

Each of the other dates of observation, the plant height revealed a dramatic transformation as a result of the combined response of varying amounts of potassium and mulching. The maximum plant height (54.33 cm) was acquired by M_1K_2 (Water hyacinth and 85 kg k/ha), whereas the lowest height was recorded by the control condition (36.78 cm). The number of leaves per plant at various days after planting varied significantly as a result of the combined effects of various mulching and potassium. M_1K_2 showed the highest number of leaves per plant (17.87) whereas the control treatment combination showed the lowest number of leaves per plant (10.41).

The M_1K_2 condition (water hyacinth and 85 kg k/ha) produced the highest fresh weight of leaves per plant (99.39 g), whereas the lowest fresh weight (73.24 g) was achieved under the control condition. The highest reported dry matter percentage of leaves (17.76 %) came from M_1K_2 (water hyacinth and 85 kg k/ha), while the lowest (6.98 %) was detected in M_0K_0. Different quantities of mulching and potassium together had a massive effect on each plant's root length and root diameter. The application of 85 kg k/ha reported highest root length and diameter readings of 22.97cm and 5.91 cm, respectively, whereas the control treatment combination yielded minimum root length and diameter measurements of 10.61 cm and 1.96 cm.

Different levels of mulching and potassium had a noticeable impact on the fresh weight of the root and the dry matter percentage of the root. From M_1K_2, the maximum fresh weight of the root and the maximum dry matter proportion to root were determined to be 185.80 g and 22.97%, respectively. The control treatment combination produced a minimum fresh weight of 117.07 g and a dry matter percentage of 10.61%. (M_0K_0). Different amounts of mulching and potassium together had a noticeable impact on the percentage of cracked root and rotting root production. The control treatment combination resulted in the most cracked root (18.88%), whereas M_1K_2 (water hyacinth and 85 kg k/ha) produced the lowest broken root (3.51%).

However, M_0K_0 had the highest percentage of branching roots (27.31%), whereas M_1K_2 had the lowest percentage (1.95%). The maximum gross yield of carrot root was acquired from M_1K_2 (water hyacinth and 85 kg k/ha), while the lowest gross yield was noted from the control treatment combination (5.03 kg/plot, 2.08 kg/plot). Various levels of potassium and mulching also had a big impact on the marketable yield. The interaction of M_1K_2 and treatment resulted in the highest commercial yield (4.60 kg/plot), and lowest (1.80 kg/plot) from M_0K_0.

The highest gross yield of carrot root was acquired from M_1K_2 (water hyacinth and 85 kg k/ha), while the lowest gross yield was noted from the control treatment combination (36.03 t/ha, 23.61 t/ha). Varying quantities of potassium and phosphorus also had a big effect on the marketable yield. The interaction of M_1K_2 and treatment resulted in the highest commercial yield (35.60 t/ha) and the lowest resulted (21.69 t/ha).

5.2 CONCLUTION

On the basis of results of the present study, it may be concluded that yield of carrot is increased by the judicial application of mulching and potassium.

1. The result revealed that mulching material water hyacinth (M_1) was used for the highest yield of carrot.
2. The potassium level K_2 (85 kg k/ha) gave the highest yield.
3. Application of water hyacinth (M_1) mulch with potassium 85 kg k/ha (K_1) is one of the most effective management practice to improve soil productivity. Thus considering crop productivity, economic return and maintaining soil fertility, combined application of water hyacinth mulch with potassium (85 kg k/ha) may be recommended to farmers for profitable carrot production with affecting the soil health.
4. The combination M_1K_2 (Water hyacinth and 85 kg k/ha) (2.18) was resulted the highest benefit cost ratio.

Further trial of this research work in different location with another variety of carrot is needed to justify the result for common farmers.

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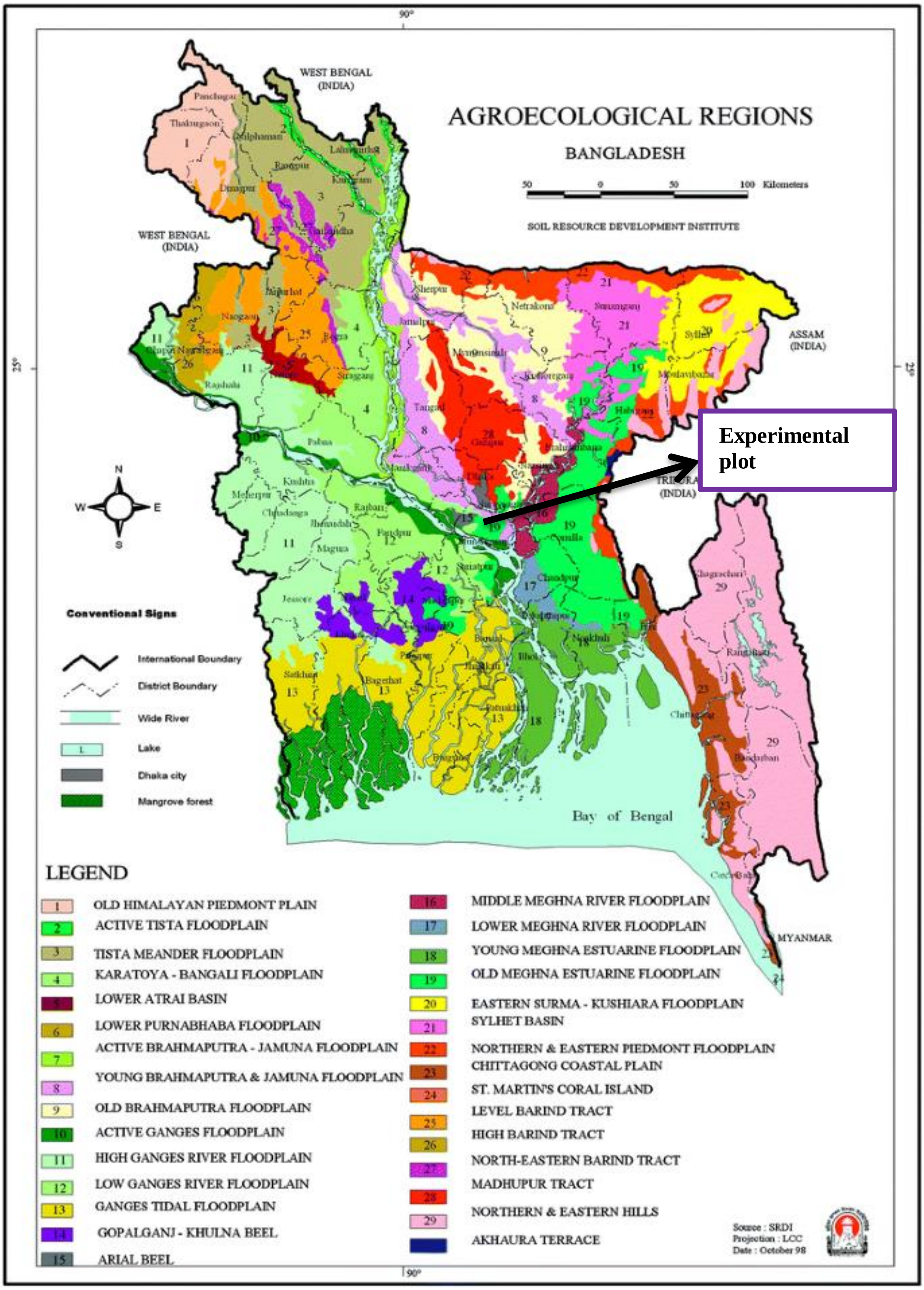
APPENDICES

Appendix I. Map showing the experimental site under the study.



Appendix II. Characteristics of Sher-e-Bangla Agricultural University soil was analyzed by Soil Research 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, 2019 to February, 2020 (site Dhaka).

Month	Air temperature (C)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum	Mean			
November 2019	29.85	18.50	24.17	70.12	00	235.2
December 2019	26.76	16.72	21.74	70.63	00	190.5
January 2020	24.05	13.82	18.93	62.04	00	197.6
February 2020	28.90	18.03	23.46	68.79	09	220.5

Appendix IV. Analysis of variance for plant height and leaf number at different days of Carrot.

Source of variance	Degrees of freedom	Mean Square of							
		Plant height (cm)				Number of leaves per plant			
		30DAS	50DAS	70DAS	At harvest	30DAS	50DAS	70DAS	At harvest
Replication	2	0.3060	29.676	15.8187	38.5939	0.21783	5.3878	2.2503	4.4005
Factor A (mulching)	3	5.9250ns	66.061**	52.2440**	84.5825**	4.87455ns	10.2300**	12.3402**	17.9407**
Factor B (potassium)	3	27.1244**	110.585**	68.7009**	84.8653**	4.20327ns	10.6669**	20.3789**	18.5616**
Combination (A×B)	9	6.7529ns	43.816*	55.3083**	43.7813**	3.75801ns	6.5324*	6.0154*	8.5861**
Error	30	0.2215	0.932	1.7606	2.1445	0.29398	0.2844	0.2421	0.4293

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ns =Non-significant.

Appendix V. Analysis of variance for fresh leaves weight, fresh roots weight, roots diameter, roots length of Carrot.

Source of variance	Degrees of freedom	Mean of square			
		Fresh leaves weight (g)	Fresh roots weight (g)	Root diameter (cm)	Root length (cm)
Replication	2	48.557	47.01	2.7031	0.7880
Factor A (mulching)	3	104.854**	339.561**	3.1812**	43.3373**
Factor B (potassium)	3	356.704**	200.921**	4.839**	26.4034**
Combination (A×B)	9	84.461**	576.76**	1.789*	5.8373*
Error	30	7.053	3.17	0.9273	0.2527

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ns =Non-significant.

Appendix VI. Analysis of variance for dry matter of leaves, dry matter of roots, branched root and cracked root percentage of carrot.

Source of variance	Degrees of freedom	Mean of square			
		Dry matter of leaves(g)	Dry matter of roots (g)	Branched roots %	Cracked root %
Replication	2	8.8312	3.0392	1.3060	0.7771
Factor A (mulching)	3	26.635**	38.8338**	307.169**	11.0953*
Factor B (potassium)	3	40.4242**	33.8888**	339.009**	227.729**
Combination (A×B)	9	7.8962*	15.6242**	55.8281**	34.094**
Error	30	1.578	3.5391	0.9921	0.8484

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ns =Non-significant

Appendix VII. Analysis of variance for total yield per plot, total yield per hectare, marketable yield per plot and marketable yield per hectare of Carrot.

Source of variance	Degrees of freedom	Mean of square			
		Total yield (plot/kg)	Total yield (t/ha)	Marketable yield (plot/kg)	Marketable yield (t/ha)
Replication	2	0.00023	0.7657	0.00384	0.819
Factor A (mulching)	3	2.30678**	84.3961**	2.31852**	107.953**
Factor B (potassium)	3	2.08593**	47.0834**	1.99672**	61.707**
Combination (A×B)	9	0.74185**	13.1457**	0.93230**	14.783**
Error	30	0.01246	1.0780	0.01676	0.644

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ns =Non-significant

Appendix VIII. Cost of production of carrot per hectare.
A. Input Cost.

Treatments	Cultivation with labour	Seed cost	Pesti-cides	Intercultural operation	Seed sowing cost	Mulching (price& labour cost)	Manures and Fertilizer					Harvesting cost	Sab Total of A
							Cow dung	TSP	Urea	MoP	Gypsum		
M0K0	35000	26000	8500	20600	8000	0	30000	15000	10000	0	9600	25000	187700
M0K1	35000	26000	8500	20600	8000	0	30000	15000	10000	15000	9600	25000	202700
M0K2	35000	26000	8500	20600	8000	0	30000	15000	10000	17200	9600	25000	204900
M0K3	35000	26000	8500	20600	8000	0	30000	15000	10000	19400	9600	25000	207100
M1K0	35000	26000	8500	20600	8000	28000	30000	15000	10000	0	9600	25000	215700
M1K1	35000	26000	8500	20600	8000	28000	30000	15000	10000	15000	9600	25000	230700
M1K2	35000	26000	8500	20600	8000	28000	30000	15000	10000	17200	9600	25000	232900
M1K3	35000	26000	8500	20600	8000	28000	30000	15000	10000	19400	9600	25000	235100
M2K0	35000	26000	8500	20600	8000	35000	30000	15000	10000	0	9600	25000	222700
M2K1	35000	26000	8500	20600	8000	35000	30000	15000	10000	15000	9600	25000	237700
M2K2	35000	26000	8500	20600	8000	35000	30000	15000	10000	17200	9600	25000	239900
M2K3	35000	26000	8500	26000	8000	35000	30000	15000	10000	19400	9600	25000	242100
M3K0	35000	26000	8500	20600	8000	31000	30000	15000	10000	0	9600	25000	218700
M3K1	35000	26000	8500	20600	8000	31000	30000	15000	10000	15000	9600	25000	235700
M3K3	35000	26000	8500	20600	8000	31000	30000	15000	10000	17200	9600	25000	235900
M3K3	35000	26000	8500	20600	8000	31000	30000	15000	10000	19400	9600	25000	238100

B. Overhead cost (TK/ha)

Treatments	Overhead cost (TK/ha) Cost of leased land for 6 months (8% value of land tk-1000000)	Miscellaneous cost(TK-5% of the input cost)	Interest on running capital for 6 months (8% of cost per year)	Sub Total (B)	Sub Total (A)	Total of cost of production (A+B)	Yield (t/ha)	Gross Return (TK/ha)	Net Return (TK/ha)	BCR
M0K0	50000	2844	12016	64860	187700	252560	21.69	433800	181240	1.71
M0K1	50000	3456	16216	76867	202700	279567	25.30	506000	226433	1.80
M0K2	50000	4536	16392	75970	204900	280870	24.43	488600	207730	1.73
M0K3	50000	4536	16568	75975	207100	283075	25.33	506600	223525	1.78
M1K0	50000	3456	17256	69176	215700	284876	26.23	524600	239724	1.84
M1K1	50000	6547	18456	88887	230700	319587	31.63	632600	313013	1.97
M1K2	50000	6548	18632	92754	232900	325654	35.60	712000	386346	2.18
M1K3	50000	5467	18808	95654	235100	330754	30.83	616600	305846	1.98
M2K0	50000	4567	17816	76170	222700	298870	26.06	521200	222330	1.74
M2K1	50000	6546	19016	44367	237700	282067	30.20	604000	304933	2.01
M2K2	50000	6754	19192	59960	239900	299860	29.43	588600	288740	1.96
M2K3	50000	5647	19368	72443	242100	314543	33.44	668800	354257	2.12
M3K0	50000	4352	17496	79054	218700	297754	26.46	529200	231446	1.77
M3K1	50000	4536	18856	77380	235700	313080	33.04	660800	347720	2.11
M3K2	50000	4357	18872	64865	235900	300765	27.40	548000	247235	1.82
M3K3	50000	4567	19048	741444	238100	312244	28.53	570600	258356	1.83

(a)

(b)

(c)

(d)

(e)

(f)

Plate 1: Pictorial presentation of experimental mulching and data collecting (a) after mulching field, (b) data collecting, (c) water hyacinth mulch, (d) saw dust, (e) straw, (f) no mulching.