GROWTH AND YIELD OF CARROT AS INFLUENCED BY MULCHING AND POTASSIUM

BY

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CERTIFICATE

This is to certify that the thesis entitled, **"GROWTH AND YIELD OF CARROT AS INFLUENCED BY MULCHING AND POTASSIUM" TOMATO** submitted to the Department of Horticulture and Postharvest Techonology, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M. S.) in HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by **FATIMA FERDOUSI** bearing Registration No. 00874 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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Dedicated To

My Beloved Parents

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ABSTRACT

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, during October 2006 to march 2007 to find out the effect of mulching and potassium on growth and yield of carrot. The experiment consisted of two factors. Factor A: Four levels of mulch viz. M_0: Control, M_1: Black polythene, M_2: Water hyacinth and M_3: Saw dust; Factor B: Four levels of potassium viz. K_0: Control, K_1: 180 kg K_2O/ ha, K_2: 200 kg K_2O/ ha and K_3: 220 kg K_2O/ ha. The experiment was laid out with randomized complete block design (RCBD) with three replications. In case of mulching, plant height and fresh weight of root is significant for growth stage. The highest (36.35 t/ha) marketable yield was obtained from M_1, while the minimum (31.57 t/ha) marketable yield was recorded from M_0. In case of potassium, plant height and dry matter content of roots is significant for growth stage, K_2 produced the highest (36.20 t/ha) marketable yield of carrot while control plots produced the lowest (30.05 t/ha). For combined effect, plant height, length of root, diameter of root and fresh weight of root is significant for growth stage and M_1K_2 produced the highest marketable yield (38.93 t/ha), while M_0K_0 gave the lowest (25.14 t/ha). So, black polythene mulch with application of 200 kg K_20/ha is suitable for better growth and yield of carrot.

ABBREVIATIONS

AEZ	=Agro- ecological Zone
BAU	=Bangladesh Agriculture University
BARC	=Bangladesh Agricultural Research Council
BARI	=Bangladesh Agricultural Research Institute
BCR	=Benefit Cost Ratio
BBS	=Bangladesh Bureau of Statistics
BRRI	=Bangladesh Rice Research Institute
CAP	= Controlled Atmospheric Packaging
cm	= Centimeter
DAP	= Days After Planting
DAS	=Days After Sowing
DM	=Dry Matter
DW	=Dry Weight
DMRT	=Duncane's Multiple Range Test
et al.	= and others
etc.	=Etcetera
FAO	=Food and Agricultural Organization of United Nations
FW	=Fresh Weight
g	= Gram
HRC	=Horticultural Research Centre
Kg	=Kilo gram(s)
LSD	=Least Significant Difference
m	=Meter
MP	=Muriate of Potash
P^H	=Hydrogen ion concentration
RCBD	= Randomized Complete Block Design
RH	= Relative Humidity
SAU	= Sher-e-Bangla Agricultural University
t/ha	=Ton per hectare
TSP	=Triple Super Phosphate
UK	=United Kingdom
Viz	= Namely

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Chapter I

Introduction

INTRODUCTION

Carrot (*Daucus carota* L.) is one of the most popular vegetable crops in the world, belongs to the genus *Daucus*, species *carota* and the member of Apiace family. It is considered to be a native of Mediterranean region (Pierce, 1987). It is well distributed throughout the temperate, tropical and subtropical parts of the world (Bose *et al.*1990) and extensively cultivated in Europe, Asia, North Africa and North and South America (Thompson and Kelly, 1957). Carrot grows successfully in Bangladesh during Rabi season and mid November to early December is the best time for its cultivation to get satisfactory yield as mentioned by Rashid (1993).

Vegetables are one of the most important components of human food which provides proteins, carbohydrates, fats, vitamins and minerals but vegetable production in Bangladesh is very low than its requirement. Carrot contains high amount of carotene (10 mg/100 g), thiamin (0.04 mg/100 g), riboflavin (0.05 mg/100 g) and also serves as a source of carbohydrate, protein, fat, minerals, vitamin - C and calories (Yawalker, 1985). The ratio of sucrose to reducing sugar increases with root maturity but decreases after harvest and during cold storage. Blindness in children for the serve vitamin-A deficiency is a problem of public health in some countries, particularly in the rice dependent countries of Asia (Woolfe, 1988). So, carrot (rich in vitamin-A) may contribute a lot of vitamin-A to overcome this situation in Bangladesh.

The popularity of carrot is increasing day by day in Bangladesh especially among the urban people because of its high nutritive value and possible diversified use in making different palatable foods. Carrot can be eaten either row or by making halua, a preparation of sweets in Bangladesh. Carrot root is also used as vegetable for preparing soups and curries and roots are used as salad. But large-scale production of carrot is yet to be started to meet up its demand. In Bangladesh, the production statistics of carrot is not available and even not included in the BBS report.

The area under carrot cultivation was 992 thousand hectares with total production of 21020 thousand metric tones in the world (FAO, 2002). Rashid (1999) mentioned an average yield of 25 tones per hectare of carrot. This production is relatively low compared to other carrot producing countries like Switzerland, Denmark, Sweden, UK, Australia and Israel, where the average yield per hectare y are reported to be 40.88, 42.67, 51.88, 54.88, 56.70 and 64.20 tones, respectively (FAO, 2002) .

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

In Bangladesh, carrot is grown in winter season when rainfall is sparse. Therefore, irrigation becomes essential for providing sufficient moisture to grow crop. But in the place where carrot is cultivated irrigation facilities are not easily available. Moreover, irrigation increases the cost of production. So, mulching could be an effective cultural practice alternative to irrigation to maintain the soil moisture status as well as to help better utilization of fertilizer (Rhee *et al.*, 1990) leading to increased carrot production in Bangladesh. Natural mulching is done by breaking the upper crust of soil for checking evaporation of soil moisture; and in artificial mulching, water hyacinth or saw dust or black polythene ensures economic utilization of existing soil moisture and regulates soil temperature (Devaux and Havercort, 1987; Jaiswal *et al.,* 1996) and can control the weeds effectively (Shrivastava *et al.*, 1994). It also enhances soil microbial activity (Harries, 1995).

Mulching saves labour cost in controlling plant diseases, insects and weeds (Zehender and H. Goldstein, 1989). As a consequence, mulching increases yield in many Horticultural crops like sweet potato, carrot, ginger and potato (Kim *et al.*, 1988; Choudhury *et a*l., 1993; Jaiswal *et al.*, 1996).

Carrot cultivation requires ample supply of plant nutrients. Use of potassium fertilizer is essential for its growth and root development. All root crops respond to liberal applications of potassium. Potassium helps in the root development and is essential for photosynthesis and for starch formation and its translocation from upword to downword. It is also necessary for quality of carrot (Dyachenko and Kurumli, 1978). Among the yield contributing factors, application of proper doses of potassium is of great importance (Sotomayor, 1975). However, excessive or under dose of potassium can effect the growth and yield of the crop. Only an optimum dose of potassium is necessary to produce maximum yield of good quality carrot. Muraite of potash (MP) is widely used as the source of potassium because of its maximum available form of potassium and cheaper than any potash fertilizer.

From the above stated facts, it is apparent that growing plants with mulching and potassium may bring some promising effects on the growth and yield of carrot. Therefore, the present study was undertaken with the following objectives:

i) to study the growth and yield of carrot as influenced by different mulch materials;

ii) to find out the optimum dose of potassium for maximizing the production of quality carrots;

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

Chapter II

Review of Literature

REVIEW OF LITERATURE

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

2.1 Effect of mulching on the growth and yield of carrot

Carrot is grown generally in Bangladesh during winter season of the year. It is self succulent and a herbaceous root crop. Moisture status of the soil is very important for growth and development of this crop. In this situation, moisture conversation through mulching might ensure sufficient moisture supply and thus carrot production will be highly influenced. However, important works with respect to mulching pertaining to the present study have been reviewed here.

Akand (2003) conducted an experiment at Horticulture Farm of Bangladesh Agricultural University, Mymensingh and stated that black polythene mulch had significant effect on growth and yield contributing characters. Black polythene mulch performed the highest (35.79 t/ha) yield compare to straw and water hyacinth mulch..

Resende *et al.* (2005) conducted an experiment on the effects of different mulches on the yield of carrots cv. Brasilia, in a field experiment in Sao Paulo, Brazil from September to December 1998. The mulching materials included wood dust, wood chips, dry grass (*Cynodon* spp.), rice straw and control (soil without cover). Mulching resulted in better plant development, mild soil temperature (3-5^0 C less compared to the control) and better soil moisture (2-3% higher than control). Mulching with dry grass and wood chips resulted in lower weed infestation. Mulching with dry grass, wood chips and wood dust increased carrot stand. Mulching with rice straw and wood increased carrot yield (112.6 and 99.6 t/ha, respectively).They reported that mulching was technically and economically viable for carrot cultivation, particularly in small areas and in organic farms.

Singh *et al.* (2004) conducted an experiment in India with sweet potato where the treatment were T_1 (no irrigation, no mulch); T_2 (one irrigation of 30 mm given at 30 DAP); T_3 (one irrigation of 30 mm given at 60 DAP) and T_4(mulching with rice straw) applied just after planting. The highest tuber yield (16.35 t/ha) was obtained with mulch (T_4) treatment, followed by T_2, T_1 and T_3.

Nakajima *et al.* (2003) applied mulch for leaf and root crop cultivation with high planting density. They used paper mulch combined with seed tape, which allows simultaneous mulch installation and seed sowing. When growing Komatsuna (*Brassica campestris*) and turnips using the trial paper mulch, the germination exceeded 90%. The germination rate for radishes and carrots exceeded 80%. In Komatsuna culture, growth and development were improved using this mulch. Moreover, the amount of time needed for weeding was shortened by about 10% using mulch culture compared to that without mulch culture.

Munir (2003) in an experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh mentioned that mulching had significant effect on most of the yield contributed parameters. Black polythene mulch was the most effective for successful carrot production (43.06 t/ha).

Woldetsadik (2003) reported that different types of mulching materials were influenced on shallot crop and some soil characteristics. Parameters of plant growth and yield were assessed in relation to applied treatments. The results showed that all mulching treatments improved shallot yields during the short season. During the main season, however, straw and clean plastic mulches favoured heavy weed infestation and reduced yields. Black plastic mulches increased yield upto three-fold without negative effects on the quality of bulbs.

Luik *et al.* (2002) worked in Estonia on the influence of intercropping and saw dust mulching on carrot yield and entomofunna. They observed that intercropping of carrot with garden beans (40 cm row spacing) and mulching with fresh saw dust significantly disoriented pests and decreased the damage of carrots by *Trioza viridula, Trizola cirin* and *Psila rosae*. Intercropping and saw dust separately did not significantly affect pests. Nineteen species of carabids were found in carrot beds.

Ramert *et al.* (2001) conducted a similar experiment in South Sweden, the impact of different agricultural measures (mulching and intercropping) on the species of composition in the carabids and staphylinides. They found that mulching generally increased the number of individuals belonging to the genus *Philonthus*.

Rahman (2000) conducted an experiment on carrot in Bangladesh Agricultural University, Mymensingh with mulching trial and stated that successful carrot production was possible by using mulches as an alternative to irrigation. He suggested for using water hyacinth mulch to minimiz root production and also economic production of carrot.

In India, Bose and Som (1999) showed that color development in carrot roots depend on cultivers, growing season and age of the root. It was reported that certain opaque mulches of vegetative origin, acting as thermal insulators could minimize the diurnal fluctuation of soil temperature considerably. The temperature for 24 hours cycle fluctuated from 20 to 40^0 C within 25 cm of bare soil, whereas it was around 22.27 for the soil mulched with coles. Among Saw dust and straw mulched plots maintained the lowest temperature (Denison *et al.*1953)

Crossman *et al.* (1998) conducted an experiment using plastic and grass as artificial mulching to study the performance of sweet potato var. Sunny. They found that mulching generally increased the yield of cultivar Sunny, with the plastic mulch producing the highest yield of medium sized roots, while grass mulch reduced sweet potato weevil infestation of storage roots.

Utilization of indigenous materials, i.e. rice straw, wheat straw, rice husk and charcoal as soil aerating materials to increase yield of storage root of carrot under field conditions in wet lowland was investigated by Islam *et al.* (1998). The materials were placed in soil ridges to make aerial spaces in the soil for better storage root development. The fresh and dry weight of storage roots were greatest in the rice husk charcoal mixture, rice husk mass, rice straw mass and rice husk mixture.

Jaiswal *et al.* (1997) conducted a mulching trial with carrot (cv. Early Nantes and New Kuroda) at different sites in Nepal. Early Nantes was shown to better than New Kuroda in terms of both root yield and quality. On average, Early Nantes out yielded 7.7% irrespective of mulching practices. Mulching in carrot was effective only at Bhoteodar where root yield was increased by 34.6% compared with no mulching.

Lee *et al.* (1997) observed that the best emergence (87%) was occurred by using transparent film and black flim mulches in taro (*Colocasia autiquorum*). Black film mulch also resulted in the tallest (164 cm) plants with the highest leaf stalk yield (41.65 t/ha) while cormel yield was promoted by transparent film treatment. It was said that transparent film was the best as mulching materials.

Jaiswal *et al.* (1996) conducted an experiment with mulching trial on carrot in Nepal. They found that the carrot cultivars New Kuroda and Early Nantes performed well during the off-season. The use of mulching in carrot was found to be useful at most locations in terms of conserving soil moisture and for preventing the crop from moisture stress although yield effects were not significant. Mulching reduced the burden of applying irrigation and increased the root yield by 8.7-24% at 5 sites.

Adetunji (1994) reported that mulching significantly enhanced vegetative growth and bulb yield of onion. Similarly mulching in carrots greatly increased the yields and size of carrot (Benoit and Ceustermans, 1975).

Jangil *et al.* (1994) carried out an experiment on sweet potato cv. Shinyulmi and Yulmi in the field with vinyl mulch on plastic tunnels or grown conventionally and found that mulch conserved soil moisture, increased plant height and leaf area index than unmulched condition.

Rasul *et al.* (1994) conducted an experiment at the Regional Agricultural Research Station, Jessore on the production of Mukhikachu with different types of mulching materials and reported that the mulches significantly improved plant growth and yield. Earliest emergence occurred with the large cormels mulched with wheat straw but overall plant growth and primary corm and cormel yields were higher with water hyacinth.

Shrivastava *et al.* (1994) reported that black plastic mulch reduced 95% weed infestation. From another study, transparent mulch was inferior owing to aboundant weed growth compared to black polythene, rice-husk and saw dust mulch (Amador and Vives, 1978)

From an experiment on sweet potato with mulching trial, Choudhury *et al.* (1993) stated that mulching significantly influenced the yield contributing characters of the crop. Better yield (43.03 t/ha) was obtained from mulched with 3 irrigation at 30 days interval however, the highest yield (46.90 t/ha) was obtained from one irrigation at 30 DAP followed by mulching. It is also noticed that mulching increased the carrot yield by more than 92% in USSR.

Ramert (1993) studied the effect of mulching with grass and bark and intercropping with *Medicago litoralis* against carrot fly (*Psila rosae* F.). Over a 3 year period, intercropping with *Medicago litoralis* and 2 mulching treatments (grass clippings or bark) were evaluated in carrot plots in 3 areas in Sweden in order to establish a reliable method for reducing damage by *Psila rosae* without decreasing yield. The only treatmenr which clearly and consistently reduced carrot fly damage was intercropping with *Medicago litoralis*. This treatment, however, also led to a reduction in yield.

Taja and Vander-Zaag (1992) conducted an experiment in Phillipine and reported that mulching by rice straw with optimum organic fertilizer application of 50 kg N/ha were good for canopy coverage of potato.

An experiment was conducted in Korea by Suh *et al.* (1991) where transparent polythene film and black polythene film mulches were applied in onion crops. The mean soil water content was 2.1-2.8% higher in the mulched plots than in the control. In another experiment on onion with polythene film mulch, they found that soil moisture content, soil temperature and growth, especially in terms of plant height was increased by mulching.

Vizzotto and Muller (1990) carried out an experiment in Brazil using 6 soil covers in carrot cultivation such as shaded plot, sugarcane bagasse, rice husks, saw dust, dry straw or sand. They found that emergence occured 14 days after sowing incase of shaded plot which was followed by sugarcane bagasse, rice husk and saw dust. This was attributed to lower temperature and higher humidity under the cover.

Roy *et al.* (1990) conducted an experiment in Bangladesh Agricultural University, Mymensingh where they used straw and saw dust in potato and recommended that water hyacinth is the best mulching material to increase crop growth.

Sarker and Hossain (1989) conducted a trial in Bangladesh Agricultural Research Institute with 8 different weeding and mulching treatments on potato cv. Cardinal and observed that one weeding just after planting and mulching by paddy straw appeared optimal for the production of good potato crop.

According to Zehender and Hough-Goldstein (1989) mulching has been proved effective in controlling plant disease, insects and weeds. They also reported that the number of adult egg masses and larvae of Colorado potato beetle were significantly lower in potato plants with straw mulch compared to those without it. Straw was found to be better mulch for garlic production than transparent plastic, black plastic and cabbage residues (Asandhi *et al.*, 1998). The Largest bulbs and the highest number of cloves/bulb were recorded with straw mulch.

Berle *et al.* (1988) found that black plastic mulch increased yields, gross and net returns over environmental practices of muskmelon prodection. Struzina and Kroner (1988) stated that from of the economic point of view, the using of straw mulch gave profitable yields covering all additional costs.

Kim *et al.* (1988) conducted an experiment in Korea to observe the effect of transparent polythene film mulch on the soil temperature, growth and yield of spring potato. They reported that polythene mulched increase soil temperature from 2.4-2.6^{0}C and moisture content of the soil was also increased. They also observed that 80% emergence was occurred within 29-39 days compared to that of the control (41-54 days).

While conducting an experiment, Rikabdar (1987) used straw and leaves as mulch materials for ginger cultivation and found that mulch retained soil moisture, reduced weed growth and provided organic matter to the soil when decomposed which ultimately enhanced crop growth and yield.

Sutater (1987) in a field trial found that the yields were higher in potato with mulch than without mulch. Mulched reduced day soil temperature. Number of leaves were increased slightly with mulching.

In Korea, Finch (1986) carried out an experiment on the effects of fluid drilling and seed covering medium on early carrot production under polythene mulch. It was noticed that earlier emergence generally led to roots reaching a marketable size earlier and more uniform emergence led to less variation in root weights at harvest.

Schoningh (1985) conducted an experiment in Brazil to observe the effect of mulch on yield and factors of soil fertility and stated that mulching increased hydrolic conductivity, nutrient content, organic matter status, cation exchange capacity, earthworm and microbial activity of soil.

Rijbroek (1985) carried out an experiment on fifteen carrot cultivers and selecyed for suitability for spring culture with or without direct covering under plastic film or for autumn culture in 3 year trials at different places of Netherland. The cvs. Mokum, Minicor and Ampri performed well in all types.

The anthor experiment conducted by Lang (1984) in Peru and reported that polythene mulch increased the yield of potato (31.4-32.5 t/ha) compared with 23.2-32.6 t/ha in unmulched control.

From a seasonal study in Peru, Manrique and Meyer (1984) observed that plastic mulches raised soil temperature in the winter giving significantly high tuber yields.In summer, plastic mulches significantly increased day soil temperature to above 300^0 C, giving an unfavourable environment for plant growth and tuber formation in potato. But favourable soil temperature in both winter and summer was mainted by straw mulch.

Neururer (1984) worked with mulching trial on carrot in Australia. He found that bitumen mulch reduced water, wind erosion, improved crop emergence and early development. Carrot yield was increased from 28.1 to 43.3 tons per hectare.

Hochmuth and Howell (1983) conducted an experiment in India and reported that leaf area, leaf number and fresh weight of leaves of sweet potato cv. Jewel were significantly higher from mulches than from unmulched plants. They also obtained the highest marketable yield (18.6 t/ha) from the mulched plot while, unmulched produced the lowest yield (7.0 t/ha).

Mannan *et al.*(1983) reported that the use of stubble mulch increased the yield of pancha mukhikachu. They indicated that mulching might have reduced the evaporation of soil moisture and helped in conserving the moisture received in the from of rains during the early stage of plant growth.

In Bangladesh Agricultural Research Institute, Rashid *et al.* (1981) conducted an experiment and found an increase in plant height of potato when mulched with straw and water hyacinth. They found the highest tuber yield with water hyacinth mulch followed by rice straw.

Yu *et al.* (1981) found the highest tuber yield with water hyacinth mulch followed by rice straw. In another experiment on 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 actinomycetes in soil (Gour and Mukargee, 1990).

Jacobson *et al.* (1980)mentioned that black polythene sheets placed on the soil during the hot season increased soil temperature by 8-120C in the upper 5 cm layer and thereby controlled the weed in the mulched plots where carrot grew normally.

2.2 Effect of potassium on the growth and yield of carrot

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

Pekarskas and Bartaseviciene (2007) conducted an experiment in Lithuania, during 2001-04, to determine the effect of different potassium fertilizer forms on ecologically cultivated carrot yield and quality. Treatment with potassium magnesia and potassium sulfate increased the total harvest of carrots while the marketable harvest of carrot was 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) says that Potassium (K) is required for successful carrot (*Daucus carota*) production on sandy soils of the southeastern United States. Soil test methods for K in carrot production have not been vigorously validated. Excessive fertilization sometimes is practiced by carrot growers to compensate for potential losses of K from leaching and because some growers believe that high rates of fertilization may improve vegetable quality. Carrots were grown in three plantings during the winter of 1994-95 in Gainesville,. to test the effects of K fertilization on carrot yield and quality on a sandy soil testing medium (38 ppm) in Mehlich-1 soil-test K. Large-size carrot yield was increased linearly with K fertilization. Yields of U.S. No. 1 grade carrots and total marketable carrots were not affected by K fertilization. K fertilizer was not required on this soil even though the University of Florida Cooperative Extension Service recommendation was for 84 lb/acre K. Neither soluble sugar nor carotenoid concentrations in carrot roots were affected by K fertilization. The current K recommendation for carrots grown on sandy soils testing 38 ppm Mehlich-1 K could be reduced and still maintain maximum carrot yield and root quality.

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 and mineral composition of carrot. A increase in the saturation of K to the level 13.5% resulted in a significant decrease in carrot yield. A decrease in K saturation of CEC below 5% also caused significant decrease in the yield of carrot roots. An increase in K saturation of CEC from 2.3 to 13.5% and a simultaneous decrease in Mg saturation from 13.3 to 5.7% caused an increase in the concentration and uptake of potassium and a decrease in the uptake and content of magnesium in carrot roots and leaves. The result was that the value of K:(Ca + Mg) ratio in carrot roots increased from 0.96 to 2.68 (mmol(+).

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

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

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

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

Akhilesh-Sharma *et al.* (2003) studied the effects of integrated use of farmyard manure, and N, P and K fertilizers on the yield components (root weight, root girth, root diameter, root top ratio, and total plant weight) and root yield of carrot (*D. carota* cv. Nantes). Three levels of N, P and K (50, 100 and 150% of the recommended rates of 50:40:35 kg $N:P_2O_5:K_2O$/ha) and 3 levels of farmyard manure (0, 10 and 20 t/ha) were evaluated in split-plot design with 3 replications. The application of 10 t farmyard manure/ha resulted in a significant increase in root yield and other characters over the control in both years. The application of 100% NPK was superior over the other fertilizer combinations in terms of root yield, whereas 100 and 150% of the recommended rate were equally effective and significantly better than the 50% level with regard to the other characters. The interaction between farmyard manure and NPK fertilizers was also significant. The highest net return (155 000 rupees/ha) and a benefit: cost ratio of 4.37 were obtained with 10 t farmyard manure/ha + 100% of the recommended NPK rate. The application of 10 t farmyard manure/ha reduced the required N, P_2O_5 and K_2O rates by 25, 20 and 15 kg/ha, respectively.

Feller *et al.* (2003) studied on-farm nutrient 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 N min target value in kg/ha are compared with data published in 2001. The highest N demand was found in celery (270 kg N/ha), followed by Japanese radish (245 kg N/ha), spring onion (160 kg N/ha), bunching carrot (145 kg N/ha), dill (110 kg N/ha), rocket salad (100 kg N/ha) and lambs' lettuce (38 kg N/ha). For rocket salad, nitrogen uptake curves modelled and measured are presented for different sowing dates. The model underestimated the uptake by 40% for June-sown plants.

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

Subrahmanyam *et al.*(2000) conducted field experiments to determine the effect of foliar feeding with 0.1 and 0.5% water-soluble fertilizers (Multi-K, PF 19-19-19 + micro elements (ME), PF 19-09-19+2 Mgo + ME and PF 17-10-27 + ME) on carrot (*Daucus carota*) 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. The crops responded well to all the fertilizers. All the treatments increased yields substantially compared to the control although yield improvement varied marginally among the fertilizers applied. On average, Multi-K (13-00-46) alone increased yield by 25.9% in carrot, respectively. The highest and lowest additional yields were 12.5 and 0.5 t/ha, respectively. However, carrot yield decreased with increased spray concentration of both Multi-K and PF 19-19-19 + ME. Carrot yields increased when the concentration of PF 19-09-19 + 2 Mgo + ME was increased. A decrease in the yields of the crops was observed with the increase in concentration of PF 17-10-27 + ME.

Flick *et al.* (1998) results of a field trial with carrot cv. Panther, grown on sandy loam, to determine the effects of applying 24 kg P/ha and 83 kg K/ha and 4 biocompost treatments (autumn, autumn + spring, spring, control) on glucose and sucrose contents and sensory quality are briefly discussed and tabulated.

Lazar *et al.* (1997) conducted an experiment 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 KCl + 150 kg NH_4NO_3/ha; and 150 kg KNO_3 + 100 kg NH_4NO_3/ha. Late-March sown Chantenay gave the best yield. However, Nantes, particularly those sown in early-June, showed higher quality than Chantenay. The application of KNO_3 increased the yield and quality of carrot roots.

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

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

Konopinski (1995) carried out field trials near Lublin, Poland, with carrot cv. Perfection. The plants received N:P:K at 150:150:300 kg/ha (control) or Super Fertilisant of French manufacture containing 11% organic matter, 14% Ca, 3.5% Mg, 4% 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 rate gave the best yield increase in carrot viz., 70 and 30% over the control, respectively. Crop quality was also best in this variant.

Sharangi and Paria (1995) carried out an experiment where carrots (cv. *Pusa Kesar*) were grown in the winter seasons of 1992 and 1993 on a sandy loam soil with N fertilizer at 0, 50, 70 or 80 kg/ha and K at 0, 40, 50 or 60 kg K_2O/ha. P was applied at 60 kg/ha. The crop was harvested 120 days after sowing. Shoot growth, root diameter and root TSS, carotene and total sugar contents increased with increasing rate of N. Root yield was also highest with the highest N rate (22.08 t/ha). With K application, most parameters increased with up to 50 kg/ha, then remained steady or declined with 60 kg/ha, although yield increased further with

60 kg/ha (19.66 t/ha). An interactive effect between N and K was found for plant height, root length, root diameter and root sugar content.

Kadi *et al.*(1994) carried out a trial at the Bajo Seco experimental station in Venezuela with carrot cv. Super Flakkee. Seeds were sown on 22 Feb. on an Orthoxic Tropudults Ultisol soil to which 0-200 kg P_2O_5, 0-300 kg K_2O and 0-40 t poultry manure/ha had been applied. Thinning was carried out on 15-18 April so that the distance between plants was 3, 6, 9, 12 or 15 cm. The highest yield at harvest (95.6 t/ha) was obtained with 150 kg P_2O_5 + 225 kg K_2O + 10 t poultry manure/ha and a distance of 12 cm between plants, but the results were not statistically significant.

Roa (1994) conducted a field experiment on red sandy loam soil, the effects of K at 0, 50, 100, 150, and 200 kg K_2O/ha as KCl or K_2SO_4 on growth, yield and quality of carrot. Mean root weight and yield were highest at 50 kg K_2O/ha. Carotene content was increased by K application.

Balooch *et al.* (1993) carried out a field trial during 1988-89. Tandojam carrots were grown from seed in seedbed to which 75 and 100 kg P_2O_5 and 75, 100 or 125 kg K_2O/ha had been applied. All plots also received 100 kg N in 3 split application during seed beds preparation. They observed that root yield was highest at the highest NPK rate. This was due to increased root size and weight.

Abo-Sedera and Eid (1992) studied in a field experiment 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 and 72 kg/feddan, respectively in 2 equal applications, 4 and 8 weeks after sowing. Overall, the best results, in terms of vegetative growth, yield and quality, were obtained with 60 kg N + 72 kg K_2O/feddan.

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

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

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

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

Bruckner (1986) conducted an experiment over 3 years and reported that increasing the N supply (0-200 kg N/ha) produced a relatively small increases in yields. N at 100 kg/ha gave the best yield without increasing the NO_3 content of carrots. Cultivers Flakkeer RZ and Flakkeer Karaf had a high uptake of K_2O

(242.8-326.6 kg/ha) and a 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 fertilizers was studied in a field trial involving NPK at 16-5-12 or 14-4-17 with N at 60,120,180 and 240 kg/ha.Yield was not significantly affected, but the incidence of cavity spot was least at the lowest rate of N and at all rates of N was less with the formulation of K.

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

Krarup *et al.* (1984) conducted an experiment where chantenay carrot were fertilized with K_2O (0, 100 or 200 units/ha). There were no difference in total yield with the medium and high K_2O levels. K_2O contents regard from 0.67 to 0.83% in roots and from 0.54 to 0.76% in leaves. Nutrient extraction by the whole plant (calculated on the basis of yields and contents) varied in accordance with the level of application; from 63.35 to 94.33 kg/ha for K_2O. Leaf and root K_2O contentsand the level of K_2O extraction were lower than expected, probably due to the characteristics of the soil, which was deficient in K.

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

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

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

Considering the above review of literature and the findings, the present study was undertaken with a view to investigate the effect of mulching and potassium on growth and yield of carrot.

Chapter III

Materials & Methods

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used to carry out the experiment.

3.1 Location of the experiment field

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during October 2006 to March 2007. The location of the experimental site was at $23^{0}74'$ N latitude and $90^{0}35'$ E longitude with an elevation of 8.2 meter from sea level (Anon., 1989).

3.2 Weather condition of the experimental site

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon or the rainy season from May to October, premonsoon period or hot period from March to April and post monsoon or winter or drought period from November to February (Edris *et al.*, 1979). Details of the meterological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix I.

3.3 Soil of the experimental field

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

3.4 Planting materials

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

3.5 Treatments of the experiment

The experiment was considered of two factors. Details were presented below:

Factor A: Four different types of mulch

1. M_0= No mulch (control)
2. M_1= Black polythene
3. M_2= Water hyacinth
4. M_3= Saw dust

Factor B: It comprised of 4 levels of potassium

1. K_0= 0 Kg K_20 (control)
2. K_1= 180 Kg K_20 per hectare
3. K_2= 200 Kg K20 per hectare
4. K_3= 220 Kg K_20 per hectare

There were altogether 16 treatments combinations used in the experiment as follow:

M_0K_0, M_0K_1, M_0K_2, M_0K_3, M_1K_0, M_1K_1, M_1K_2, M_1K_3, M_2K_0, M_2K_1, M_2K_2, M_2K_3, M_3K_0, M_3K_1, M_3K_2 and M_3K_3.

3.6 Experimental design and layout

The experiment was conducted in the Randomized Complete Block Design (RCBD) having two factors with three replications. The experimental plot was 182 m^2 (14m x 13m) which was divided into three equal blocks and each block was then divided into 16 unit plots. The size of each plot was 1.5m x 1m and maintaing spacing 25 x 15 cm. and each plot consisted of 40 plants. Thus, there were 48 (16 x 3) unit plots altogether in the experiment. The distance between blocks were 0.75m and 0.5 m wide drain was made between the plot to facilite different intercultural operations. The complete layout of the experimental plot has been shown in figure 1.

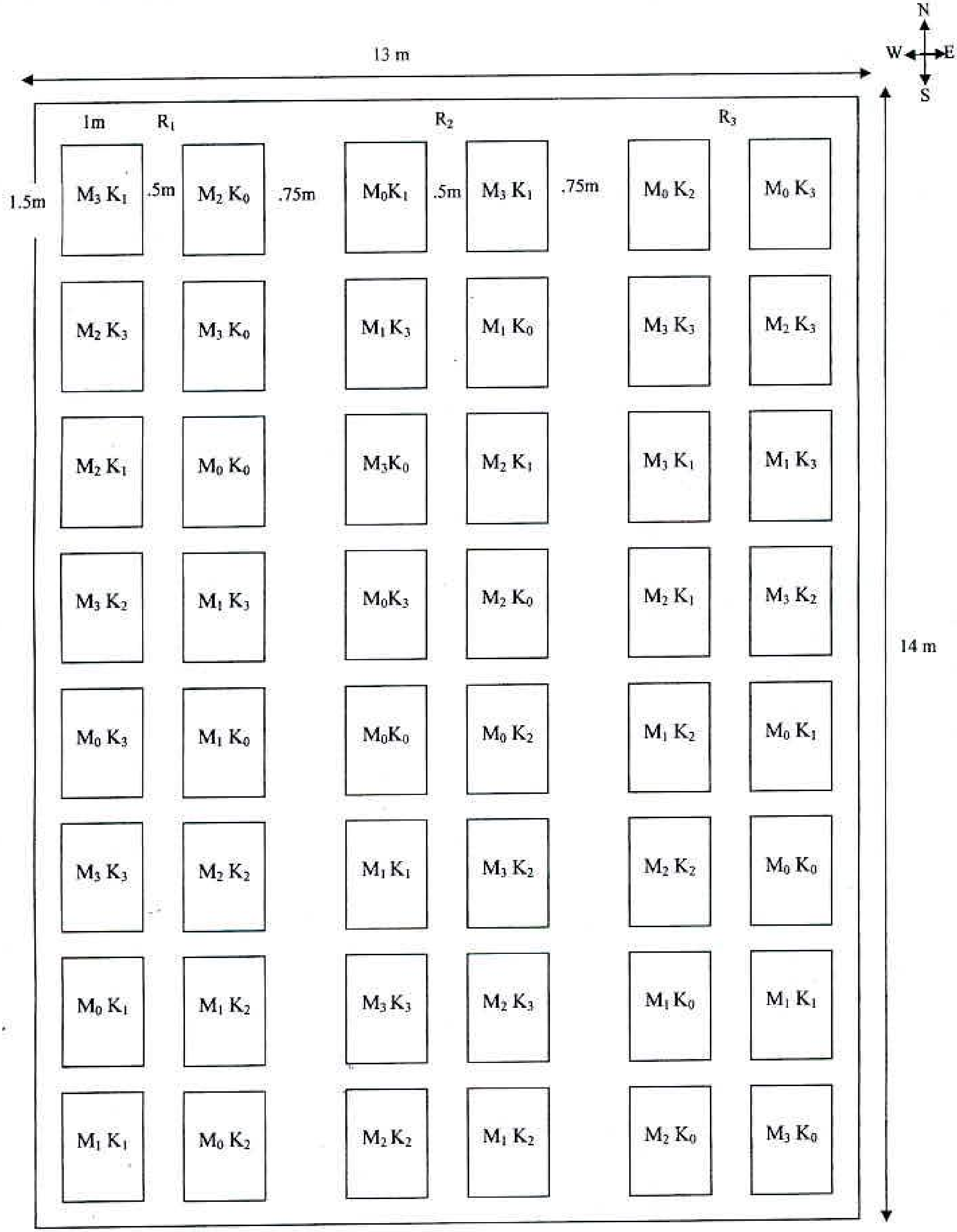

Fig. 1. Field layout of the two factor experiment follwing Randomized Complete Block Design (RCBD)

Sclae : 1000 cm = 1 m

Number of treatment = 16
Replication = 3
Total Plot = 48
Total area = 182 m^2
Unirt Plot size = 1.5 m^2
Plot to Plot distance = 0.5m
Block to block distance = 0.75m
Spacing = 25 x 15 cm

Factor A : Mulching
M_0 = No mulch (Control)
M_1 = Black polythene
M_2 = Water hyacinth
M_3 = Sawdest

Factor B : Potassium
K0 = 0 K (Control)
K1 = 180 kg K/ha
K2 = 200 kg K/ha
K3 = 220 kg K/ha

3.7 Cultivation procedure

3.7.1 Land preparation

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

3.7.2 Application of manure and fertilizers

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

Manures/Fertilizers	Dose/ha	Dose/plot *
Well decomposed cowdung	10 tons	1.50 kg
Urea	150 kg	22.50 g
Triple Super Phosphate (TSP)	125 kg	18.7 g
Potassium	As per treatment	

*Unit plot size was 1.5m x 1.0m =1.5m^2

Potassium was applied at the rate of 0, 180, 200, 220 kg K_20 per hectare in the form of muriate of potash as per treatments in different plots. The entire amount of cowdung was applied at the time of initial land preparation and the total amount of urea and TSP was applied during the final land preparation. Potassium (K_2O) applied as per treatment schedule.

3.8 Seed soaking

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

3.9 Sowing of seeds

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

3.10. Application of mulches

Three types of mulching materials, viz. black polythene, water hyacinth and saw dust were used. Incase of black polythene mulch, holes were made at proper distance and seeds were sown in the holes. The water hyacinth and saw dust mulched were placed around the holes immediately after sowing of seeds. The fresh water hyacinth plants were chopped into small pieces (5-7cm) and in the sun dried for three days before placing over the plot. The thickness of water hyacinth and saw dust mulches were maintained at 30 cm (Approximately) .

3.11 Intercultural operations

a. Thinning

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

b. Weeding

Weed emerged less in mulched plots than non-mulched plots. Less weeds grown in the plots where saw dust and water hyacinth were provided compare to black polythene mulched plots. Weeding was done four times in non-mulched plots, three times in water hyacinth and saw dust mulched plots and two times in black polythene mulched plots to keep the plots free from weeds. In control plots, earthing up along with weeding was done to prevent discoloration of roots as well as obtaining healthy and quality products.

3.12 Plant protection

a. Insect pest

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

b. Diseases

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

3.13 Harvesting

The crop was harvested on 17 March 2007 after 105 days from seed sowing when the foliage turned pale yellow (Bose and Som, 1990). Rikabdar (2000) suggested that carrots should be harvested in Bangladesh within 90-105 days after sowing for maximum yield and quality. The crop was harvested plot wise carefully by hand. The soil and fibrous roots adhearing to the roots were cleaned with water than after cloth.

3.14 Parameters assessed

Ten plants were selected at random and uprooted very carefully from each unit plot at the time of harvest and mean data on the following parameters were recorded.

A. Growth stage

1. Plant height
2. Number of leaves per plant

B. Maturity stage

1. Number of leaf per plant
2. Length of root per plant
3. Diameter of root per plant
4. Fresh weight of leaves per plant
5. Fresh weight of root per plant
6. Percent dry matter of roots
7. Percent dry matter of leaves
8. Cracked roots per plot
9. Rotten roots per plot
10. Branched roots per plot
11. Total yield of roots per plot
12. Total yield of roots per hectare
13. Marketable yield of roots per plot
14. Marketable yield of roots per hectare

3.15 Collection of data

Ten plants per plot were sampled in the middle rows and marked by bamboo stick for collection of 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

The plant height, was measured by a meter scale at 45, 60, 75 and 90 days after sowing (DAS) from the point of the attachment of the leaves to the root (ground level) upto the tip of the longest leaf.

3.15.2 Number of leaves per plant

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

3.15.3 Length of root per plant

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

3.15.4 Diameter of root per plant

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

3.15.5 Fresh weight of leaves per plant

Leaves were detached by a sharp knife and fresh weight was recorded from 10 sampled plants at harvest and their average value was expressed in gram (g).

3.15.6 Fresh weight of root per plant

Under ground modified roots were detached by knife from the attachment of leaves and after the cleaning the soil and the average fresh weight of roots was recorded from sampled plants by a triple beam balance and expressed in gram (g).

3.15.7 Percent dry matter of roots

Immediately after harvest, roots were thoroughly washed with water and air dried. Then from several roots, a sample of 100 g was taken and cut into small pieces and were sun dried for 3 days and then oven dried for 72 hours at 70^0-80^0 C. temperature. After oven drying, the samples were weighed by an electrical balance and matter content was calculated by using the following formula--

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

3.15.8 Percent dry matter of leaves

Fresh leaves of 100 g as per treatment samples weighted and cut into small pieces. After sun drying for 3 days the samples were oven dried at 72 hours. Then the samples weighted by an electrical balance and the weight of dry leaves were calculated by using the following formula--

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

3.15.9 Percent cracked roots per plot

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

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

3.15.10 Percent rotten roots per plot

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

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

3.15.11 Percent branched roots per plot

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

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

3.15.12 Total yield of roots per plot (kg)

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

3.15.13 Total yield of roots per hectare

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

3.15.14 Marketable yield of roots per plot (kg)

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

Marketable yield = Gross yield – Non marketable yield

Here none marketable yield mean = (no.of cracked, branched and rotten roots)

3.15.15 Marketable yield of roots per hectare

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

3.16 Statistical analysis

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

3.17 Cost analysis

Cost and return analysis was done according to the procedure of Alam *et al.* (1989).

Chapter IV

Results and Discussion

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix III-VI. The recorded results presented and discussed, and possible interpretations given under the following headings-

4.1 Plant height

Plant height varied significantly at 45, 60, 75 and 90 DAS on different mulch materials that was used in this experiment (Appendix III). At 45 DAS, the longest (23.86 cm) plant was recorded from M_1 (Black polythene mulch) which was statistically similar (22.77 cm) to M_3 (Saw dust mulch) and closely followed (21.26 cm) by M_2 (Water hyacinth mulch), while the shortest (17.05 cm) was obtained from M_0 (no mulch). The longest (40.83 cm) plant was recorded from M_1 which was closely followed (38.73 cm and 38.68 cm) by M_2 and M_3, while the shortest (35.97 cm) was found from M_0 at 60 DAS. At 75 DAS, the longest (44.63 cm) plant was obtained from M_1 which was followed by M_3 42.57 cm and M_2 42.14 cm, while the shortest (39.65 cm) was recorded from M_0. The longest (43.30 cm) plant was recorded from M_1 which was statistically similar (41.24 cm) to M_3 and followed (40.53 cm) by M_2, while the shortest (37.41 cm) was recorded from M_0 at 90 DAS (Figure 2). Mulch materials produced longest plant through ensuring optimum soil moisture. Resende *et al.* (2005) reported that mulch materials are technically and economically viable for carrot cultivation. Akand (2003) mentioned that mulch materials had significant effect on most of the yield contributing parameters. Suh *et al.* (1991) found from their experiment that plant growth, especially plant height was increased by mulch materials. Munir (2003) also found the similar trends of results which support the result of present study.

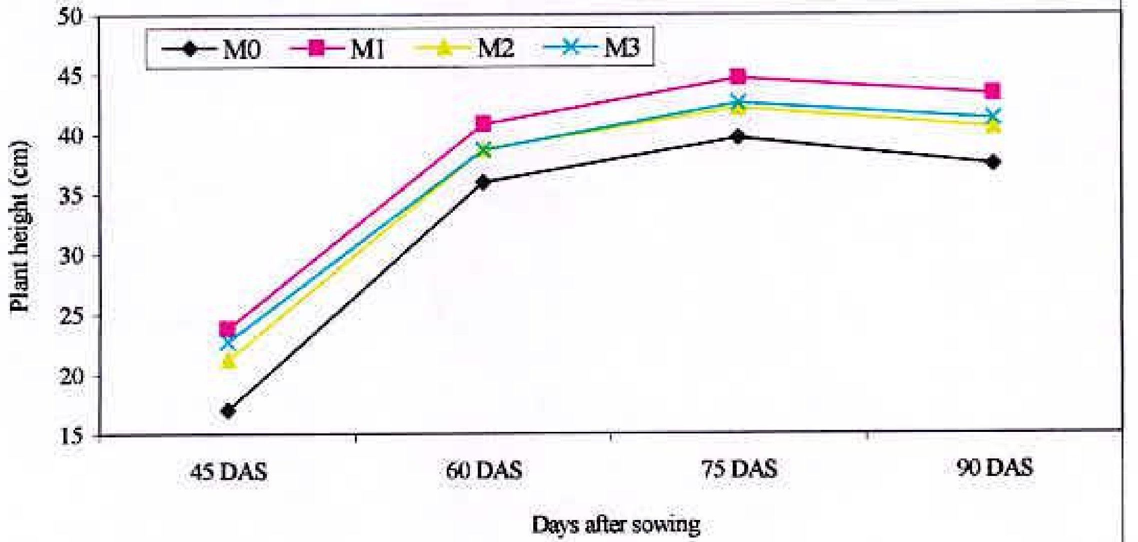

Figure 2. Effect of mulching on plant height of carrot

M_0 : No mulch M_1 : Black polythene

M_2 : Water hyacinth M_3 : Saw dust

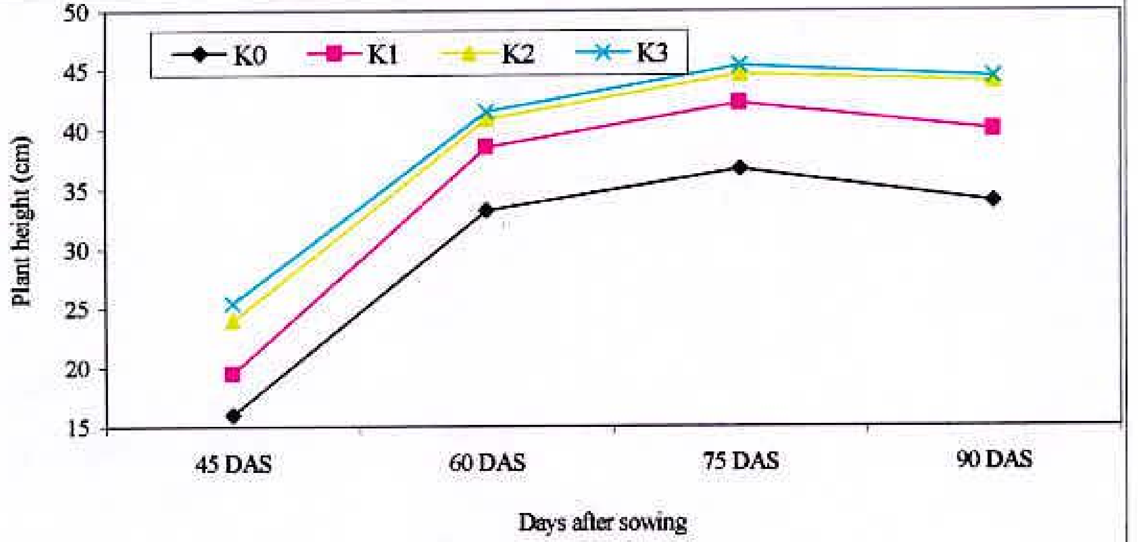

Figure 3. Effect of potassium on plant height of carrot

K_0 : 0 kg K_2O ha^{-1} K_1 : 180 kg K_2O ha^{-1}

K_2 : 200 kg K_2O ha^{-1} K_3 : 220 kg K_2O ha^{-1}

Significant variation was observed on plant height due to application of different levels of potassium at 45, 60, 75 and 90 DAS (Appendix III). At 45 DAS, the longest (25.44 cm) plant height was found from K_3 (220 kg K_2O ha^{-1}) which was statistically similar (23.98 cm) to K_2 (200 kg K_2O ha^{-1}) and followed (19.50 cm) by K_1 (180 kg K_2Oha^{-1}), while the shortest (16.00 cm) was obtained from K_0 (control condition). The longest (41.49 cm) plant was recorded from K_3 which was statistically similar (40.91 cm) with K_2 and followed (38.56 cm) by K_1, while the shortest (33.25 cm) was obtained from K_0 at 60 DAS. At 75 DAS, the longest (45.38 cm) plant was found from K_3 which was statistically similar (44.67 cm) to K_2 and followed (42.25 cm) by K_1, while the shortest (36.68 cm) plant height was recorded from K_0. The longest (44.46 cm) plant was recorded from K_3 which was statistically similar (44.06 cm) to K_2 and followed (39.98 cm) by K_1, while the shortest (33.96 cm) was recorded from K_0 at 90 DAS (Figure 3). Sharangi and Paria (1995) reported that with K application plant height increased with up to 50 kg/ha, then remained steady or declined with 60 kg/ha.

Combined effect of mulch materials and potassium showed significant differences on plant height at 45, 60, 75 and 90 DAS (Appendix III). At 45 DAS, the longest (29.37 cm) plant was obtained from M_3K_3 (Saw dust and 220 kg K_2Oha^{-1}) which was statistically similar to M_1K_3 and M_3K_2, while the shortest (13.47 cm) plant was recorded from M_3K_0 (Saw dust and no potassium). The longest (43.28 cm) plant was recorded from M_3K_3 and the shortest (29.54 cm) was obtained from M_3K_0 at 60 DAS. At 75 DAS, the longest (47.12 cm) plant was obtained from M_3K_3 and the shortest (33.49 cm) was recorded from M_3K_0. The longest (46.71 cm) plant was found from M_1K_3 and the shortest (29.74 cm) was found from M_3K_0 at 90 DAS (Table 1). Mulch materials ensured the uptake of essential nutrient through holding optimum moisture. Potassium also helps in proper growth and ultimate results were the longest plant of carrot. Sharangi and Paria (1995) reported an interactive effect between mulch materials and K fertilizer on plant height.

Table 1. Combined effect of mulch materials and potassium on plant height of carrot

Treatment(s) combination	Plant height (cm) at			
	45 DAS	60 DAS	75 DAS	90 DAS
M_0K_0	15.65 fg	32.49 ef	36.54 ef	32.04 gh
M_0K_1	15.56 fg	35.77 cde	39.11 cde	37.74 ef
M_0K_2	17.76 def	37.56 bcd	41.09 bc	39.37 def
M_0K_3	19.69 de	38.17 bc	41.65 bc	40.38 cde
M_1K_0	19.37 def	37.14 bcd	39.51 cde	39.32 def
M_1K_1	23.63 bc	41.98 a	46.03 a	40.96 bcde
M_1K_2	25.54 b	42.01 a	46.45 a	46.17 a
M_1K_3	27.13 ab	42.36 a	46.49 a	46.71 a
M_2K_0	16.03 efg	33.79 de	37.07 def	34.73 fg
M_2K_1	18.19 def	37.01 bcd	40.74 bcd	38.41 ef
M_2K_2	25.36 b	41.99 a	44.58 ab	44.66 abc
M_2K_3	25.65 b	42.15 a	46.46 a	44.31 abcd
M_3K_0	13.47 g	29.54 f	33.49 f	29.74 h
M_3K_1	20.75 cd	39.70 ab	43.12 abc	42.81 abcde
M_3K_2	27.48 ab	42.22 a	46.54 a	45.95 ab
M_3K_3	29.37 a	43.28 a	47.12 a	46.52 a
$LSD_{(0.05)}$	3.413	3.315	3.652	4.631
Level of significance	**	**	*	*
CV(%)	8.72	6.26	5.92	7.63

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.2 Number of leaves per plant

Different mulch materials that were used in this experiment showed a significant difference on number of leaves per plant at 45, 60, 75 and 90 DAS (Appendix IV). At 45 DAS, the maximum (7.30) number of leaves per plant was recorded from M_1 (Black polythene mulch) which was statistically similar (7.14 and 6.89) to M_3 (Saw dust) and M_2 (Water hyacinth mulch), while the minimum (6.14) number of leaves per plant was recorded from M_0 (no mulch). The maximum (8.67) number of leaves per plant was recorded from M_1 which was statistically identical (8.39 and 8.31) to M_3 and M_2, whereas the minimum (7.86) number of leaves per plant was recorded from M_0 at 60 DAS. At 75 DAS the maximum (11.39) number of leaves per plant was found from M_1 which was statistically identical (11.39) with M_3, while the minimum (9.72) number of leaves per plant was obtained from M_0. The maximum (11.03) number of leaves per plant of carrot was recorded from M_1 which was statistically similar (10.78) to M_3 and closely followed (10.31) by M_2, while the minimum (7.89) was found from M_0 at 90 DAS (Figure 4). Roy *et al.* (1990) reported that straw and saw dust increased number of leaves per plant and they also recommended that water hyacinth is the best mulch materials in increasing crop growth. Sutater (1987) reported that number of leaves was increased slightly with the application of mulch materials.

Potassium at different levels showed statistically significant variation on number of leaves per plant at 45, 60, 75 and 90 DAS (Appendix IV). At 45 DAS the maximum (7.36) number of leaves per plant was recorded from K_3 (220 kg K_2O ha^{-1}) which was statistically similar (7.25) to K_2 (200 kg K_2O ha^{-1}) and followed (6.80) by K_1 (180 kg K ha^{-1}), while the minimum (6.05) was recorded from K_0 (control). The maximum (8.78) number of leaves per plant was recorded from K_3 which was statistically similar (8.72) to K_2 and followed by K_1 (8.33) while the minimum (7.39) was obtained from K_0 at 60 DAS. At 75 DAS, the maximum (11.78) number of leaves per plant was recorded from K_3

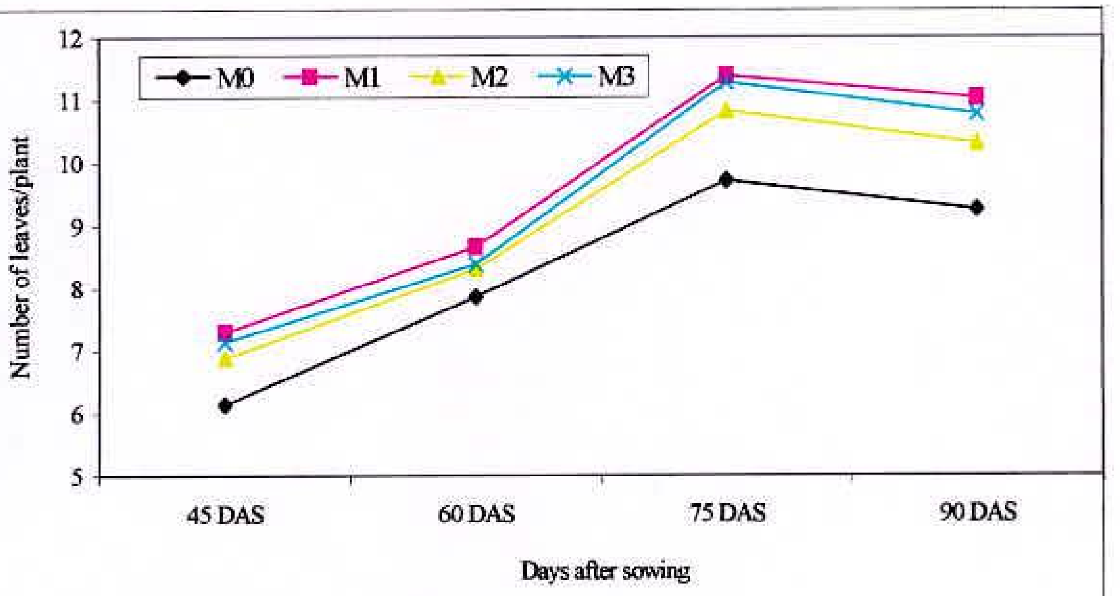

Figure 4. Effect of mulching on number of leaves per plant of carrot

M_0 : No mulch M_1 : Black polythene
M_2 : Water hyacinth M_3 : Saw dust

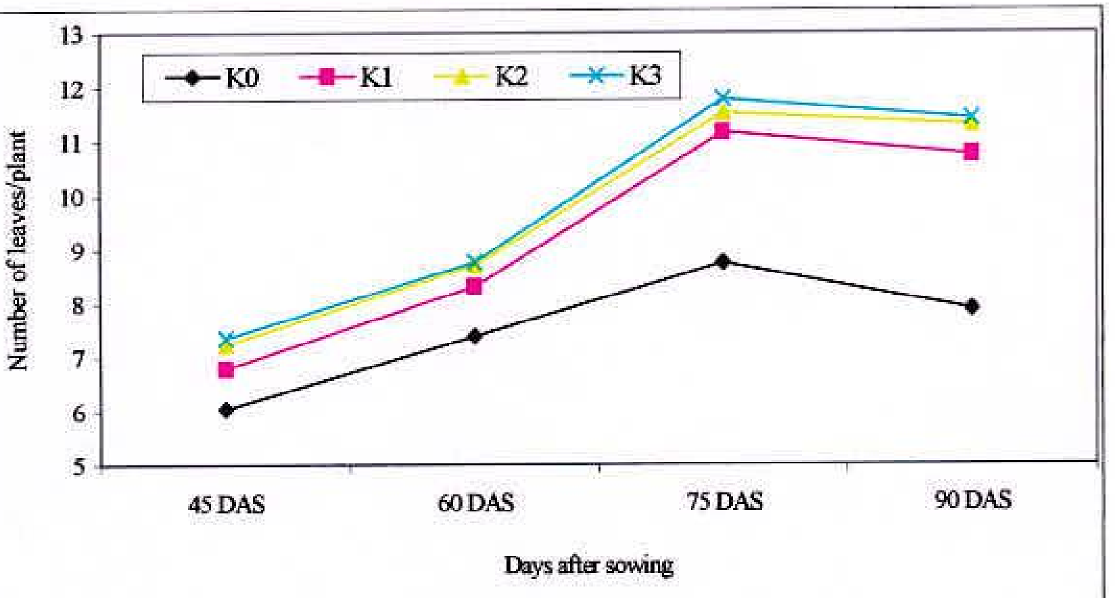

Figure 5. Effect of potassium on number of leaves per plant of carrot

K_0 : 0 kg K_2O ha^{-1} K_1 : 180 kg K_2O ha^{-1}
K_2 : 200 kg K_2O ha^{-1} K_3 : 220 kg K_2O ha^{-1}

which was statistically similar to K_2 (11.53) while the minimum (8.75) was recorded from K_0. The maximum (11.42) number of leaves per plant was recorded from K_3 which was statistically similar (11.30) to K_2, where as the minimum (7.89) was obtained from K_0 at 90 DAS (Figure 5). Mulch materials and optimum level of potassium produced the maximum number of leaves per plant by ensuring appropriate soil moisture and essential nutrients.

Combined effect of mulch materials and different levels of potassium showed significant variation on number of leaves per plant at 45, 60, 75 and 90 DAS (Appendix IV). At 45 DAS, the maximum (8.00) number of leaves per plant was recorded from M_3K_3 (Saw dust and 220 kg K_2O ha^{-1}) which was statistically similar with M_3K_3, M_2K_3, M_2K_2 and M_1K_3 (Table 2) and the minimum (5.44) number of leaves per plant was found from M_3K_0 (Saw dust and no potassium). The maximum (9.11) number of leaves per plant was recorded from M_3K_3 and the minimum (6.67) number of leaves per plant was obtained from M_3K_0 at 60 DAS. At 75 DAS, the maximum (12.33) number of leaves per plant was recorded from M_3K_3, whereas the minimum (8.00) number of leaves per plant was found from M_0K_0. The maximum (12.22) number of leaves per plant was recorded from M_3K_3, while the minimum (7.00) number of leaves per plant was recorded from M_0K_0 at 90 DAS (Table 2).

4.3 Length of root

Length of root differs significantly for different mulch materials (Appendix V). The longest (20.25 cm) root was recorded from M_1 (Black polythene mulch) which was followed (18.41 cm and 18.02 cm) by M_3 and M_2 (Saw dust and Water hyacinth mulch), while the shortest (15.38 cm) root was recorded from M_0 (no mulch) under the present trial (Table 3). Munir (2003) mentioned that mulch materials had significant effect on most of the yield contributed parameters like root length. Akand (2003) stated that mulch materials obviously influence the root length of carrot.

Table 2. Combined effect of mulch materials and potassium on number of leaves per plant of carrot

Treatment(s) combination	Number of leaves per plant at			
	45DAS	60 DAS	75 DAS	90 DAS
M_0K_0	5.56 ef	6.78 f	8.00 e	7.00 e
M_0K_1	6.22 def	8.00 cde	10.03 b	9.94 c
M_0K_2	6.33 cdef	8.18 bcde	10.36 b	10.11 bc
M_0K_3	6.48 bcde	8.33 abcde	10.49 b	10.00 c
M_1K_0	7.11 abcd	8.20 bcde	9.33 c	8.78 d
M_1K_1	7.22 abc	8.67 abcd	11.97 a	11.62 a
M_1K_2	7.29 ab	8.92 ab	12.01 a	11.66 a
M_1K_3	7.56 a	8.90 ab	12.05 a	11.92 a
M_2K_0	6.11 ef	7.78 e	9.22 cd	8.56 d
M_2K_1	6.41 bcde	7.89 de	10.46 b	9.99 c
M_2K_2	7.77 a	8.61 abc	11.88 a	11.31 ab
M_2K_3	7.56 a	8.66 abc	12.09 a	11.76 a
M_3K_0	5.44 f	6.67 f	8.44 de	7.13 e
M_3K_1	7.39 ab	8.80 abc	12.00 a	11.55 a
M_3K_2	7.84 a	8.96 ab	12.27 a	12.15 a
M_3K_3	8.00 a	9.11 a	12.33 a	12.22 a
$LSD_{(0.05)}$	0.887	0.732	0.777	1.013
Level of Significance	*	*	**	**
CV(%)	8.82	5.44	5.98	7.120

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

The longest (20.58 cm) root was recorded from K_3 (220 kg K_2O ha^{-1}) followed (19.41 cm) by K_2 (200 kg K_2O ha^{-1}), while the shortest (15.35 cm) was obtained from K_0 (no potassium) (Table 3). Sarker (1989) reported that potash significantly affected on the root length.

Combined effect of mulch materials and different levels of potassium varied significantly in terms of length of root (Appendix V). The longest (23.72 cm) root was recorded from M_1K_3 (Black polythene mulch and 220 kg K_2O ha^{-1}) and the shortest (14.08 cm) root was recorded from M_0K_0 (no mulch and no potassium) (Table 4). Sharangi and Paria (1995) reported that an interactive effect between mulch materials and K was found for root length.

4.4 Diameter of root

Diameter of root showed statistically significant variation for different mulch materials that was used in this experiment (Appendix V). The maximum (4.92 cm) diameter of root was obtained from M_1 (Black polythene mulch) which was closely followed (4.52 cm and 4.40 cm) by M_3 and M_2 (Saw dust and Water hyacinth mulch), while the minimum (4.10 cm) diameter of root was obtained from M_0 (no mulch) under the present trial (Table 3).

Different levels of potassium showed statistically significant variation on diameter of root (Appendix V). The maximum (4.85 cm) diameter of root was recorded from K_3 (220 kg K_2O ha^{-1}) which was statistically similar (4.78 cm) with K_2 (200 kg K_2O ha^{-1}), while the minimum (4.03 cm) was obtained from K_0 (no potassium) (Table 3). Sarker (1989) reported that potash significantly on affected the root diameter.

Different mulch materials and different levels of potassium showed statistically significant differences in terms of diameter of root (Appendix V). The maximum (5.15 cm) diameter of root was recorded from M_1K_3 (Black polythene mulch and 220 kg K_2O ha^{-1}) and the minimum (3.67 cm) diameter of root was found from the treatment combination of M_0K_0 (no mulch and no potassium) (Table 4). Sharangi and Paria (1995) reported that an interactive effect between mulch materials and K was found for root diameter. Farazi (1983) reported that potash had significant effect on diameter of root of carrot.

4.5 Fresh weight leaves per plant

Significant variation was found due to application of different types of mulch materials on fresh weight of leaves per plant (Appendix V). The maximum (86.46 g) fresh weight of leaves per plant was obtained from M_1 (Black polythene mulch), while the minimum (77.15 g) fresh weight of leaves per plant was recorded from M_0 (no mulch) from the present trial (Table 3). Different types of mulch materials preserved soil moisture and the ultimate results in the maximum growth with the highest fresh weight of leaves per plant.

Different levels of potassium showed statistically significant variation for fresh weight of leaves per plant (Appendix V). The maximum (87.30 g) fresh weight of leaves per plant was recorded from K_3 (220 kg K_2O ha^{-1}) which was statistically similar (86.49 g) with K_2 (200 kg K_2O ha^{-1}), while the minimum (74.39 g) was recorded from K_0 (no potassium) (Table 3). Sarkers (1989) reported that potash significantly influenced on fresh weight. Farazi (1993) reported that the weight of leaves per plant was increased with the increasing level of potash of carrot.

Combined effect of mulch materials and different levels of potassium showed statistically significant variations in terms of fresh weight of leaves per plant (Appendix V). The maximum (90.69 g) fresh weight of leaves per plant was recorded from M_1K_3 (Black polythene mulch and 220 kg K_2O ha^{-1}) and the minimum (71.49 g) fresh weight of leaves per plant was recorded from M_0K_0 (no mulch and no potassium) (Table 4). Akand (2003) mentioned that mulch materials had significant effect on most of the yield contributed parameters like fresh weight of leaves per plant.

Table 3. Effect of mulch materials and potassium on yield contributing characters of carrot

Treatment(s)	Length of root (cm)	Diameter of root (cm)	Fresh weight of leaves per plant (g)	Fresh weight of root per plant (g)	Dry matter content of roots (%)	Dry matter content leaves (%)
Mulch materials						
M_0	15.38 c	4.10 c	77.15 c	102.25 c	7.45 b	5.85 bc
M_1	20.25 a	4.92 a	86.46 a	118.49 a	8.29 a	5.55 c
M_2	18.02 b	4.40 b	82.19 b	111.87 b	8.13 a	6.14 ab
M_3	18.41 b	4.52 b	83.86 b	113.42 b	8.02 a	6.35 a
$LSD_{(0.05)}$	0.991	0.134	2.014	4.246	0.321	0.443
Level of Significance	**	**	**	**	**	**
Potassium						
K_0	15.35 d	4.03 c	74.39 c	98.45 c	7.21 b	5.20 c
K_1	17.23 c	4.40 b	81.49 b	109.68 b	7.96 a	5.70 b
K_2	19.12 b	4.78 a	86.49 a	116.78 a	8.14 a	6.02 ab
K_3	20.58 a	4.85 a	87.30 a	118.00 a	8.32 a	6.52 a
$LSD_{(0.05)}$	1.031	0.143	4.449	3.894	0.222	0.409
Level of Significance	**	**	**	**	**	**
CV(%)	9.61	10.52	9.12	8.14	7.13	8.97

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 4. Combined effect of mulch materials and potassium on yield contributing characters of carrot

Treatment(s) combination	Length of root (cm)	Diameter of root (cm)	Fresh weight of leaves/ plant (g)	Fresh weight of root /plant (g)	Dry matter content of roots (%)	Dry matter content leaves (%)
M_0K_0	14.08 e	3.67 j	71.49 g	89.99 i	6.43 d	5.47 bcd
M_0K_1	15.63 de	4.05 hi	76.40 ef	103.14 fg	7.85 bc	5.72 bc
M_0K_2	16.12 de	4.30 fgh	79.76 def	107.08 defg	7.60 bc	6.16 abc
M_0K_3	15.61 de	4.40 efg	80.75 de	108.80 cdefg	7.83 bc	6.14 abc
M_1K_0	16.77 d	4.65 cde	78.18 ef	111.99 bcdef	7.47 c	5.39 cd
M_1K_1	19.69 c	4.81 bcd	86.95 abc	115.78 abcd	8.34 ab	5.26 cd
M_1K_2	20.78 bc	5.11 ab	89.53 ab	122.49 a	8.66 a	5.46 cd
M_1K_3	23.72 a	5.15 a	90.69 a	123.11 a	8.68 a	6.18 abc
M_2K_0	15.77 de	3.92 hi	76.03 f	100.07 gh	7.42 c	5.32 cd
M_2K_1	16.48 d	4.16 gh	78.52 ef	104.92 efg	8.14 abc	6.13 abc
M_2K_2	19.82 c	4.82 bcd	85.71 bc	118.96 ab	8.36 ab	6.45 ab
M_2K_3	20.65 bc	4.79 bcd	87.63 abc	117.33 abc	8.32 ab	6.82 a
M_3K_0	14.51 de	3.77 ij	71.70 g	91.73 hi	7.52 c	4.69 d
M_3K_1	16.68 d	4.56 def	83.75 cd	114.82 abcd	7.91 bc	6.80 a
M_3K_2	20.83 bc	4.87 abc	88.79 ab	121.99 ab	8.13 abc	6.86 a
M_3K_3	22.18 ab	5.05 ab	89.81 ab	122.87 a	8.42 ab	6.91 a
$LSD_{(0.05)}$	1.888	0.271	4.008	8.418	0.642	0.886
Level of Significance	**	*	*	*	*	*
CV(%)	9.61	10.52	9.12	8.14	7.13	8.69

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.6 Fresh weight of root per plant

Fresh weight of root per plant varied significantly for different mulch materials that were used in this experiment (Appendix V). The maximum (118.49 g) fresh weight of root per plant was obtained from M_1 (Black polythene mulch) which was closely followed (113.4 g and 111.87 g) by M_3 and M_2 (Saw dust and water hyacinth mulch), while the minimum (102.25 g) fresh weight of root per plant was obtained from M_0 (no mulch) under the present trial (Table 3). Resende *et al.* (2005) reported that mulch materials is technically and economically viable for carrot cultivation. Akand (2003) mentioned that mulch materials had significant effect of carrot crops on most of the yield contributing parameters.

Different levels of potassium showed significant variation on fresh weight of root per plant (Appendix V). The maximum (118.00 g) fresh weight of root per plant was found from K_3 (220 kg K_2O ha^{-1}) which was statistically similar (116.78 g) with K_2 (200 kg K_2O ha^{-1}), where as the minimum (98.45 g) was recorded from K_0 (no potassium) (Table 3). Lyngdoh (2001) reported that in carrot the moderate K level produced the greatest root weight.

Combined effect showed significant differences on fresh weight of root per plant due to applied of various mulch materials and levels of potassium (Appendix V). The maximum (123.11 g) fresh weight of root per plant was obtained from M_1K_3 (Black polythene mulch and 220 kg K_2O ha^{-1}) and the minimum (89.99 g) fresh weight of root per plant was found from M_0K_0 (no mulch and no potassium) (Table 4). Sharangi and Paria (1995) reported that an interactive effect between mulch materials and K was found for fresh weight of carrot root.

4.7 Dry matter content of roots

Dry matter content of roots varied significantly for different mulch materials that were used in this experiment (Appendix V). The highest (8.29%) dry matter content of roots was found from M_1 (Black polythene mulch) which was statistically identical (8.13% and 8.02%) to M_2 and M_3 (Water hyacinth and Saw dust mulch), while the lowest (7.45%) dry matter content of roots was recorded from M_0 (no mulch) under the present trial (Table 3). Islam *et al.* (1998) reported that dry weight of storage roots of carrot were the greatest in the rice husk charcoal mixture, rice husk mass, rice straw mass and rice husk mixture.

Statistically significant variation was recorded on dry matter content of roots for different levels of potassium (Appendix V). The highest (8.32%) dry matter content of roots was recorded from K_3 (220 kg K_2O ha^{-1}) which was statistically similar (8.14% and 7.96%) to K_2 and K_1 (200 kg K_2O ha^{-1} and 180 kg K_2O ha^{-1}), while the lowest (7.21%) was obtained from K_0 (no potassium) (Table 3).

Combined effect of mulch materials and different levels of potassium varied significantly in terms of dry matter content of roots (Appendix V). The highest (8.68%) dry matter content of roots was recorded from M_1K_3 (Black polythene mulch and 220 kg K_2O ha^{-1}) and the lowest (6.43%) dry matter content of roots was recorded from M_0K_0 (no mulch and no potassium) (Table 4).

4.8 Dry matter content of leaves

Dry matter content of leaves varied significantly due to provide of different mulch materials in the experiment (Appendix V). The highest (6.35%) dry matter content of leaves was obtained from M_3 (Saw dust mulch) which was statistically identical (6.14%) with M_2 (Water hyacinth mulch), while the lowest (5.55%) dry matter content of leaves was recorded from M_1 (Black polythene mulch) under the present trial (Table 3).

Dry matter content of leaves showed statistically significant variation due to application of different levels of potassium (Appendix V). The highest (6.52%) dry matter content of leaves was recorded from K_3 (220 kg K_2O ha^{-1}) which was statistically similar (6.02%) to K_2 (200 kg K_2O ha^{-1}), while the lowest (5.20%) was obtained from K_0 (no potassium) (Table 3).

A statistically significant difference was recorded for combined effect of mulch materials and potassium in terms of dry matter content of leaves (Appendix V).

The highest (6.91%) dry matter content of leaves was recorded from M_3K_3 (Saw dust mulch and 220 kg K_2O ha^{-1}) and the lowest (4.69%) dry matter content of leaves was recorded from M_3K_0 (Saw dust mulch and no potassium) (Table 4).

4.9 Cracked root

Cracked root varied significantly for different mulch materials that was used in this experiment (Appendix VI). The maximum (1.39%) cracked root was recorded from M_3 (Saw dust mulch) which was closely followed (1.28%) by M_2 (Water hyacinth mulch), while the minimum (1.22%) cracked root was found from M_1 (Black polythene mulch) under the present trial (Table 5). Woldetsadik (2003) reported that black plastic mulches increased yield upto three-fold without negative effects on the quality in shallot crop.

Different levels of potassium showed statistically significant variation on cracked root (Appendix VI). The maximum (1.36%) cracked root was recorded from K_2 (200 kg K ha^{-1}) which was statistically similar (1.33%) to K_3 (220 kg K_2O ha^{-1}), while the minimum (1.19%) was obtained from K_0 (no potassium) (Table 5).

Combined effect of mulch materials and potassium showed statistically significant differences in terms of cracked root (Appendix VI). The maximum (1.53%) cracked root was recorded from M_3K_3 (Saw dust mulch and 220 kg K_2O ha^{-1}) and the minimum (1.15%) cracked root was found from M_3K_0 (Saw dust mulch and no potassium) (Table 6).

4.10 Rotten roots

Rotten root varied significantly for different mulch materials those were used in the experiment (Appendix VI). The maximum (1.31%) rotten root was recorded from M_3 (Saw dust mulch) which was statistically identical (1.29% and 1.28%) to M_2 and M_0 (Water hyacinth mulch and control), while the minimum (1.27%) rotten root was recorded from M_1 (Black polythene mulch) under the present trial

(Table 5). Akand (2003) mentioned that mulch materials had significant effect on most of the yield contributed parameters of carrot.

Different levels of potassium showed statistically significant variation on rotten root (Appendix VI). The maximum (1.33%) rotten root was recorded from K_3 (220 kg K_2O ha^{-1}) which was identical (1.28%) to K_2 (180 kg K ha^{-1}), while the minimum (1.22%) was recorded from K_0 (no potassium) (Table 5).

Combined effect of mulch materials and potassium showed statistically significant differences in terms of rotten root (Appendix VI). The maximum (1.38%) rotten root was recorded from M_3K_3 (Saw dust mulch and 220 kg K_2O ha^{-1}) and the minimum (1.17%) rotten root was recorded from M_3K_0 (Saw dust mulch and no potassium) (Table 6).

4.11 Branched root

Different mulch materials that were used in this experiment varied significantly for branched root (Appendix VI). The maximum (1.39%) branched root was recorded from M_1 (Black polythene mulch) which was closely followed (1.38% and 1.37%) by M_3 and M_2 (Saw dust and Water hyacinth mulch) respectively, while the minimum (1.35%) branched root was obtained from M_0 (control) under the present trial (Table 5).

Different levels of potassium showed statistically significant variation for branched root (Appendix VI). The maximum (1.39%) branched root was recorded from K_3 (220 kg K ha^{-1})

Table 5. Effect of mulch materials and potassium on yield contributing characters and yield of carrot

Treatment(s)	Cracked root (%)	Rotten roots (%)	Branched root (%)	Gross yield of roots		Marketable yield/plot (kg)
				Kg/plot	t/ha	
Mulch materials						
M_0	1.28 b	1.28 ab	1.35 c	21.71 b	33.92 b	20.20 b
M_1	1.22 b	1.27 b	1.39 a	24.85 a	38.83 a	23.27 a
M_2	1.20 b	1.29 ab	1.37 b	24.37 a	38.08 a	22.68 a
M_3	1.39 a	1.31 a	1.38 b	24.49 a	38.26 a	22.05 a
$LSD_{(0.05)}$	0.096	0.037	0.018	1.613	2.513	1.204
Level of Significance	**	**	**	**	**	**
Potassium						
K_0	1.19 c	1.22 c	1.35 c	20.39 b	31.86 b	19.23 b
K_1	1.26 b	1.28 b	1.37 b	24.64 a	38.49 a	22.70 a
K_2	1.36 a	1.32 a	1.38 a	25.16 a	39.31 a	23.10 a
K_3	1.35 a	1.33 a	1.39 a	25.23 a	39.43 a	23.17 a
$LSD_{(0.05)}$	0.065	0.026	0.008	1.490	2.328	1.162
Level of Significance	**	**	**	**	**	**
CV(%)	6.82	11.62	8.83	9.23	8.75	8.46

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 6. Combined effect of mulch materials and potassium on yield contributing characters and yield of carrot

Treatment combination	Cracked root (%)	Rotten roots (%)	Branched root (%)	Gross yield of roots		Marketable yield	
				Kg/plot	t/ha	Kg/plot	t/ha
M_0K_0	1.18 d	1.23 ef	1.33 d	17.20 c	26.88 c	16.09 e	25.14 e
M_0K_1	1.19 d	1.26 de	1.35 cd	23.16 b	36.19 b	21.68 bc	33.79 bc
M_0K_2	1.29 cd	1.30 abc	1.36 c	23.36 b	36.50 b	21.63 bc	33.59 bc
M_0K_3	1.28 cd	1.29 abc	1.36 c	23.11 b	36.10 b	21.72 bc	33.75 bc
M_1K_0	1. 18 d	1.19 fg	1.38 ab	18.33 c	28.65 c	18.66 d	29.15 d
M_1K_1	1.13 d	1.24 de	1.39 ab	26.92 a	42.06 a	24.73 a	38.63 a
M_1K_2	1.24 d	1.31 cd	1.39 ab	27.25 a	42.58 a	24.91 a	38.93 a
M_1K_3	1.22 cd	1.32 bcd	1.39 ab	26.89 a	42.02 a	24.77 a	38.70 a
M_2K_0	1.22 d	1.28 cde	1.35 cd	23.38 b	36.53 b	21.75 bc	33.99 bc
M_2K_1	1.24 cd	1.27 de	1.36 c	24.46 ab	37.93 ab	22.60 abc	35.22 abc
M_2K_2	1.41 abc	1.32 cd	1.38 ab	24.81 ab	39.07 ab	23.13 ab	36.44 ab
M_2K_3	1.21 d	1.30 cd	1.39 ab	24.77 ab	38.85 ab	23.09 abc	36.08 abc
M_3K_0	1.15 d	1.17 g	1.33 d	22.64 b	35.37 b	20.43 cd	31.91 cd
M_3K_1	1.38 bc	1.30 cd	1.38 b	24.42 ab	37.81 ab	21.90 bc	34.22 bc
M_3K_2	1.49 ab	1.38 ab	1.39 a	25.06 ab	39.67 ab	22.73 abc	35.43 abc
M_3K_3	1.53 a	1.38 a	1.40 a	26.09 ab	40.52 ab	23.17 abc	36.27 abc
$LSD_{(0.05)}$	0.129	0.053	0.017	2.980	4.657	2.408	3.763
Level of Significance	**	**	**	*	*	*	**
CV(%)	6.82	11.62	8.83	9.23	8.75	8.46	6.55

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

which was statistically identical (1.38%) to K_2 (200 kg K_2O ha^{-1}), while the minimum (1.35%) was found from K_0 (no potassium) (Table 5).

Combined effect of mulch materials and potassium showed statistically significant differences in terms of branched root (Appendix VI). The maximum (1.40%) branched root was obtained from M_3K_3 (Saw dust mulch and 220 kg K_2O ha^{-1}), while the minimum (1.33%) branched root was recorded from M_0K_0 (No mulch and no potassium) (Table 6).

4.12 Gross yield per plot

Gross yield per plot varied significantly for different mulch materials (Appendix VI). The highest (24.85 kg/plot) gross yield was obtained from M_1 (Black polythene mulch) which was statistically identical (24.49 kg/plot and 24.37 kg/plot) to M_3 and M_2 (Saw dust and water hyacinth mulch) respectively, while the lowest (21.71 kg/plot) gross yield was recorded from M_0 under the present trial (Table 5). Islam *et al.* (1998) reported that utilization of indigenous materials, i.e. rice straw, wheat straw, rice husk and charcoal as soil aerating materials to increase yield of storage root of carrot under field conditions.

Different levels of potassium showed significant variation for gross yield per plot (Appendix VI). The highest (25.23 kg/plot) gross yield was recorded from K_3 (220 kg K ha^{-1}) which was statistically identical (25.16 kg/plot and 24.64 kg/plot) to K_2 and K_1 (200 kg K_2O ha^{-1} and 180 kg K_2O ha^{-1}) respectively, while the lowest (20.39 kg/plot) was recorded from K_0 (no potassium) (Table 5). Lyngdoh (2001) reported that the highest K level produced the highest yield per plot.

Combined effect of different mulch materials and different levels of potassium showed significant difference in terms of gross yield per plot (Appendix VI). The highest (27.25 kg/plot) gross yield was recorded from M_1K_2 (Black polythene mulch and 200 kg K_2O ha^{-1}), while the lowest (17.20 kg/plot) gross yield was recorded from M_0K_0 (No mulch and no potassium) (Table 6).

4.13 Gross yield per hectare

Different mulch materials that was used in this experiment differ significantly for gross yield per hectare (Appendix VI). The highest (38.83 t/ha) gross yield was recorded from M_1 (Black polythene mulch) which was statistically identical (38.26 t/ha and 38.08 t/ha) to M_3 and M_2 (Saw dust and Water hyacinth mulch), while the lowest (33.92 t/ha) gross yield was obtained from M_0 (control) under the present trial (Table 5). Munir (2003) mentioned that black polythene mulch was the most effective for successful carrot production (43.06 t/ha).

Different levels of potassium showed significant variation on gross yield per hectare (Appendix VI). The highest (39.43 t/ha) gross yield was recorded from K_3 (220 kg K_2O ha^{-1}) which was statistically identical (39.31 t/ha, 38.49 t/ha) with K_2 and K_1 (200 kg K_2O ha^{-1} and 180 kg K_2O ha^{-1} respectively), while the lowest (31.86 t/ha) was recorded from K_0 (no potassium) (Table 5). An interactive effect between N and K was found for plant height, root length, root diameter and root sugar content of carrot.

Due to combined effect of mulch materials and potassium showed significant differences in terms of gross yield per hectare (Appendix VI). The highest (42.58 t/ha) gross yield was recorded from M_1K_2 (Black polythene mulch and 200 kg K_2O ha^{-1}), while the lowest (26.88 t/ha) gross yield was recorded from M_0K_0 (No mulch and no potassium) (Table 6).

4.14 Marketable yield per plot

Statistically significant variation was recorded for marketable yield per plot on different types of mulch materials. (Appendix VI). The highest (23.27 kg/plot) marketable yield was obtained from M_1 (Black polythene mulch) which was statistically identical (22.68 kg/plot and 22.05 kg/plot) to M_2 and M_3 (Water hyacinth and Saw dust mulch respectively), while the lowest (20.20 kg/plot) marketable yield was recorded from M_0 (control) under the present trial (Table 5).

Different levels of potassium showed significant variation on marketable yield per plot (Appendix VI). The highest (23.17 kg/plot) marketable yield was recorded from K_3 (220 kg K_2O ha^{-1}) which was statistically identical (23.10 kg/plot, 22.70 kg/plot) to K_2 and K_1 (200 kg K_2O ha^{-1} and 180 kg K_2O ha^{-1}respectively), while the lowest (19.23 kg/plot) was recorded from K_0 (no potassium) (Table 5). Rao (1994) reported that yield of carrot were highest at 50 kg K_2O/ha. Sarker (1989) reported that highest marketable yield of carrot 34.27 t/ha was recorded when potash each at 120 kg/ha were applied.

A significant variation was found due to application of mulch materials and different levels of potassium on marketable yield per plot (Appendix VI). The highest (24.91 kg/plot) marketable yield was recorded from M_1K_2 (Black polythene mulch and 200 kg K_2O ha^{-1}), while the lowest (16.09 kg/plot) marketable yield was obtained from M_0K_0 (No mulch and no potassium) (Table 6).

4.15 Marketable yield per hectare

Marketable yield per hectare varied significantly due to different types of mulch materials (Appendix VI). The highest (36.35 t/ha) marketable yield was obtained from M_1 (Black polythene mulch) which was statistically identical (35.43 t/ha and 34.46 t/ha) to M_2 and M_3 (Water hyacinth and Saw dust mulch respectively), where as the lowest (31.57 t/ha) marketable yield was recorded from M_0 (control) under the present trial (Figure 6). Islam *et al.* (1998) reported that the fresh marketable storage roots were the greatest in the rice husk charcoal mixture, rice husk mass, rice straw mass and rice husk mixture. Lang (1984) reported that polythene mulch increased the yield of carrot (31.4-32.5 t/ha) compared with 23.2-32.6 t/ha in control.

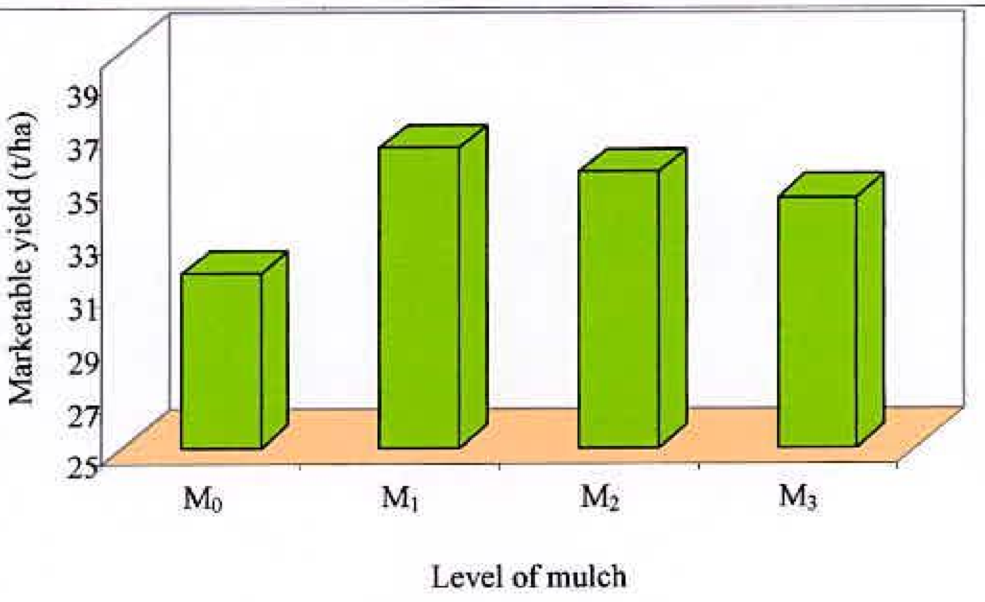

Figure 6. Effect of mulching on marketable yield of carrot

M_0 : No mulch M_1 : Black polythene
M_2 : Water hyacinth M_3 : Saw dust

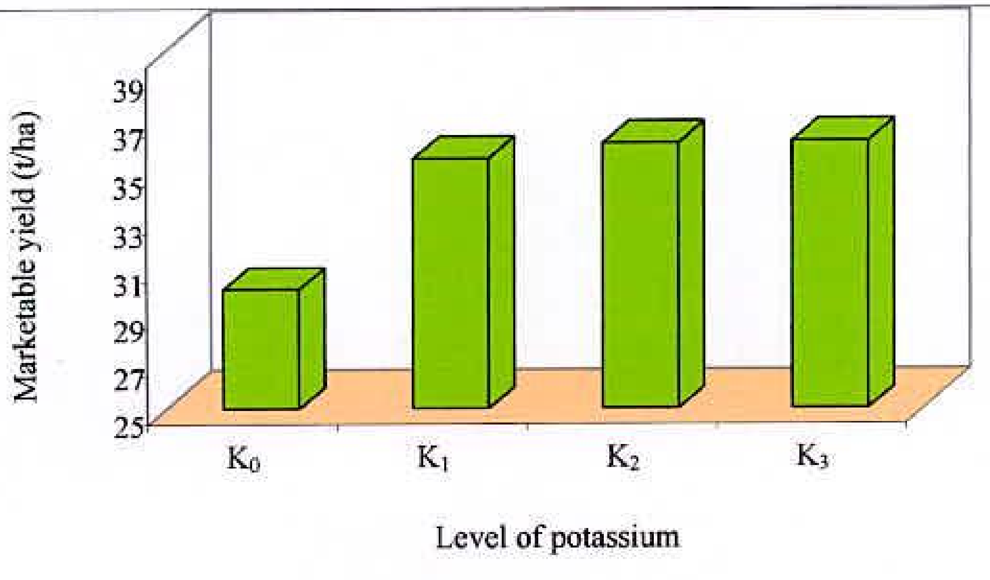

Figure 7. Effect of potassium on marketable yield of carrot

K0 : 0 kg K_2O ha-1 K1 : 180 kg K_2Oha-1
K2 : 200 kg K_2O ha-1 K3 : 220 kg K_2Oha-1

Statistically significant variation on marketable yield per hectare was recorded for the application of different level of potassium (Appendix VI). The highest (36.20 t/ha) marketable yield was recorded from K_3 (220 kg K_2O ha^{-1}) which was statistically identical (36.10 t/ha, 35.47 t/ha) with K_2 and K_1 (200 kg K_2O ha^{-1} and 180 kg K_2O ha^{-1}), while the lowest (30.05 t/ha) was recorded from K_0 i.e. no potassium (Figure 7). Crossman *et al.* (1998) found that mulch materials generally increased the marketable yield, with the plastic mulch producing the highest yield of roots. Lyngdoh (2001) reported that the highest K level produced the greatest yield of carrot per hectare.

Combined effect of mulch materials and different levels of potassium showed statistically significant differences in terms of marketable yield per hectare (Appendix VI). The highest (38.93 t/ha) marketable yield was noted from M_1K_2 (Black polythene mulch and 200 kg K_2O ha^{-1}), while the lowest (25.14 t/ha) marketable yield was obtained from M_0K_0 i. e. no mulch and no potassium (Figure 8).

4.16 Economic analysis

Input costs for land preparation, seed cost, fertilizer, mulch materials, thinning, irrigation and man power required for all the operations from sowing to harvesting of carrot were recorded for unit plot and converted into cost per hectare. Prices of carrot were considered in Kaoran bazaar market rate basis (Appendix VII). The economic analyses were done to find out the gross and net return and the benefit cost ratio in the present experiment and were presented under the following headings-

4.16.1 Gross return

In the combination of mulch materials and different levels of potassium showed different gross return under the trial (Table 7). The highest gross return (Tk. 389,300) was recorded from M_1K_2 (Black polythene mulch and 200 kg K_2O ha^{-1}) and the second highest gross return (Tk. 387,000) was recorded from M_1K_3 (Black polythene mulch and 220 kg K_2O ha^{-1}). The lowest gross return (Tk. 251,400) was noted from M_0K_0.

4.16.2 Net return

In case of net return different treatments combination showed different amount of net return. The highest net return (Tk. 223,032) was recorded from M_1K_2 and the second highest net return (Tk. 222,330) was found from M_1K_3. The lowest net return (Tk. 105,261) was recorded from M_0K_0 (Table 7).

4.16.3 Benefit cost ratio

The combination of mulch materials and potassium for benefit cost ratio was different (Table 7). The highest (2.34) benefit cost ratio was recorded of M_1K_2 and the second highest benefit cost ratio (2.32) was found from M_1K_3. The lowest benefit cost ratio (1.72) was obtained from M_0K_0. From economic point of view, it is apparent from the above results that the treatment combination of M_1K_2 was more profitable combination in compare to the other combinations.

Table 7. Cost and return of carrot cultivation as influenced by mulch materials and potassium

Mulch materials × Potassium	Cost of production (Tk./ha)	Yield of carrot	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
M_0K_0	146139	25.14	251400	105261	1.72
M_0K_1	155354	33.79	337900	182546	2.18
M_0K_2	156875	33.59	335900	179026	2.14
M_0K_3	157277	33.75	337500	180223	2.15
M_1K_0	155533	29.15	291500	135967	1.87
M_1K_1	164747	38.63	386300	221553	2.31
M_1K_2	166268	38.93	389300	223032	2.34
M_1K_3	166670	38.70	387000	222330	2.32
M_2K_0	149494	33.99	339900	190406	2.27
M_2K_1	158708	35.22	352200	193492	2.22
M_2K_2	160229	36.44	364400	204171	2.27
M_2K_3	160632	36.08	360800	200168	2.25
M_3K_0	152290	31.91	319100	166810	2.10
M_3K_1	161504	34.22	342200	180696	2.12
M_3K_2	163025	35.43	354300	191275	2.17
M_3K_3	163427	36.27	362700	199273	2.22

Market price of carrot @ Tk. 10,000/t

Gross return = Total yield (t/ha) × Tk. 10,000

Net return = Gross return - Total cost of production

Benefit Cost Ratio (BCR) = Gross return/Total cost of production

Chapter V

Summary and Conclusion

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from October 2006 to March 2007 to find out the effect of mulching and potassium on growth and yield of carrot. The experiment consisted of two factors. Factor A: 4 levels of mulch materials i.e. M_0: Control, M_1: Black polythene, M_2: Water hyacinth and M_3: Saw dust; Factor B: 4 levels of potassium viz. K_0: Control, K_1: 180 kg K_2O ha^{-1}, K_2: 200 kg K_2O ha^{-1} and K_3: 220 kg K_2O ha^{-1}. There were 16 treatments combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. Data on different yield contributing characters and yield were recorded.

The longest (43.30 cm) plant of carrot was obtained from M_1 and the shortest (37.41 cm) plant was recorded from M_0 at 90 DAS. The maximum (11.03) number of leaves per plant of carrot was found from M_1, while the minimum (7.89) was found from M_0 at 90 DAS. The largest (20.25 cm) length of root was obtained from M_1, while the smallest (15.38 cm) length of root was observed from M_0. The maximum (4.92 cm) diameter of root was recorded from M_1, while the minimum (4.10 cm) diameter of root was produced from M_0. The maximum (86.46 g) fresh weight of leaves per plant was found from M_1, while the minimum (77.15 g) fresh weight of leaves per plant was found from M_0. The maximum (118.49 g) fresh weight of root per plant was produced from M_1, while the minimum (102.25 g) fresh weight of root per plant was recorded from M_0. The highest (8.29%) dry matter content of roots was observed from M_1 and the lowest (7.45%) dry matter content of roots was observed from M_0. The highest (6.35%) dry matter content of leaves was collected from M_3, while the lowest (5.55%) dry matter content of leaves was collected from M_1. The maximum (1.39%) cracked root was found from M_3, while the minimum (1.22%) cracked root was found from M_1. The maximum (1.31%) rotten root was recorded from M_3, while the minimum (1.27%) rotten root was recorded from M_1. The maximum (1.39%) branched root was measured from M_1 and the minimum (1.35%) branched root was measured from M_0. The highest (24.85 kg) gross yield per plot was recorded from M_1, while the lowest (21.71 kg) was recorded from M_0. The highest (38.83 t/ha) gross yield was found from, while the lowest (33.92 t/ha) gross yield was found from M_0. The highest (23.27 kg) marketable yield per plot was observed from M_1 and the lowest (20.20 kg) was observed from M_0. The highest (36.35 t/ha) marketable yield was collected from M_1, while the lowest (31.57 t/ha) marketable yield was collected from M_0.

The longest (44.46 cm) plant was recorded from K_3, while the shortest (33.96 cm) was obtained from K_0 at 90 DAS. The maximum (11.42) number of leaves per plant was found from K_3, while the minimum (7.89) was found from K_0 at 90 DAS. The longest (20.58 cm) length of root was collected from K_3, while the shortest (15.35 cm) was collected from K_0. The maximum (4.85 cm) diameter of root was observed from K_3, while the minimum (4.03 cm) was observed from K_0. The maximum (87.30 g) fresh weight of leaves per plant was measured from K_3, while the minimum (74.39 g) was measured from K_0. The maximum (118.00 g) fresh weight of root per plant was recorded from K_3 and the minimum (98.45 g) was recorded from K_0. The highest (8.32%) dry matter content of roots was found from K_3, while the lowest (7.21%) was found from K_0. The highest (6.52%) dry matter content of leaves was observed from K_3, while the lowest (5.20%) was observed from K_0. The maximum (1.36%) cracked root was collected from K_2, while the minimum (1.19%) was collected from K_0. The maximum (1.33%) rotten root was measured from K_3, while the minimum (1.22%) was measured from K_0. The maximum (1.39%) branched root was recorded from K_3, while the minimum (1.35%) was recorded from K_0. The highest (25.23 kg) gross yield per plot was found from K_3, while the lowest (20.39 kg) was found from K_0. The highest (39.43 t/ha) gross yield was observed from K_3, while the lowest (31.86 t/ha) was observed from K_0. The highest (23.17 kg) marketable yield per plot was collected from K_3, while the lowest (19.23 kg) was collected from K_0. The highest (36.20

t/ha) marketable yield was measured from K_3, while the lowest (30.05 t/ha) was measured from K_0.

The longest (46.71 cm) plant was obtained from M_1K_3 and the shortest (29.74 cm) plant was recorded from M_3K_0 at 90 DAS. The maximum (12.22) number of leaves per plant was found from M_3K_3 and M_3K_2, while the minimum (7.00) number of leaves per plant was recorded from M_0K_0 at 90 DAS. The longest (23.72 cm) length of root was obtained from M_1K_3 and the shortest (14.08 cm) was recorded from M_0K_0. The maximum (5.15 cm) diameter of root was collected from M_1K_3 and the minimum (3.67 cm) diameter of root was collected from M_0K_0. The maximum (90.69 g) fresh weight of leaves per plant was observed from M_1K_3 and the minimum (71.49 g) fresh weight of leaves per plant was observed from M_0K_0. The maximum (123.11 g) fresh weight of root per plant was obtained from M_1K_3 and the minimum (89.99 g) fresh weight of root per plant was recorded from M_0K_0. The highest (8.68%) dry matter content of roots was collected from M_1K_3 (Black polythene mulch and 220 kg K ha^{-1}) and the lowest (6.43%) dry matter content of roots was collected from M_0K_0. The highest (6.91%) dry matter content of leaves was recorded from M_3K_3 and the lowest (4.69%) dry matter content of leaves was recorded from M_3K_0. The maximum (1.53%) cracked root was found from M_3K_3 and the minimum (1.15%) cracked root was found from M_3K_0. The maximum (1.38%) rotten root was collected from M_3K_3 and the minimum (1.17%) rotten root was collected from M_3K_0. The maximum (1.40%) branched root was observed from M_3K_3 and the minimum (1.33%) branched root was observed from M_0K_0. The highest (27.25 kg) gross yield per plot was collected from M_1K_2, while the lowest (17.20 kg) gross yield was collected from M_0K_0. The highest (42.58 t/ha) gross yield was recorded from M_1K_2, while the lowest (26.88 t/ha) gross yield was recorded from M_0K_0. The highest (24.91 kg) marketable yield per plot was obtained from M_1K_2 and the lowest (16.09 kg) was obtained from M_0K_0. The highest (38.93 t/ha) marketable yield was recorded from M_1K_2, while the lowest (25.14 t/ha) marketable yield was recorded from M_0K_0. The highest (2.34) benefit cost ratio was found of M_1K_2 and the lowest benefit cost ratio (1.72) was found from M_0K_0. From economic point of view, it is apparent from the above results that the treatment combination of M_1K_2 was more profitable combination.

Considering the situation of the present experiment, the following recommendation in the following areas may be suggested:

1. Another mulch material that was available commonly in village may be included for future study.
2. Another doses of potassium may be used for future study for identify specific doses of potassium.
3. Other inorganic fertilizer may be included for specification of fertilizer doses.
4. Such study may be carried out in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.

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APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from September 2006 to March 2007

Month	Air temperature (^0C)		R..H. (%)	Total rainfall (mm)
	Maximum	Minimum		
September 06	26.20	24.1	73	07
October 06	26.70	21.1	89	07
November 06	24.00	20.1	87	02
December 06	21.00	20.9	64	04
January 07	20.20	21.85	74	15
February 07	20.25	18.55	71	22
March 07	22.25	19.30	75	38

Source : Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka-1212

Appendix II. Results of mechanical and chemical analysis of soil of the experimental plot

Mechanical analysis

Constituents	Percent
Sand	33.45
Silt	60.25
Clay	6.20
Textural class	Silty loam

Chemical analysis

Soil properties	Amount
Soil pH	6.12
Organic carbon (%)	1.32
Total nitrogen (%)	0.08
Available P (ppm)	20
Exchangeable K (%)	0.2

Source: Soil Resource Development Institute (SRDI)

Appendix III. Analysis of variance of the data on plant height of carrot as influenced by mulching and potassium

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		45 DAS	60 DAS	75 DAS	90 DAS
Replication	2	2.223	1.275	3.138	8.259
Mulching (A)	3	107.095**	47.626**	50.208**	71.594**
Potassium (B)	3	667.725**	169.254**	186.532**	285.336**
Interaction (A×B)	9	163.935**	12.012**	10.779*	17.071*
Error	30	126.956	4.021	4.709	7.625

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of leaves per plant of carrot as influenced by mulching and potassium

Source of variation	Degrees of freedom	Mean square			
		Number of leaves per plant at			
		45 DAS	60 DAS	75 DAS	90 DAS
Replication	2	0.142	0.169	0.320	0.029
Mulching (A)	3	3.184**	1.350**	6.935**	7.426**
Potassium (B)	3	4.218**	4.942**	23.300**	33.051**
Interaction (A×B)	9	0.664*	0.522*	0.624**	1.153**
Error	30	0.265	0.193	0.218	0.363

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on yield contributing characters and yield of carrot as influenced by mulching and potassium

Source of variation	Degrees of freedom	Mean square					
		Length of root (cm)	Diameter of root (cm)	Fresh weight leaves per plant (g)	Fresh weight root per plant (g)	Dry matter content of roots (%)	Dry matter content leaves (%)
Replication	2	0.216	0.026	13.716	2.616	0.073	0.526
Mulching (A)	3	49.163**	1.330**	181.195**	541.810**	1.534**	1.523**
Potassium (B)	3	65.608**	1.670**	408.131**	996.976**	3.082**	3.921**
Interaction (A×B)	9	5.205**	0.072*	15.340*	58.588*	0.321*	0.658*
Error	30	1.414	0.026	5.836	25.932	0.148	0.282

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield contributing characters and yield of carrot as influenced by mulching and potassium

Source of variation	Degrees of freedom	Mean square						
		Cracked root (%)	Rotten roots (%)	Branched root (%)	Total yield of roots		Marketable yield	
					Kg/plot	t/ha	Kg/plot	t/ha
Replication	2	0.001	0.001	0.0001	2.300	5.615	0.546	1.334
Mulching (A)	3	0.066**	0.003**	0.003**	25.062**	61.187**	21.117**	51.556**
Potassium (B)	3	0.068**	0.037**	0.004**	64.910**	158.472**	42.903**	104.743**
Interaction (A×B)	9	0.019**	0.004**	0.0001**	8.951*	21.854*	4.633*	11.311**
Error	30	0.006	0.001	0.0001	3.194	7.798	2.086	5.092

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VII. Production cost of carrot as influenced by mulching and potassium per hectare

A. Input cost

Treatment Combination	Labour cost	Ploughing cost	Seed Cost	Water for plant Establishment	Mulch Materials	Manure and fertilizers				Insecticide/ pesticides	Sub Total (A)
						Cowdung	Urea	TSP	MP		
M_0K_0	14000.00	8000.00	2500.00	2000.00	0.00	20000.00	1200.00	2700.00	0.00	6000.00	56400.00
M_0K_1	19000.00	8000.00	2500.00	2000.00	0.00	20000.00	1200.00	2700.00	3240.00	6000.00	64640.00
M_0K_2	20000.00	8000.00	2500.00	2000.00	0.00	20000.00	1200.00	2700.00	3600.00	6000.00	66000.00
M_0K_3	20000.00	8000.00	2500.00	2000.00	0.00	20000.00	1200.00	2700.00	3960.00	6000.00	66360.00
M_1K_0	14000.00	8000.00	2500.00	2000.00	8400.00	20000.00	1200.00	2700.00	0.00	6000.00	64800.00
M_1K_1	19000.00	8000.00	2500.00	2000.00	8400.00	20000.00	1200.00	2700.00	3240.00	6000.00	73040.00
M_1K_2	20000.00	8000.00	2500.00	2000.00	8400.00	20000.00	1200.00	2700.00	3600.00	6000.00	74400.00
M_1K_3	20000.00	8000.00	2500.00	2000.00	8400.00	20000.00	1200.00	2700.00	3960.00	6000.00	74760.00
M_2K_0	14000.00	8000.00	2500.00	2000.00	3000.00	20000.00	1200.00	2700.00	0.00	6000.00	59400.00
M_2K_1	19000.00	8000.00	2500.00	2000.00	3000.00	20000.00	1200.00	2700.00	3240.00	6000.00	67640.00
M_2K_2	20000.00	8000.00	2500.00	2000.00	3000.00	20000.00	1200.00	2700.00	3600.00	6000.00	69000.00
M_2K_3	20000.00	8000.00	2500.00	2000.00	3000.00	20000.00	1200.00	2700.00	3960.00	6000.00	69360.00
M_3K_0	14000.00	8000.00	2500.00	2000.00	5500.00	20000.00	1200.00	2700.00	0.00	6000.00	61900.00
M_3K_1	19000.00	8000.00	2500.00	2000.00	5500.00	20000.00	1200.00	2700.00	3240.00	6000.00	70140.00
M_3K_2	20000.00	8000.00	2500.00	2000.00	5500.00	20000.00	1200.00	2700.00	3600.00	6000.00	71500.00
M_3K_3	20000.00	8000.00	2500.00	2000.00	5500.00	20000.00	1200.00	2700.00	3960.00	6000.00	71860.00

Seed 500 g @ Tk. 5000/kg; Black polythene 1200 m/ha @ Tk. 10.0/m; Saw dust 140 bag/ha @ Tk. 50/bag, Water hyacinth @ Tk. 3000/ha; Urea @ Tk. 7/ka; TSP @ Tk. 18/kg; MP @ Tk. 18 kg/ha; Labour cost @ Tk. 100/day