PERFORMANCE OF NITROGEN AND MOISTURE MANAGEMENT TECHNIQUES ON GROWTH AND YIELD OF KOHLRABI

By

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CERTIFICATE

This is to certify that the thesis entitled, "*PERFORMANCE OF NITROGEN AND MOISTURE MANAGEMENT TECHNIQUES ON GROWTH AND YIELD OF KOHLRABI*" submitted to the Department of Horticulture and Postharvest Technology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE*** in ***HORTICULTURE***, embodies the result of a piece of bona fide research work carried out by *Mahbubur Rahman, Registration No. 03-01140* under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or sources of information as has been availed of during the course of this inquire have been duly acknowledged and the contents & style of the thesis have been approved and recommended for submission.

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DEDICATED TO

MY BELOVED PARENTS

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ABSTRACT

The field experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2007 to January, 2008 to study the performance of nitrogen and moisture management techniques on growth and yield of kohlrabi. The trial consisted of four levels of nitrogen fertilizer, viz., N_0: 0; N_1: 80; N_2: 160; N_3: 240 kg N/ha respectively and five different moisture management techniques, viz., M_0: No moisture management; M_1: Straw mulch; M_2: Water hyacinth mulch; M_3: Black plastic mulch; M_4: Three times of irrigation. The experiment was carried out in randomized complete block design with three replication. Most of the parameter varied insignificantly as influenced by the application of moisture management techniques and nitrogen fertilizer. Maximum marketable yield (35.9 t/ha) was obtained from N_3 and the lowest (24.5 t/ha) was obtained with N_0. For moisture management, M_2 produced the highest yield (35.4 t/ha) and the lowest yield (27.4 t/ha) was recorded from M_0. Combination of N_3M_2 gave the highest yield (41.3 t/ha) and the lowest (12.9 t/ha) was received from N_0M_0. Benefit cost ratio was maximum (3.9) in the treatment combination of N_3M_2 and the lowest (1.4) was in control treatment. So, 240 kg N/ha with water hyacinth was best for growth and yield of kohlrabi.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
ANOVA	=	Analysis of Variance
BARI	=	Bangladesh Agricultural Research Institute
BADC	=	Bangladesh Agricultural Development Corporation
BARC	=	Bangladesh Agricultural Research Council
BCR	=	Benefit Cost Ratio
cv.	=	Cultivar
CV%	=	Percentage of Coefficient of Variance
DAT	=	Days after Transplanting
DMRT	=	Duncan's Multiple Range Test
et al.	=	And others
F. C.	=	Field Capacity
FAO	=	Food and Agricultural Organization
ha	=	Hectare
Hort	=	Horticulture
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
Max	=	Maximum
Man	=	Minimum
NS	=	Not Significant
Ppm	=	Parts per million
Rh	=	Relative humidity
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
TSP	=	Triple Super Phosphate
t/ha	=	Ton per hectare

CHAPTER I

INTRODUCTION

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Kohlrabi (*Brassica oleracea* var. *gongylodes*) is known as Knolkhol often called "Turnip rooted cabbage", originated in North-Europe. Generally, the modified stem is used as vegetable. Kohlrabi is one of the winter vegetables of Bangladesh under the family of Cruciferae.

Kohlrabi is a member of cole crops and closely related to cabbage. It is also a short duration vegetable crop. It has high nutritive value, contains substantial amount of moisture (92.7 g), protein (1.1 g), fat (0.2 g), mineral (0.7 g), vitamin A (38 IU) and vitamin C (85 mg) per 100 g of edible portion (Choudhury, 1967). Due to lack of awareness regarding its nutritive value and method of production, the kohlrabi cultivation has not been much extended beyond the farms of different agricultural organizations.

All types of soil are suitable for kohlrabi cultivation. However, fertility favors growth in a uniform manner. Judicious application of fertilizer and proper cultural management are related to get proper growth and high yield of kohlrabi.

Kohlrabi responds greatly to major essential elemental nutrient like N, P and K in respect to its growth and yield (Thomson and Kelly, 1957). In tropical to subtropical regions, the soils are seriously impoverished in plant nutrients due to intensive weathering and leaching. Plants require food for growth and development in the form of proper doses of nitrogen (N), phosphorus (P), potassium (K), sulfur (S), boron (B) and zinc (Zn). Nitrogen is a part of chlorophyll molecule, amino acid, proteins, nucleic acid and pigments. Adequate supply of nitrogen favors the transformation of carbohydrates into proteins and promotes the good quality foliage (Rai, 1981). Addition of nitrogen enhances vegetative growth and its deficiency leads to stunted growth with small yellow leaves and low production (Haque and Jakhro, 1996).

Generally, kohlrabi is cultivated in Bangladesh during the winter season when rainfall is scanty. In most of the time irrigation expenses increase the cost of production of kohlrabi and make grower frustrated. Necessity of irrigation is not costly but not easily available all over the country. To overcome such problems, mulching can play a vital role by conserving soil moisture of the preceding season and which is exploited during the growing season to make cultivation of kohlrabi profitable. Mulching is of two types, natural and artificial mulching. Natural mulching means the breaking of the upper crust of soil to disconnect the capillary tube for checking evaporation. Artificial mulching is the covering of soil with crop residues or polythene sheet or any other materials. Mulching increases the efficiencies of the applied fertilizer (Roy *et al.*, 1990).

Nitrogen and soil moisture management are the two important variables in kohlrabi production. There is no enough information with conclusive evidence of optimum use of nitrogen and soil moisture management for the production of kohlrabi under Bangladesh condition.

Present study was undertaken with the following objectives:

i). to study the growth and yield of kohlrabi under different doses of nitrogen fertilizer.
ii). to study the growth and yield of kohlrabi under different soil moisture management.
iii). to evaluate the interaction effect of nitrogen fertilizer and soil moisture management on growth and yield of kohlrabi.

CHAPTER II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

Kohlrabi is grown in Bangladesh in the rabi season. Its growth and yield were influenced by nitrogen and soil moisture management techniques. Researches on various aspects of its production technology have been carried out world wide. Limited number of research finding regarding the effects of nitrogen fertilizer and soil moisture management techniques on the growth and yield of kohlrabi and related crops have been presented under the following headings.

2.1 Effect of nitrogen on growth and yield of kohlrabi

Fertilizers are indispensable for the production system of modern agriculture and play a vital role to increase the yield, provided other factors are not limiting. Chemical fertilizers today hold the key to the success of the crop production system of Bangladesh agriculture, being contributed 50 percent of the total production (BARC, 1997). Chemical fertilizer supplies sufficient available nutrients readily for proper growth and development of plant. Among the major macro nutrients largely the plants use NPK. Physio-morphological and biological developments of plants depend on the judicious application and supply on NPK. An excess or deficiency of NPK causes remarkable effect on growth and development of plant. An excess of nitrogen results in a stimulation of vegetative growth, which may lead to delayed maturity. Some available information about in effects of nitrogen fertilizer on growth and yield of kohlrabi are reviewed here.

Effects of N fertilizer with nitrification inhibitor DMPP (3, 4-dimethylpyrazole phosphate) on nitrate accumulation and quality of cabbage was studied by Xu-Chao *et al.* (2004). The fertilizer used was ammonium sulfate nitrate (ASN), with the new nitrification inhibitor (NI), 3, 4-dimethylpyrazole phosphate (DMPP). Two field trials were conducted in Jinhua and Xinchang County, Zhejiang province (China) in 2002. NPK 15-15-15S was applied as basal; NPK as basal + ASN as topdressing; and NPK as basal and ASN + DMPP as top dressing. DMPP increased the main yield by 2 t/ha in Jinhua and 5.5 t/ha in Xinchang, and decreased NO_3—N content by -9.4% in Jinhua, -7.3%. DMPP improved nutritional quality by increasing the vitamin C, soluble sugars, K, Fe and Zn contents.

Devi *et al.* (2003) reported that cabbage cv. Vignesh plants were supplied with 100 and 75% recommended N rate alone or in combination with bio-fertilizer (*Azospirillum brasilense*) 75 and 50% recommended N rate and cowdung manure on poultry or in combination with bio-fertilizers in a field experiment conducted in Mohanpur, West Bangal, Indian during the rabi season of 2000-21. They observed that crop yield was highest (55.82 t/ha) with the application of 50% recommended N + 25% poultry manure + bio-fertilizer, where as benefit cost ratio was highest (4.3) with the application of 75% N + bio-fertilizers.

Ahmed *et al.* (2003) showed by an experiment the effect of seven different NPK levels on the growth and yield of kohlrabi. Nitrogen, phosphorus and potassium were applied alone ass well as in various combinations and had a significant effect on various plant growth and yield parameters. Maximum tuber weight (430.80 g) tuber diameter (10.23 cm), number of leaves per plant (14.38) and tuber yield (25.85 t/ha) was recorded in plots fertilizer with 160-120-160 kg NPK/ha. It can be concluded that NPK @ 160-120-60 kg/ha was found to be the best fertilizer dose for the higher yield of Kohlrabi.

Patil *et al.* (2003) conducted a field experiment, the effect of spacing (30x15, 30x20 or 30x30 cm) and N rate (0, 50, 100 or 150 kg/ha) on the growth and yield of *B. oleracea* var. caulorapa [*B. oleracea* var. *gongylodes*] cv. White Vienna were studied in Akola, Maharashtra, India, during the rabi season of 2001/02. The widest spacing (30 x 30 cm) resulted in the greatest plant height (32.0 cm), number of leaves per plant (16.60), leaf area per plant (1927.23 cm^2), plant spread (50.88 cm in the north-south direction and 47.89 cm in the east-west direction), fresh weight of knob (196.24 g), and horizontal (6.17 cm) and vertical (6.04 cm) diameter of knob, and in the lowest number of days to edible maturity (61.20 days). However, the highest knob yield (272.21 quintal/ha) was obtained under the closest spacing (30x50 cm). N at 150 kg/ha was superior to lower N rates in terms of plant height (32.91 cm), number of leaves per plant (17.20), plant spread (52.10 cm in the north-south direction and 48.88 cm in the east-west direction), leaf area per plant (1925.06 cm^2) and knob yield (272.21quintal/ha).

Rai *et al.* (2003) observed the effects of spacing (25cm x 25cm, 30cm x 25cm and 30cm x 30cm) and NPK level (80:60:60, 100:80:80, 120:100:100 and 140:120:120 kg/ha) on the growth and yield of knolkhol (*Brassica oleracea* var. *gongylodes*) cv. White Vienna in Raipur, Madhya Praddesh, India, during winter season. The growth and yield contributing parameters, except for leaf breadth, horizontal head length and yield did not differ with spacing. However, in the NPK treatments, all the growth and yield attributes, except for horizontal knob length, significantly increased as the level of NPK increased. A spacing of 25cm x 20cm and NPK level of 140:120:120 kg/ha were found the most effective treatments to obtained high yield of knolkhol.

Yadav *et al.*(2003) reported by an experiment to study the effects of amino acid (0.4, 0.6 or 0.8%) and urea (2 or 3%), applied once or twice, on the growth and yield of knolkhol (*Brassica oleracea* var. *gongylodes*) cv. White Vienna were studied in Jobner, Rajasthan, India during 1994. Plant height, number of leaves per plant, leaf fresh weight, leaf N content, knob: leaf ratio, fresh weight of knob, knob yield per ha, and biological yield increased with increasing rate of amino acid. The greatest plant height (35.25 cm), number of leaves (13.46 per plant), leaf fresh weight (198.0 g), leaf N content (3.89%), knob:leaf ratio (0.755), knob yield (244.58 quintal/ha) and biological yield (573.1 quintal/ha) were obtained with 0.8% amino acid. These parameters also increased with increasing rate of urea. Spraying of 3% urea resulted in the greatest plant height (33.42 cm), leaf fresh weight (176.9 g), fresh weight of knobs per plant (130.56 g), volume of knob (112.17 ml), knob yield (quintal/ha), and biological yield (511.4 quintal/ha).

Shalini *et al.* (2002) conducted field trial during rabi season of 1999 in Dharwad, Karnataka, India to study the effect of two organic manures (Farmyard manure and Vermicompost (Vc) along with inorganic N fertilizer with and without Azospirillum, it was found that both the organic manures had significant effect in increasing growth, yield and as well as in maintaining the fertility of red sandy clay soil. Application of 50% (urea) + 50% N (vc) + Azospirillum resulted in higher availability and uptake of nutrients by knolkhol (kohlrabi) and thus produced the maximum yield of 37 t/ha.

Fink (2001) carried out the field experiment and showed the yield and external quality of kohlrabi as affected by soil mineral nitrogen residue at harvest. Vegetable crops often leave large amounts of nitrogen (N) in the field after harvest, both in harvest residues and as residual mineral nitrogen (N) in the soil. If there is a risk of leaching after harvest the residual N (mineral) should not be higher than required to secure good yield and quality.

To determine the required N residue for the vegetable crop kohlrabi (*Brassica oleracea* var. *gongylodes*), field experiment were carried out over two years (1991-95) with a range of nitrogen supplies, and yield and external quality (leaf color and leaf fresh matter) were measured. The required N residue was estimated using the break point of a linear response and plateau regression model. The break points estimated (35 kg N/ha for leaf color, 35 kg N/ha for leaf fresh matter and 28 kg N/ha for total fresh matter yield) were similar and agreed well both with break points estimated from other published data and empirically derived values for kohlrabi.

Das *et al*. (2000) investigated by an experiment and observed that the effect of various levels of N:P:K fertilizers (80:60:50, 120:90:75, 160:120:100 and 200:150:125 kg/ha) and plant densities (45x45, 60x45 and 60x60 cm) on curd production of cauliflower cv. pusa katki was evaluated in a field experiment in Assam, India. Curd yield per plant was maximum at spacing of 60x60 cm and at a NPK rate of 160:120:100 kg/ha.

Elkhorn (2000) carried out a field experiment in Poland to investigate the effect of the cultivar and nitrogen fertilization on the content of dietary fiber and its composition in some cruciferous vegetables. The amount and composition of the dietary fiber in kohlrabi was studied. N fertilization was based on the nitrate contained in the superficial soil layer down to a depth of 60 cm. The growing kohlrabi was top dressed with ammonium nitrate (50 kg, 100 kg and 150 kg/ha) three weeks after transplanting. Increasing the rate of N application decreased the dietary fiber of kohlrabi, which could be related to changes in the cellulose, hemicellulose, lignin and pectin contents. The increase in N fertilizer caused a decrease in the hemicellulose and cellulose contents of these species. Pectin, however, increased under the influence of N fertilization.

Liu *et al*. (1999) investigated the effect of different ratios of NPK combination on yield and nitrate accumulation of Chinese cabbage. The level of N were 0, 90, 180, 270 kg/ha; the levels of K_2O were 0, 90, 180, 270 kg/ha. The results showed that the best results were obtained with N 360 + P 90 + K 180. The nitrate accumulation was increased with the increase or the amount of N applied.

Schlereth *et al*. (1998) conducted an experiment in Germany and studied the effect of CULTAN fertilizing for kohlrabi. The kohlrabi was given with 110, 135 or 160 kg N/ha using the CULTAN system (controlled uptake long term ammonium nutrition) where by concentrated urea is injected into the soil to the row or was given with 160 kg N/ha calcium nitrate. Average tuber diameter was about 80 mm and was not significantly by N amount or source nitrate content of tuber was the lowest with CULTAN fertilizer and the highest with the standard calcium ammonium nitrate fertilizer.

A field experiment was conducted by Andreas (1997) in Germany to assess the long-term N fertilizer for vegetables without leaching and nitrate problem. In the CULTAN (controlled uptake long-term ammonium nutrition) system, N is given in the form of an ammonium / urea solution. It is supplied by injection to a depth of about 8 cm some 5cm form the routable. Because ammonium solution is concentrated (25% N) and toxic to nitrifying bacteria, and the ions bind to soil colloids prevention leaching. In experiments during 1995-96 with the CULTAN method supplying 100 or 80% of the estimates N requirement was compares with nitrate fertilization or of fertilizer. The CULTAN method produced yields similar to the nitrate treatment, with good external and internal quality, low soil nitrate, and reduced nitrate concentration in plant tissues. Labor requirements were low, and growers were stratified with the CULTAN system.

Bjelic (1997) carried out a field trials in the lazarevac region of yogoslavia, with cauliflower cv. Lawyna on pseudogley soil and given N fertilizer at 80, 120, 160 or 200 kg N/ha, in addition to 120 kg P/ha and 90 kg k/ha, at the time of transplanting (all P all k and half N dose and as top dressing (half N dose). He observed that nitrogen application increase curd diameter and significantly increased cauliflower yields (average 10.68 t/ha increase over control). However N fertilizer rates greater than 160 kg/ha did not significantly increase cauliflower.

An experiment was carried out by Chaltoo *et al.* (1997) to investigate the effect of *Azospirillium* and *Azotobacter* on growth, yield and quality of kohlrabi. The experiments were conducted during winter and kharif (monsoon) 1996 in Shalimar, Srinagar, India on kohlrabi cv. early White Vienna. In the experiment, N fertilizer was applied at 0, 25, 50, 75 or 100% of the recommended rate. They observed that crop yield increased N rate increased.

According to Lopandic *et al.* (1997) 10 fertilizer combination were used to investigated the actual effect of nitrogen fertilizer on the yield of cabbage the treatment combination of 240 kg N/ha + 140 kg N/ha + 210 kg K/ha + 46% foliar sprayed urea showed the best result (average 42.14 t/ha over the 3 years).

An experiment was trialed by Blank *et al.* (1996) in Germany to assess the ammonium nutrition that enhances chlorophyll and glaucoseness in kohlrabi. Kohlrabi plant cv. Express Forcer was grown in pots in a greenhouse from mid-September at day/night temperature 15-21/10-13°C. The pots content with a peat mixture which was deficient in N (<17 mg total N/plant). All plants were supplied with 0.6 g N, either as pellets (40% ammonium sulfate, 60% urea) or complete nitrate based Hoagland solution (94% of N as nitrate, 6% as ammonium). Plants given pellets (high ammonium) developed glucose leaves, where as those supplied with nutrient solution (high nitrate) produced glossy leaves. Ammonium induced glaucousness was the result of a doubling in the amount of epicuticular wax and a markedly altered fine structure. Leaves from ammonium fertilized plants also had a 21% increase in chlorophyll concentration and reductions in the chlorophyll a : b ratio and ground state fluorescence compared with nitrate fertilized plants. N from did not affect photosynthesis or stomatal transpiration.

An experiment was conducted by Gopal and Lal (1996) to find out the effect of silnegen and spacing on yield and quality of cabbage cv. Golden Aere in India. They used different levels of nitrogen 0, 50, 75 or 100 kg/ha. Growth (number of leaves, height of plant and weight of head) was increased with increasing rates of N. The highest yield (254.85 q/ha) was observed at a rate of 100 kg N/ha compared with 168.73 q/ha in control.

Hodges and Nozzolillo (1996) conducted an experiment in Canada to assess the anothocyanin and anothocyanoplast contents of cruciferous seedlings subjected to mineral nutrient deficiencies. Seedlings of kohlrabi were grown hydroponically with complete nutrient solutions or with nutrient solutions lacking nitrogen (N), phosphorus (P) or potassium (K). Generally, anothocyanin content was increased and growth was reduced on N and P nutrients as compared with plants on complete or K nutrients.

Hochmuth *et al.* (1993) conducted an experiment to investigate the reponse of cabbage yields, head quality and leaf nutrient status to poultry manure fertilization. They reported that the marketable yield of cabbage responded quadratically to increasing rates of poultry manure during 1990, with the maximum yield (28.4 t/ha) being obtained by 18.8

t/ha. Yields recorded with 1.0 to 1.4 of conventional NPK fertilizer/ha were same as those with the highest rate of manure. The results showed that manuring efficiency was initially higher with commercial fertilizer than the poultry manure alone, since lower amounts of total nutrients were applied using commercial fertilizer.

An experiment was carried out by Fischer (1992) in Germany to assess the influence of different nitrogen and potassium fertilization on the chemical flavour composition of kohlrabi (*Brassica oleracea* var. *gongylodes* L.) kohlrabi plants (cv. Lanro) were grown in pots and fertilized with varying amount of N.P.K and with Fe, Mn, Cu, Zn, Mo and boric acid. Edible parts were harvested 14 weeks after transplanting and samples were analyzed for dry matter, crude protein and K content. Volatile components were isolated by dynamic head space sampling and analyzed by GC. Increasing N and K supplies in variable amounts of isothicyanates, organic cyanides, sulphides and aldehydes. The inverse relationship which existed between the levels of flavour compounds and N supply could be utilized in production practices to obtain optimum flavour quality. It was concluded that changes in the aroma of kohlrabi after increased fertilizers inputs were use of alkylisothio cynates with their low threshold values and specific odour qualities.

Sommer (1992) applied ammonium nitrate either in split application of topdressing or according to the cultan system to spinach, kohlrabi, lettuce, endives and beet roots. It was found that cultan system gave similar yields to topdressing, while reducing the amount of N applied by 20-30%.

A field trial was conducted by Hill (1990) with 6 levels of N on the yield of chinese cabbage. In this experiment 0, 50, 100, 200 or 400 kg N/ha were used. The maximum marketable yield of 166.6 and 123.6 t/ha with the N-rates of 200 and 300 kg/ha respectively were obtained and the yield decreased when the N-rates was increased to 400 kg/ha. It was also noted that damage due to soft rot which was severe at the highest N-rate and contributed to reduce of yield.

Will and Hahndel (1989) carried out a field experiment and found that kohlrabi was grown under polythene sheeting alone and given 0-300 kg N/ha. The added N was in a slow release from and the soil mineral N content at the beginning of the experiment was 10 kg/ha. When grown under plastic and/or veils the highest yields were obtained with 240 kg N/ha compared with 180 kg N/ha for plant without protection.

Wendt (1989) found that kohlrabi was grown in 8 consecutive periods using NFT (nutrient film technique) with a different N fertilization regimes by supplying nitrate (concentration unspecified) from the beginning of the culture period but with drawing it 6-8 days before harvest, the nitrate content of the stems could be kept below 1600 p.p.m. without affecting the carbohydrate concentration. Supplying N in the form of 80% NH_4 + 20% NO_3 also reduced the nitrate concentration, but resulted in poorly developed stem.

During 1983-86 a field experiment was conducted by Lawande *et al.* (1988) to study the effect of N, P and K fertilizers demonstrated that yield and average stem tuber weight at kohlrabi cv. White Vienna increased with increasing N rate 185.8 q/ha and 125.4 g, respectively at 80 kg N/ha, P and K had no significant effect on yield.

An experiment was conducted by Burghardt and Ellering (1987) and observed that kohlrabi was supplied with 150-300 kg/ha of various N fertilizers. Crop yields were similar when supplied with solid or liquid area or $NH4NO_3$ + urea of equivalent N rates and were significantly higher than in unfertilized controls. Late application of fertilizer produced slightly higher yields and markedly higher crop NO_3 contents than early-season application. Applying the fertilizer in >3 split doses produced no further increases in yield but tended to increase crop NO_3 contents.

Heins and Schenk (1987) were investigated in the field and in solution culture. Optimum mineral N supply of kohlrabi was 250 and 150 kg/ha. respectively lower fertilizer rates decreased shoot yield, where as root yield was slightly diminished.

Prabhakar and Srinivas (1987) used three nitrogen levels (0, 75 and 150 kg/ha) and found that individual head yield was increased with increasing nitrogen upto 150 kg/ha (1.76 t/ha) compared with 1.04 with 75 kg N/ha and 0.23 t/ha in the control.

An experiment was carried out at Joydebpur, Gazipur on cabbage (var. Atlas-70) during the Rabi season to find out the effect of chemical fertilizer and manure (Ann., 1985). There were five levels of nitrogen (0, 60, 120, 180 and 240 kg N/ha from urea) four levels of phosphorus (0, 60, 90 and 120 kg N/ha from TSP) and four levels of potassium (0, 60, 120 and 180 kg K_2O/ha from MP) along with cowdung @ 5 t/ha. The head yield increased with the increasing rate of NPK. The highest head of 110.98 t/ha was obtained from the combined effect of 180 kg N/ha, 120 kg P_2O_5/ha and 120 kg K_2O/ha with 5 t/ha of cowdung.

Voigtlander (1978) studied when kohlrabi received 1-4 dressings of liquid fertilizer (N) by sprinkler irrigation instead of by normal application higher yields were obtained.

Simon (1976) the result are presented of 3 years trial with the early kohlrabi cv. moravia receiving 3 irrigation and 3N treatments. The higher yields regardless of the N rate were produced by the lowest irrigation rate 50% available water capacity. Application had a greater effect on yields than irrigation. Rising N rates increased yields and earliness proportionately and reduced cracking.

An experiment was conducted by Saxena *et al.* (1975) to evaluate the effect of N, P and K on cabbage and tomato and reported that application of nitrogenous fertilizer cause vigorous vegetative growth and linear increase in yield. The yield of cabbage cv. SO-cross increased from 13.1 to 26.8 t/ha when N was increased from 56 to 224 kg/ha white the KK-cross yielded from 21.9 to 32.0 t/ha. Head size of both the cabbage cultivars was also increased by the increased rate of N.

An experiment was conducted in India by Choudhury and Som (1969) to study the response of kohlrabi cv. Early White Vienna to nitrogen (0 to 120 kg/ha) and phosphorus (0 to 60 kg/ha) in sandy loam soil. The availability of nitrogen and phosphorus was low. Best yield was obtained with the application of 100.7 kg nitrogen and 60 kg phosphorus per hectare.

2.2 Effect of soil moisture management techniques on growth and yield of kohlrabi

Proper soil moisture management practices must be ensured during kohlrabi production. Irrigation may be used to supply soil but it is a costly practice. Mulching may be an alternative proposition for successful production of kohlrabi. Some available information about in effects of soil moisture management practices on growth and yield of kohlrabi are reviewed here.

Eberhard (2000) carried out a study in Germany to compare pipe irrigation with trickle irrigation (at a depth of 30 cm) in fields in of bulb fennel, lettuce, cauliflowers, carrots and kohlrabi. Data were collected on irrigation requirements, crop yield, and damage caused by *Xanthomonas campestris* pv. *Carotae* in carrots. Trickle irrigation reduced damage by plant diseases and increased crop yields of bulb fennel and cauliflowers. However, crop yield of lettuce decreased due to superficial roots.

Hossain (1999) reported that mulching had a significant effect on plant height spread of plant, number of leaves, number of roots per plant, length of root diameter of head, thickness of head, fresh weight and dry weight of cabbage, % of dry matter content, maximum gross and marketable yield (116.67 t/ha and 97.53 t/ha) found black polythene mulch and the lowest (86.17 t/ha) from control treatment.

Mannan *et al*. (1999) working with six water regime treatments and three plants spacing observed that 80 ± 5% F.C. showed highest growth and dry matter of stem, leaf and total dry matter and the highest marketable yield per hectare. On the contrary, severe stress treatment (40 ± 5% F.C.) produced the highest dry of roots per plant. Maximum marketable yield was obtained from moderate spacing of 50 cm x 50 cm.

Jadhav and Sreenivas (1998) conducted an experiment with cabbage at Pune, India in clay loam soil during the rabi season and observed that 8 irrigation of 50 mm each applied at 16 days interval were adequate for cabbage production.

Pool and Geven (1996) conducted an experiment from 1991 to 1994 in the Netherlands on the effects of mulching (black paper, black polythene, straw) on iceberg and Butterhead lettuces, chinese cabbage and leaks. Mulches increased yield of ice berg and Butterhead lettuces and winter cabbage. Nitrogen leaching to ground water was decreased with mulches.

Hembry *et al*. (1994) reported that ground cover with mulches including black paper, polythene, straw for their effect on weed control by which savoy cabbage yielded well. Excellent weed control was achieved with all mulches except straw where some weed growth occurred.

Pessala (1994) observed that kohlrabi plants were transplanted in the field and mulched with black polythene and/or covered with tan fiber cloth. The fiber cloth covering increased yield from 104 to 135 kg/100m^2.

A study with four different mulches viz., water hyacinth, black polythene, straw and saw dust on growth and yield of cabbage by Saifullah *et al.* (1993) yield and most of the yield contributing character like plant height, number of loose leaves per plant, diameter and thickness of head, weight of loose leaves, stem, root, head whole plant and total dry matter per head were significantly increased by irrigation and mulch treatment. Mulching was found to be more effective during the early stage of plant growth. The highest marketable yield was obtained by irrigation treatment (37.09 t/ha) followed by black polythene (33.16 t/ha), water hyacinth (26.91 t/ha), sawdust (20.66 t/ha) and straw (24.64 t/ha) and the lowest (12.t/ha) by control treatment. They concluded that as an alternative to irrigation, water hyacinth and straw can be adopted as feasible mulches to increase the yield by conserving the residual soil moisture.

Benoit and Ceustermans (1990) investigated the influence of mulch in National Vegetable Research Station, UK, on cabbage. They found that the yield of the crop was better with double layer of paper mulch had better temperature condition for the growth of the first twenty outer leaves than single layer. Similar results were reported by Gattorsen (1992) who investigated the effects of plastic film mulch on the yield of cabbage and found that the single layer of polythene resulted in either or higher yield that of double layer in chinese cabbage.

In 1987 and 1988 the effects of lukewarm watering (water, temp. of 20, 30, 40^{o}C) were investigated by Cistinova and Admovsky (1990) in some crops (cucumbers, radishes, tomatoes, kohlrabi). With the exception of lukewarm watering on the given crops were observed in all remaining species, or lukewarm watering did not have any influence. The best results were achieved in cucumbers treated with water at 30^{o}C (21% yield increase) and in radishes which were watered at 20^{o}C.

To study the effect of irrigation and spacing on growth and yield of cabbage Islam *et al.* (1990) conducted an experiment in Bangladesh Agricultural University, Mymensingh, with 4 levels of irrigation and 3 levels of spacing. They reported that irrigation increased the number of leaves, size of heads, gross and marketable yield. Maximum number of leaves, diameter of head and yield were produced by the plants which were irrigation at 12 days interval at the widest spacing (76.2 cm x 60.9 cm). The lowest number of leaves was recorded in the non-irrigated plants. The moderate irrigation was desirable for successful cabbage production.

Sritharan and Lenz (1990) reported that six-week-old seedling of kohlrabi cv. Express Forcer were transferred from the greenhouse to growth chambers and growth at 300 or 900 µl CO_2, with irrigated at 100%, 50% or 25%, based on the amount of water consumed by the 100% (control) plants. Photosynthetic parameters were measured after 19-20 days using a portable promoter. The rate of photosynthesis was significantly higher for plants grown in 900 µl CO_2/litre than in 300 µl CO_2/litre, at all irrigation rates. Water supply restricted photosynthesis to a greater extent under low CO_2. After photosynthesis measurement had been made, plants were harvested. Plants grown at high CO_2 had greater leaf number, leaf area and tuber diameter, the response to CO_2 being most marked with reduced water supply. DM production was significantly greater under high CO_2 conditions, the increases over plants grown in low CO_2 at 100%, 50% and 25% irrigation being 36%, 81% and 101% respectively. The effect of CO_2 was most pronounced in tuber and root DM increase. The nitrate concentration in all plant parts was significantly lower with high CO_2. Nitrate concentration in the lamina, tuber and root decreased with increasing irrigation rate.

While reporting on the effect of mulching on cv. K-K cross, Subhan (1989) while working with mulching on cabbage in Indonesian Institute of Horticulture, Indonesia observed that mulching increased significant the head weight and yield of cabbage.

Sammis and Wu (1989) studied the yield responses of cabbage to different irrigation rates. They reported that marketable yield increased linearly with increasing water applied in Hawaiian condition.

Fischer and Nel (1987) while working in Warwick, UK, observed that the soil moisture level above 50% in the top 80 mm is necessary particularly for head formation. They also added that high soil moisture levels during vegetative growth improved leaf growth, but did not increase yields. The crop gave satisfactory yield even at low moisture levels indicating considerable drought resistance.

The effect of amount of irrigation and intervals of irrigation on growth and yield of Chinese cabbage was studied by Suh *et al.* (1987) Horticultural Research Institute, Pyongsong, Korea. They concluded that there was a greater use of irrigation in spring than in autumn and yields increased with increasing frequency of irrigation.

Mayne and Reidel (1986) reported that covering with plastic until early April produced the highest yield in kohlrabi. Single plastic was the cheapest material to use.

The effects of the slow release fertilizer Nitrophoska Permanent (15N + 9P + 15K + 2Ca) were compared with those of the liquid fertilizer Hakaphos in a greenhouse growing tomatoes or capsicum, with kohlrabi and radish as preceding crops and kohlrabi or lettuce as the following crop by Will and Hahndel (1986). Broad strip application of Nitrophoska increased the yields much more than whole area application or liquid feeding with Hakaphos, except for tomatoes which produced higher yields with liquid feeding. The yields of vegetables given Hakaphos Blue (15N + 11P + 15K + 1Ca) or Hakaphos Green (20N + 5P + 10K + 2Ca) were similar.

Bhatnagar *et al.* (1986) reported that in trials with the kohlrabi cv. White Vienna the plants received N at 50-150 kg/ha and were irrigated at 4 levels (low to high). After harvest the tubers were stored for 15 or 30 days at 35 or 60°F. Moderate irrigation, low N rates (50 kg/ha) and cold storage gave the best keeping quality.

Radishes, lettuce, kohlrabi and cucumbers were irrigated directly with cooling water from nuclear power stations. Water was applied at different temp. (25, 30, 35, 40°C). The control groups were watered using mains water at 18-21°. With the exception of kohlrabi, forcing vegetable varieties responded positively to irrigation with hot water. A secondary effect of this type of irrigation is that the temp. within the greenhouse rises Stambera (1986).

Data are presented from several glasshouse trials with 9 kohlrabi cultivars or selections compared with the standard cv. Express Forcer, grown in solution culture with continuous circulation or circulation for 5 minutes every 30, 60 or 90 minutes by Sande (1986). The first trial was sown on 17 May, planted in the solution gulley on 30 May (at 20 seedling/m^2) and harvested on 10 July, in the second trial the corresponding dates were 9 and 25 July and 10 September, respectively. Foran, E295 and Express Forcer performed best. Tubers (swollen hypocotyls) were largest when grown with the solution circulating for 15 minutes every 60 minutes. The tubers were of high quality and the method of culture of was considered promising. In a sub-trial with express Forcer, spacing of 18, 20, 22 and 25 plants/m^2 was compared; tuber size was greatest at the widest spacing.

In an experiment conducted at the Horticulture Research International, Warwick, UK, to study the effect of the soil moisture condition on head cabbage, Fischer and Nel (1985) conducted that soil moisture above 50% was necessary especially during head formation stage. They also reported that good yields could be maintained at higher levels of soil moisture depletion if the moisture supply during heading was adequate.

A study with the influence of mulches on yield of cabbage was carried out by Yoon *et al.* (1984) and observed that mulch like polythene, clear polythene and straw gave higher yield of cabbage than of non-mulched.

Tumuhaiwe and Gumbs (1983) studied the effects of mulch materials (bagasse, bay leaves, coffee husks or grass) and irrigation at 3 or 7 day intervals on soil temperature, moisture and NPK content and on the growth and yield of the cabbage cv. Kono Cross in poland. Mulching reduced day time soil temperature and increases the content. Coffee husks significantly increased soil and plant K contents and therefore, had a beneficial effects on cabbage growth and yield (52.1 t/ha). Irrigation increased mean yield from 20.9 t/ha in the control, 34.1 and 40.6 t/ha at 7 and 3 day intervals, respectively.

While working with cabbage in poland cv. Amager, Kolota (1982) observed that application of irrigation between June and mid-September when the soil moisture levels decreased of 75% of field capacity, the irrigation plots gave higher yields than that of non-irrigated plots.

Yu *et al.* (1981) observed increased microbial population as fungi actinomycetes ammonifying bacteria, N-fixing bacteria and phosphobacteria in the mulched plots. They also worked on the soil water content, porosity, total N and K increased by 0.2-0.6, 1.2-3.5, 0.01-0.05 and 0.05-0.09%, respectively while volume weight decreased by 0.1-0.2-0.2 g/cc due to mulching.

Karim and Khan (1980) conducted an experiment to study the response of cabbage to irrigation in red brown terrace soil of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur observed that the amount of water per irrigation had more pronounced effect than the frequency on the growth and yield of cabbage. They also noted that yield decreased when the amount of water per irrigation was decreased. The also reported that application of water at the level between 235 to 300 mm gave the maximum yield.

While conducting a series of experiments with cauliflower during 1974-76 at the Indian Agricultural Research Institute, New Delhi to observe the effect of irrigation on different plant characters, Sharma and Parashar (1980) found that higher moisture level caused the different parts of the plants, namely, plant height, number of loose leaves/plant, size of loose leaves, size of curd, etc. to grown bigger.

Hendrix and Backus (1979) found that kohlrabi grown in the open and covered with plastic film for different periods, compared with no covering. Early yield were enhanced and quality was improved.

Will (1979) carried out an experiment on kohlrabi in a green house under plastic and showed that application of the slow release fertilizer Nitrophoska was superior to other types of manuring. It increased the yield by 8-10%, improved quality and provided earlier crops.

Wilhelm (1979) observed that kohlrabi under plastic were earlier and at better quality, particularly under moist conditions than crops in the open.

Roeland (1977) conducted an experiment and summarized that kohlrabi plants covering with polythene for various periods. Covering for a longer period depressed cropping and increased the percentage that was unmarketable.

Tyurina (1975) conducted an experiment in poland and stated that in container trials, soil water was maintained at 50 or 70% of field capacity and in field trials it was maintained at 80%. In field trials irrigation increased yields by 26-31% compared to the control.

Seitz (1974) found that kohlrabi was mulched with polystyrene granules. The treatment improved the quality of young plant and shortened the time required to raise them. The time required to apply this mulch was less than for white plastic film. However, the light reflecting capacity of the mulch was considered to be of only minor importance in improving plant growth.

Buschmann (1973) reported that kohlrabi sown in boxes or in soil blocks had stronger stems and the plants were more compact when the surface of the substrate was covered with granules of the polystyrene product styromull which reflect light.

Salter and Goode (1967) suggested that potential supply of water throughout the growth period leads to maximum growth and yield but deficit moisture content during head formation reduces the yield drastically.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This experimental period, different materials used and methodologies followed in this experiment are presented in this chapter. It includes a brief description of experiment site, location, soil, climate, design and layout, materials used for experimental treatment, methods of cultivation, methods of data collection, statistical and economic analysis.

3.1 Experimental site

The field experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from October, 2007 to January, 2008. The experimental field was located at 90° 22′ E longitudes and 23°41′ N latitude at an altitude of 8.6 meters above the sea level. (UNDP, 1988). The land was in Agro-Ecological Zone of Madhupur tract (AEZ No-28). It was deep red brown terrace soil and belonged to "Nodda" cultivated series. The soil was sandy loam in texture having pH 6.06. Physical and chemical characteristics of the soil have been presented in appendix I.

3.2 Climate and weather

Experimental area was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during Kharif season (April to September) and scantly of rainfall during the rest of the year. Plenty of sunshine and moderately low temperature prevails during rabi season (October to March), which are suitable for growing kohlrabi in Bangladesh. Monthly total rainfall, average sunshine hour and temperature during the study period (October 2007 to January 2008) are shown in appendix II.

3.3 Materials used for the experiment

White Vienna, a variety of kohlrabi was used for this experiment. Seed of this variety was procured from "Manik Seed Company", 145, Siddique Bazar, Dhaka-1000.

3.4 Raising of Seedlings

Seedlings of kohlrabi were raised at Horticulture Farm, SAU, Dhaka under special care. Soil of the seed bed was ploughed and converted into loose friable and dried masses to obtain good filth. To protect the young seedlings from the infestation of damping off disease, the seed beds were dried in the sun. Cowdung was applied to the prepared seed beds at the rate of 10 t/ha. Ten grams of seeds were sown in each seed bed on 05 October, 2007. Seeds were covered with fine light soil after sowing. Weeding, mulching and light watering were done from time to time for maintaining a favorable environmental condition for raising healthy seedlings. To protect the young seedlings from scorching sunshine and heavy rainfall; shading was given by bamboo mat (chatai).

3.5 Treatment of the experiment

This two factors experiment had five different soil moisture management techniques and four levels of nitrogen fertilizer. Treatments are described below:

Factor A: Soil moisture management techniques

i. M_0: Control
ii. M_1: Straw mulch
iii. M_2: Water hyacinth mulch
iv. M_3: Black plastic mulch
v. M_4: Three times irrigation with 15 days interval after transplanting (20 DAT, 35 DAT, 50 DAT)

Factor B: Nitrogen fertilizer

i. N_0: Control
ii. N_1: 80 kg N/ha
iii. N_2: 160 kg N/ha
iv. N_3: 240 kg N/ha

3.6 Layout and design of the experiment

Two factorial experiments were laid out in the Randomized Complete Block Design (RCBD) with three replications. Whole experimental area (32.4m x 6.8m) was first divided into three blocks. Then each block was divided into 20 unit plots that are total 60 (3 x 20) unit plots. Soil moisture management techniques and nitrogen fertilizer treatments were assigned randomly to the unit plots. Size of a unit plot was 1.6m x 1.2m. Distance between two plots was 40cm and between two blocks was 50cm. Total area used for the experiment was 220.32 square meter (Appendix VII).

3.7 Land preparation

Land was first opened on 25 October, 2007 with a power tiller and then it was exposed to the sun for five days to kill insects. It was subsequently ploughed several times with a power tiller to bring about a good tilth and suitable for growing kohlrabi. Weeds and stubbles were removes as far as possible from the field and big clods were broken through laddering into tiny pieces. Diazinon 60EC was used @ 650 ml/ha to treat soil for protection of young plant from the attack of insect like cutworm and mole cricket.

3.8 Application of manure and fertilizers

Entire amount of well decomposed cowdung @ 10 t/ha was applied at the time of initial land preparation. According to the treatment and layout whole amount of TSP and MP and 1/3 Urea were applied after laid out of the plot and 4 days before transplanting. Again half of rest amount of Urea was applied 20 days after transplanting and another half amount was applied 30 days after transplanting. Applied fertilizers were mixed properly with the soil of the plots.

Following doses of fertilizers were used in this experiment,

Treatments	Urea (kg/hectare)	Urea (g/plot)
N_o (0kg N)	0	0
N_1 (80kg N)	173.91	33.39
N_2 (160kg N)	347.83	66.78
N_3 (240kg N)	521.74	100.17

3.9 Placing of mulching materials

Three types of mulches viz. rice straw, water hyacinth and black polythene were placed on the respective plots as per treatments before transplanting. Dried water hyacinth were cut into small pieces and black polythene sheet with small opening were made at proper plant to plant and row to row spacing on the respective plots as per layout before planting. 8-10 cm thickness of mulch was maintained for water hyacinth.

3.10 Application of irrigation treatment

Light irrigation was given by a watering can at every morning and afternoon following transplanting and it was continued for a week for rapid and well establishment and then irrigation was applied as treatment.

Irrigation was applied at 20, 35 and 50 days after transplanting. It was practiced by watering can until full saturation of the soil occurred. The plots were irrigated as per layout of the experiment.

3.11 Transplanting of seedlings

Seedlings were transplanted in the experimental plots on November 05, 2007. Healthy and uniform sized 30 days old seedlings were used as transplanting materials. Seed beds were watered before uprooting of the seedlings to minimize damage to the roots of seedlings. Transplanting was done in the afternoon at a spacing of 30cm x 20cm accommodating 32 plants in each unit plot. After transplanting, the seedlings were watered immediately. Banana leaf sheath pieces were used to protect the seedlings from scorching sunshine. Until the seedlings were established, shading and watering were continued. A number of seedlings were also planted in the border of the experimental plots.

3.12 Intercultural operations

3.12.1 Gap filling

After transplanting the seedlings were kept under careful observation. Very few seedlings were damaged and those seedlings were replaced with healthy seedlings through the border plants.

3.12.2 Weeding

Weeding was done at 15, 30 and 45 days after transplanting to keep the plots free from weeds during the entire growing period.

3.12.3 Pest management

At the time of establishment of seedling in the field the attack of soil borne insects was a serious problem. Darsban 29 EC @ 3% was applied against the soil born insects like mole crickets, field crickets and cut worm.

3.13 Harvesting

Kohlrabi was harvested at maturity on January 3, 2008 when the plants formed well-sized edible part. Sharp knife was used for the harvesting of the crop.

3.14 Methods of data collection

Data was recorded from 10 randomly selected plants from the middle rows of each unit plot during the course of experiment. Following parameters were recorded;

3.14.1 Plant height

Height of plant was recorded at 15, 25, 35, 45 and 55 days after transplanting (DAT) using meter scale. The height was measured from ground level to the tip of the largest leaf of an individual plant. Thus mean value of the ten selected plants per plot was considered as the height of the plant and was expressed in centimeter.

3.14.2 Number of leaves per plant

Number of leaves per plant was counted at 15, 25, 35, 45 and 55 DAT from 10 randomly selected plants. Fallen leaves were counted on the basis of scar marks on the stem introduced by the petiole of the leaves.

3.14.3 Spread of plant canopy

Crown spread was measured in centimeter by taking the mean diameter of the canopy of an individual plant in several directions.

3.14.4 Breadth of largest leaf per plant

Breadth of largest leaf was measured at the widest part of the lamina by a meter scale and was expressed in centimeter.

3.14.5 Length of largest leaf per plant

Length of largest leaf was measured from the base of the petiole to the tip of leaf with a meter scale and was recorded in centimeter.

3.14.6 Fresh weight of leaves per plant

Fresh weight of leaves per plant was recorded at harvest in gram with a beam balance from the average of ten randomly selected plants.

3.14.7 Fresh weight of knob per plant

Fresh weight of the edible part per plant was recorded in gram.

3.14.8 Fresh weight of roots per plant

Fresh weight of root was measured at harvest in gram.

3.14.9 Diameter of knob per plant

Selected ten knobs were sectioned in the middle vertically with a sharp knife. Diameter of the knob was measured in cm with a scale as the horizontal distance from one side to another side of the sectioned knob.

3.14.10 Thickness of knob per plant

Thickness of knob was measured in cm with a scale as the vertical distance from one side to another side of the knob.

3.14.11 Average length of root per plant

A distance between the bases to the tip of the root was measured in cm at harvest with the help of scale for determining the length of root.

3.14.12 Number of lateral roots per plant

After harvesting the main root was pulled out of soil carefully and the soil was washed out by water and then the number of roots per plant was counted.

3.14.13 Dry matter content of leaves per plant

At first the fresh weight of leaves per plant was recorded then one hundred grams of leaves was taken chopped and sun dried. Sun dried sample was then dried in an oven at 70^0C for 72 hours. The weight of oven dried sample was taken in gram.

3.14.14 Dry matter content of knob per plant

A sample of 100g of edible part was collected and was dried under direct sun for 72 hours and the sun dried sample was dried in an oven at 70^0C for 72 hours. Dry weight was recorded in gram.

3.14.15 Dry weight of roots per plant

After recording the fresh weight of roots per plant, 100g of root was taken, chopped and sun dried. Sun dried roots were than dried in an oven at 70^0C for 72 hours. The dry weight of oven dried root sample was then recorded.

3.14.16 Gross yield per plot

Gross yield of a kohlrabi was measured as the whole plant weight including the leaves of all the plant within plot (harvested area was 1.6m x 1.2m) and was expressed in kilogram.

3.14.17 Marketable yields per plot and per hectare

Weight of edible parts of all the plants in a plot was taken in kg and considering as the marketable yield per plot. Marketable yield included only weight of knob. The weight of edible parts of all the plants in a plot was converted into yield per hectare and was expressed in ton per hectare.

3.14.18 Economic analysis

Cost of production was analyzed in order to find out the most economic return under different treatment combinations. All input costs, including the cost for lease of land and interest on running capital were considered for computing the cost of production. The interests were calculated @ 13% per year for 6 month. The cost and return analyses were done in details according to the procedure followed by Alam *et al*. (1989). Benefit Cost Ratio (BCR) was calculated as follows:

$$\text{Benefit Cost Ratio} = \frac{\text{Gross return per hectare (Tk)}}{\text{Total cost of production hectare (Tk)}}$$

3.14.19 Statistical analysis

Calculated data on various parameters under study were statistically analyzed using MSTAT-C statistical package programme. Means for all the treatments were calculated and analyses of variances for all the characters under consideration were performed by 'F' variance test. Significance of differences between pairs of treatment means was evaluated by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV
RESULTS AND DISCUSSION

Present study was conducted to investigate the effects of nitrogen and moisture management techniques on the growth and yield of kohlrabi. Analysis of variance (ANOVA) of the data on different yield contributing characters and yield of kohlrabi as influenced by nitrogen and moisture management techniques presented in appendix III-VI. Results on main and combined effect of nitrogen and moisture management techniques and their interactions have been presented and discussed in this Chapter.

4.1 Effect of nitrogen on growth and yield of kohlrabi

4.1.1 Plant height

Insignificant effect of plant height was influenced by application of different doses of nitrogen with different days after transplanting except at 55 DAT. Highest plant height was recorded (38.5 cm) at 55 DAT having treatment 240 kg N/ha and the lowest plant height was recorded (32.7 cm) at the same DAT having treatment 0 kg N/ha (Fig.1). Gopal and Lal (1996) also found that plant height of cabbage was increased with increasing rates of nitrogen.

4.1.2 Number of leaves per plant

Variation due to the number of leaves produced per plant under different treatment of nitrogen application was found insignificant. Maximum (17.0) and the minimum (13.4) number of leaves were found at 55 DAT having 240 kg N/ha and 0 kg N/ha treatment respectively (Fig. 2).

4.1.3 Length of largest leaf per plant

Length of largest leaf was also influenced by different treatments of nitrogen application. Treatment of nitrogen fertilizer 240 kg N/ha gave the highest leaf length (32.4 cm) and the lowest leaf length (28.4 cm) was recorded from the treatment of 0 kg N/ha at 55 DAT respectively (Fig. 3). Increasing levels of nitrogen increased the height of plant as well as the length of largest leaf. It might be due to increased photosynthetic activity which might have helped in increased leaf length.

4.1.4 Breadth of largest leaf per plant

Application of nitrogen showed insignificant variation in respect to breadth of leaf in kohlrabi. Maximum breadth of leaf (14.3 cm) was observed from treatment of 240 kg N/ha at 55 DAT and the minimum breadth of largest leaf (12.0 cm) was found with 0 kg N/ha treatment (Fig. 4).

4.1.5 Spread of plant

It was observed that the maximum spread of plant (62.8 cm) was obtained from treatment of 240 kg N/ha at 55 DAT. The lowest spread of plant 54.4 cm was obtained from the treatment of 0 kg N/ha at same DAT (Fig. 5). Higher doses of nitrogen increase vegetative growth of plant as well as spread of plant by increasing photosynthesis rate and maximum utilization of natural resources.

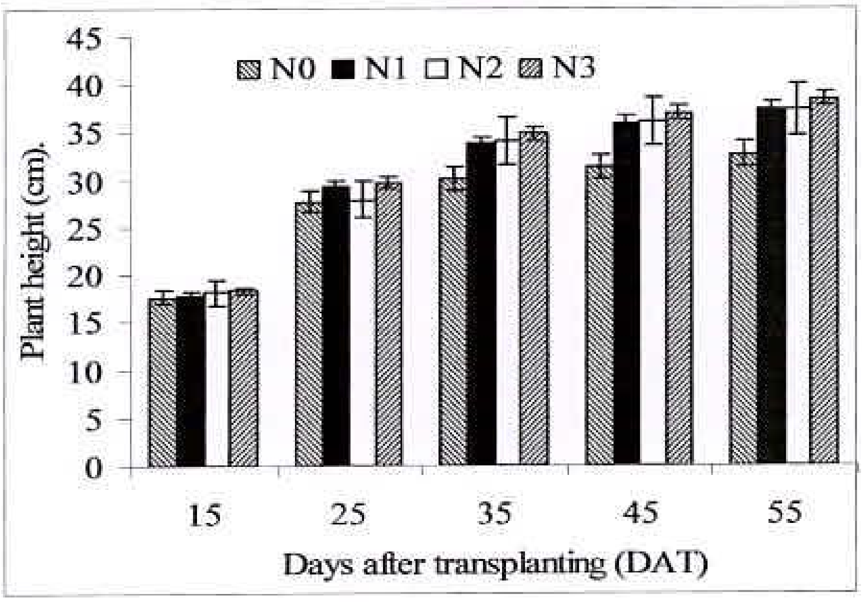

Fig. 1. Effect of nitrogen on plant height of kohlrabi at different days after transplanting. No, 0 kg N/ha; N_1, 80 kg N/ha; N_2, 160 kg N/ha; N_3, 240 kg N/ha

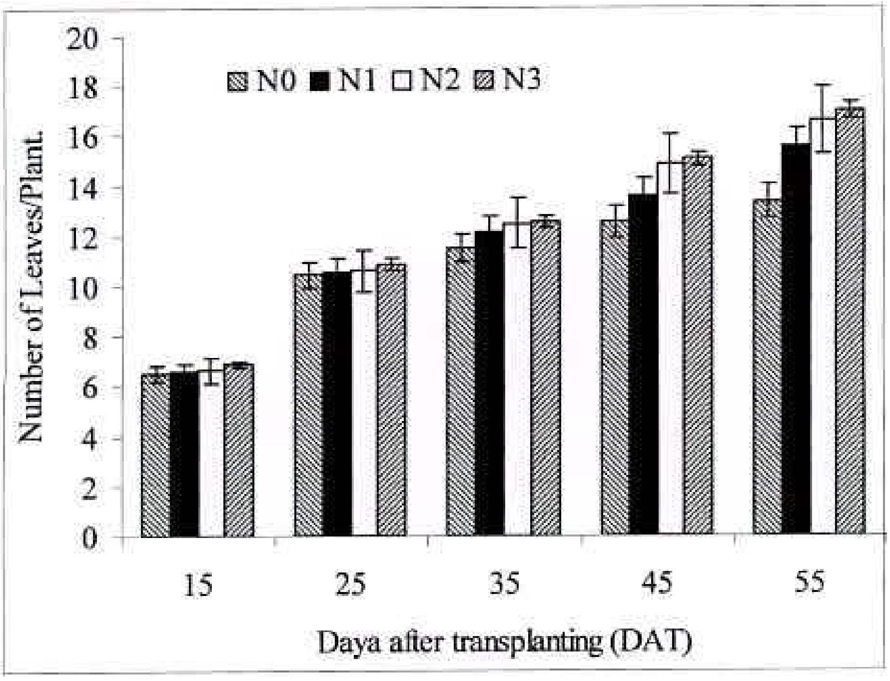

Fig. 2. Effect of nitrogen on number of leaves /plant of kohlrabi at different days after transplanting. No, 0 kg N/ha; N_1, 80 kg N/ha; N_2, 160 kg N/ha; N_3, 240 kg N/ha

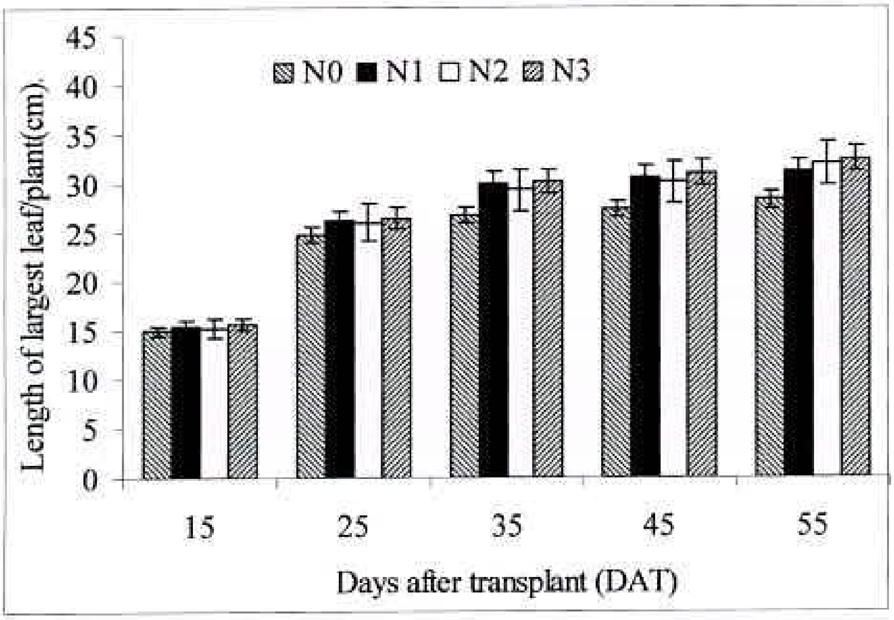

Fig. 3. Effect of nitrogen on length of largest leaf/ plant of kohlrabi at different days after transplanting. No, 0 kg N/ha; N_1, 80 kg N/ha; N_2, 160 kg N/ha; N_3, 240 kg N/ha.

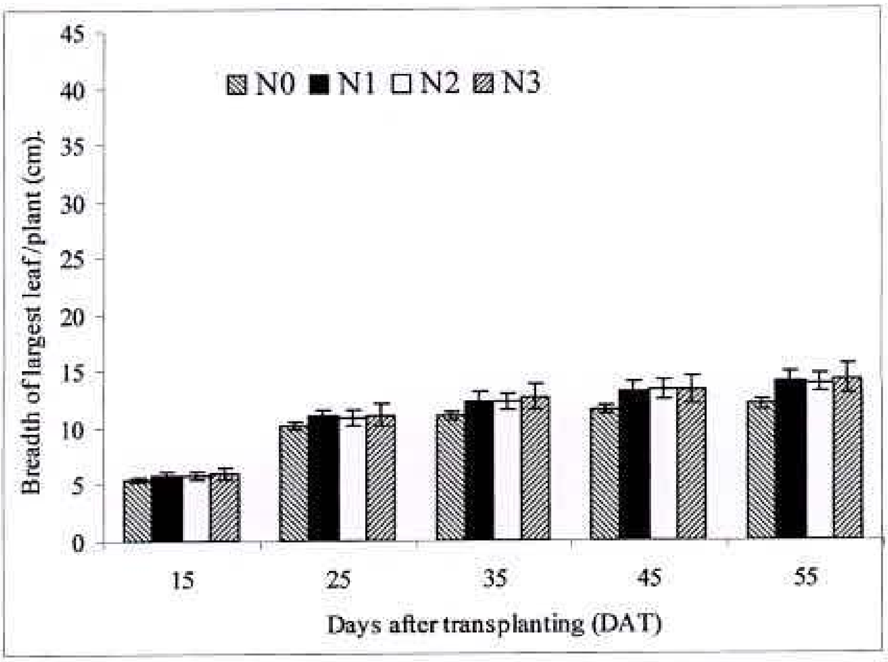

Fig. 4. Effect of nitrogen on breadth of largest leaf/ plant of kohlrabi at different days after transplanting. No, 0 kg N/ha; N_1, 80 kg N/ha; N_2, 160 kg N/ha; N_3, 240 kg N/ha

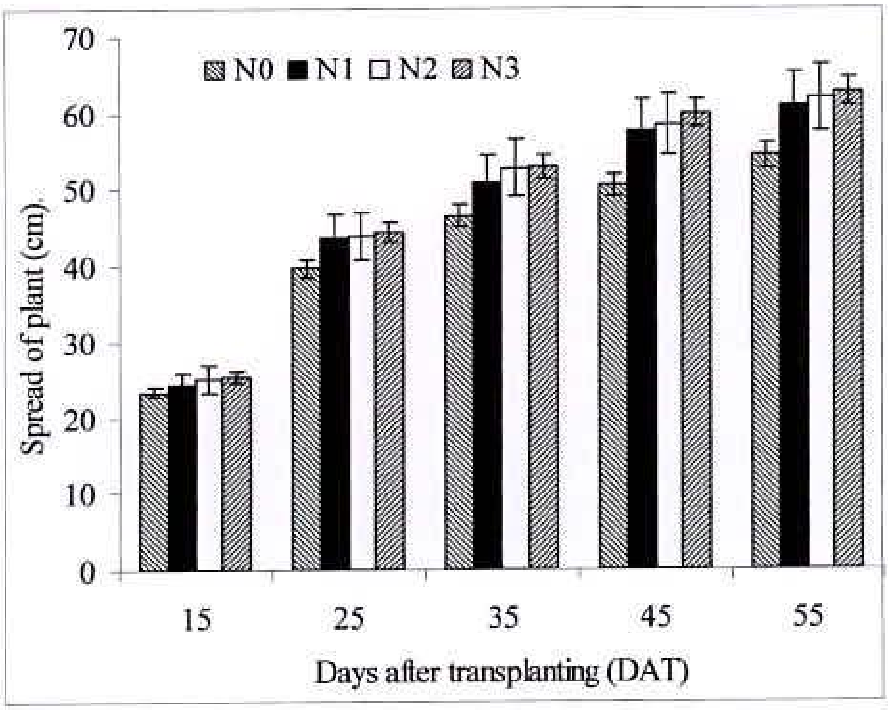

Fig. 5. Effect of nitrogen on spread of plant of kohlrabi at different days after transplanting. No, 0 kg N/ha; N_1, 80 kg N/ha; N_2, 160 kg N/ha; N_3, 240 kg N/ha

4.1.6 Fresh weight of leaves per plant

Fresh weight of leaves varied significantly by the application of nitrogen fertilizer. Highest fresh weight of leaves per plant (108.3 g) was recorded when the plants received 240 kg N/ha and the lowest fresh weight of leaves (51.8 g) per plant was obtained from the treatment of 0 kg N/ha at 55 DAT (Table 1). In the present study it was observed that the highest supply of nutrient produced highest fresh weight of leaves.

4.1.7 Fresh weight of knob per plant

The effect of nitrogen was also found statistically significant in the respect of fresh weight of knob per plant in kohlrabi. Highest fresh weight of knob per plant (343.8 g) was found from the treatment of 240 kg N/ha and the lowest (255.1 g) from the treatment of 0 kg N/ha at 55 DAT (Table 1). Lawande *et al.* (1988) also observed that yield and average stem tuber weight at kohlrabi increased with increasing nitrogen rate.

4.1.8 Fresh weight of root per plant

There was an insignificant effect of nitrogen fertilizer on the fresh weight of roots in kohlrabi. Highest fresh weight (5.2 g) of roots was observed from the treatment of 160 kg N/ha and the minimum fresh weight (3.8 g) of roots was found in the treatment of 0 kg N/ha (Table 1).

4.1.9 Diameter of knob

Application of different nitrogen doses had insignificant influence on diameter of knob in kohlrabi. Maximum diameter of knob (8.0 cm) was produced by the plants receiving 240 kg N/ha and the minimum diameter of knob (7.1 cm) was observed from 0 kg N/ha treatment (Table 1).

Table 1. Effect of nitrogen on yield and yield contributing characters of kohlrabi [x]

Treatment [y]	Fresh weight of leaves per plant (gm)	Fresh weight of knob per plant (gm)	Fresh weight of roots per plant (gm)	Diameter of knob per plant (cm)	Thickness of knob per plant (cm)	Average length of roots per plant (cm)	Number of lateral roots per plant	Dry weight of leaves (%)	Dry weight of knob (%)	Dry weight of roots (%)	Gross yield per plot (kg)	Marketable yield per plot (kg)	Marketable yield (t/ha)
N_0	51.8 b	255.1 c	3.8 a	7.1 a	6.7 a	5.5 a	20.9 a	10.0 a	5.4 a	24.2 a	5.9 b	4.7 ab	24.5 b
N_1	107.5 a	334.3 ab	4.9 a	7.9 a	7.5 a	6.4 a	24.6 a	10.1 a	5.9 a	24.7 a	8.5 ab	6.3 ab	32.8 a
N_2	98.0 a	322.0 b	5.2 a	7.7 a	7.5 a	7.0 a	24.4 a	10.6 a	5.7 a	25.4 a	9.3 a	6.8 ab	35.4 a
N_3	108.3 a	343.8 a	4.8 a	8.0 a	7.7 a	6.9 a	25.3 a	10.9 a	6.0 a	28.0 a	9.4 a	6.9 a	35.9 a
CV (%)	5.0	2.0	22.5	13.7	14.0	20.4	10.5	13.7	19.1	9.9	25.3	26.5	26.7
LSD (0.05)	11.8	15.9	2.7	2.7	2.7	3.4	6.5	3.7	2.8	6.6	2.6	2.1	3.4

[x] means bearing the same letter (s) in a column do not differ significantly at 5% levels of probability

[y] N_o, 0 kg N/ha; N_1, 80 kg N/ha; N_2, 160 kg N/ha; N_3, 240 kg N/ha

4.1.10 Thickness of knob

It was observed that there was an insignificant effect of different nitrogen doses on thickness of knob of kohlrabi. Maximum thickness (7.7 cm) of knob was found from the application of 240 kg N/ha and the minimum thickness of knob (6.7 cm) was found from the treatment of 0 kg N/ha (Table 1).

4.1.11 Average length of root per plant

Length of kohlrabi root was insignificantly influenced by different treatment of nitrogen application. Maximum length of root (7.0 m) was recorded in plant receiving nitrogen fertilizer 160 kg/ha. Minimum length of root (5.5 cm) was observed from the treatment of 0 kg N/ha (Table 1). This result revealed that root length increased with the increasing level of nitrogen.

4.1.12 Number of lateral roots per plant

An insignificant variation in number of lateral roots per plant was observed due to application of different doses of nitrogen. At harvest highest number of lateral roots (25.3) was obtained when the fertilizer treatment of nitrogen 240 kg N/ha was used. On the other hand the lowest number (21.0) of roots per plant was obtained when the plants received with 0 kg/ha (Table 1).

4.1.13 Dry weight of leaves

Insignificant variation in the percent dry matter of leaves was observed due to the effect of different nitrogen treatment. The highest percentage (10.9) of dry matter was accumulated in leaves when the plants received nitrogen 240 kg/ha. The lowest percentage (10.0) was produced by the application of nitrogen 0 kg/ha (Table 1).

4.1.14 Dry weight of knob

Application of nitrogen also insignificantly influenced on the dry weight of knob in kohlrabi. The maximum dry weight of knob (6.0 %) was produced by the plants receiving nitrogen 240 kg/ha while the minimum (5.4 %) dry weight of knob was found from treatment of nitrogen 0 kg/ha (Table 1). This result has got support of Fischer (1992) in kohlrabi.

4.1.15 Dry weight of root

Variation due to the effect of application of different doses of nitrogen in relation to percent dry weight of roots was found insignificant (Table 1). The maximum percent dry weight (28.0 %) of roots was recorded in the treatment of nitrogen @ 240 kg/ha and the minimum dry weight of roots (24.2 %) was recorded in the treatment of nitrogen @ 0 kg/ha respectively.

4.1.16 Gross yield per plot

Variation in yield of kohlrabi was found to be significant due to the application of fertilizers. The treatment with nitrogen 240 kg/ha gave the highest yield per plot (9.4 kg) which was statistically similar to N_2 treatment and the lowest yield (6.0 kg) per plot was found from the treatment of nitrogen 0 kg/ha (Table 1).

4.1.17 Marketable yield per plot and hectare

Application of different treatments of nitrogen had statistically significant effects on marketable yield per plot of kohlrabi (Table 1). Maximum (6.8 kg) marketable yield of kohlrabi was recorded from the treatment of nitrogen 240 kg/ha and the minimum (4.7 kg) marketable yield of kohlrabi was recorded from the treatment of nitrogen 0 kg/ha. In case of yield per hectare a similar trend was also observed where N_3 gave the maximum marketable yield (35.9 t/ha) which statistically similar to N_2 and N_1 treatment. Minimum marketable yield (24.5 t/ha) was recorded from the treatment of nitrogen 0 kg/ha. Gianquinto and Borin (1995) reported that kohlrabi received medium or high level nitrogen fertilizer, marketable yield were greatest. Krieg (1978) had similar views. It might be due to nitrogen fertilizer supplied readily available plant nutrient for vigorous growth.

4.2 Effect of moisture management techniques on growth and yield of kohlrabi

4.2.1 Plant height

Results on main effects of moisture management techniques on plant height have been presented in Fig. 6. Plant height was insignificantly influenced by different mulching. Maximum plant height attained with water hyacinth (M_2) was 38.2 cm at 55 DAT and the minimum (34.9 cm) was found with M_0 treatment.

4.2.2 Number of leaves per plant

Variation in number of leaves produced per plant under different moisture management techniques was found statistically insignificant. Maximum number of leaves (17.2) at 55 DAT was produced by the plant grown with water hyacinth and minimum number of leaves (14.6) was obtained in control treatment (Fig. 7). The higher number of leaves per plant was obtained due to mulching may be attributed of higher plant height caused by conserving soil moisture utilized by plants.

4.2.3 Length of largest leaf per plant

Length of largest leaf per plant was influenced by the application of moisture management techniques. The highest leaf length (32.4 cm) was found from M_2 (water hyacinth) and the lowest (29.5 cm) was recorded from M_0 (control) treatment (Fig. 8).

4.2.4 Breadth of largest leaf per plant

Breadth of largest leaf was found to be insignificant due to the application of different types of moisture management techniques. Maximum breadth of largest leaf (14.1 cm) was obtained from the treatment M_2 (water hyacinth) and the M_0 (control) treatment produced minimum (13.2 cm) breadth of largest leaf at harvest. (Fig. 9).

4.2.5 Spread of plant

Spread of plant was insignificantly influenced by the application of different moisture management techniques at different DAT except 35 DAT and 55 DAT. It was observed that the maximum spread of plant (64.1 cm) was obtained from water hyacinth. The lowest spread of plant 55.7 cm was obtained from no mulch (M_0) treatment (Fig. 10). The more positive effect of water hyacinth mulching might be due to ensuring of optimum moisture and mix some organic matter inside the top soil.

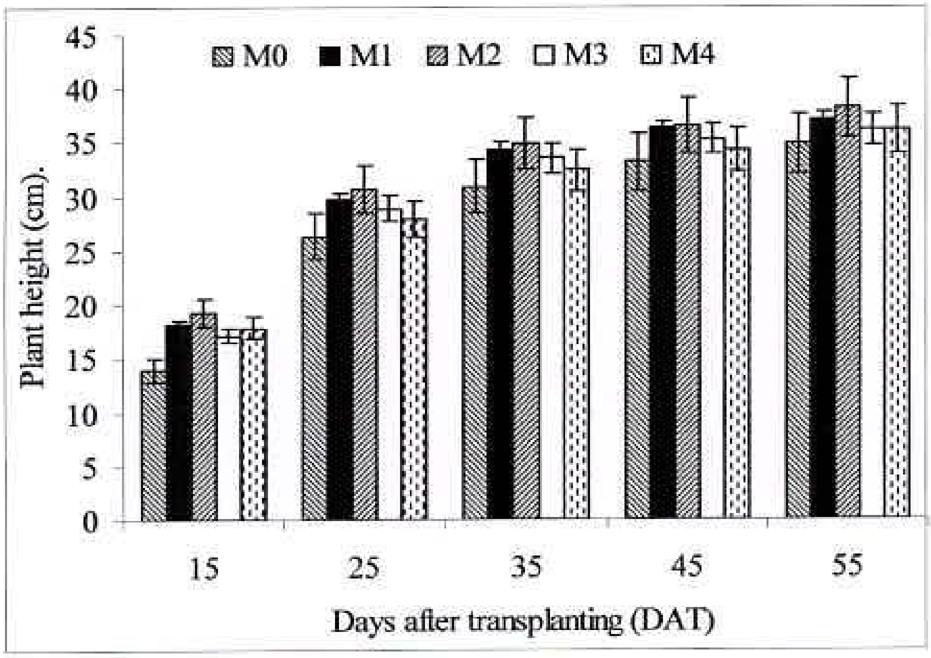

Fig. 6. Effect of moisture management techniques on plant height of kohlrabi at different days after transplanting. Mo, Control; M_1, straw; M_2, water hyacinth; M_3, Black plastic; M_4, Irrigation three times.

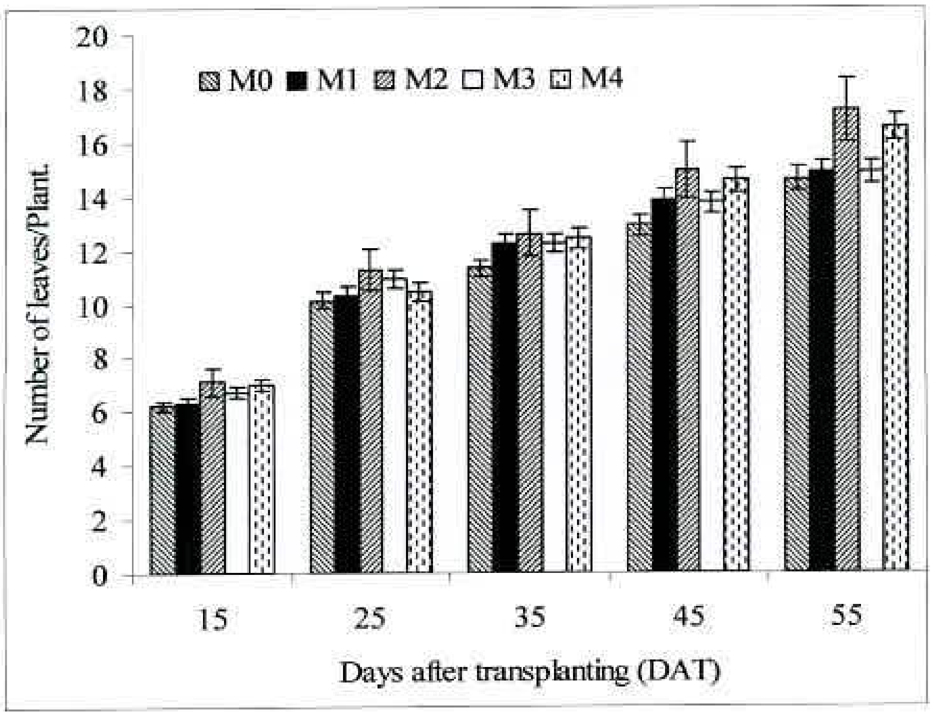

Fig. 7. Effect of moisture management techniques on number of leaves per plant of kohlrabi at different days after transplanting. Mo, Control; M_1, straw; M_2, water hyacinth; M_3, Black plastic; M_4, Irrigation three times

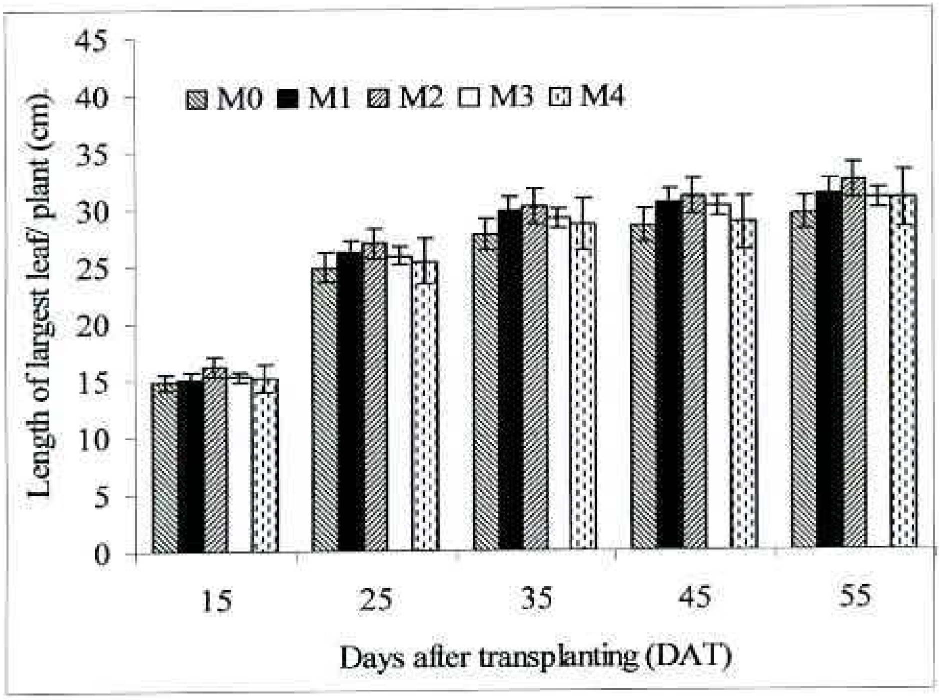

Fig. 8. Effect of moisture management techniques on length of largest leaf/ plant of kohlrabi at different days after transplanting. Mo, Control; M_1, straw; M_2, water hyacinth; M_3, Black plastic; M_4, Irrigation three times.

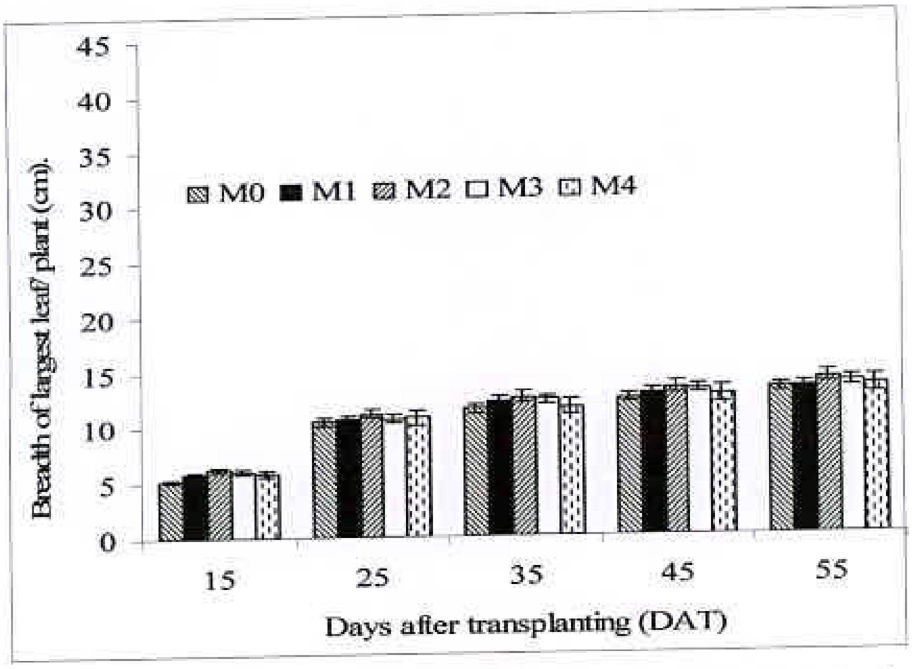

Fig. 9. Effect of moisture management techniques on breadth of largest leaf/ plant of kohlrabi at different days after transplanting. Mo, Control; M_1, straw; M_2, water hyacinth; M_3, Black plastic; M_4, Irrigation three times

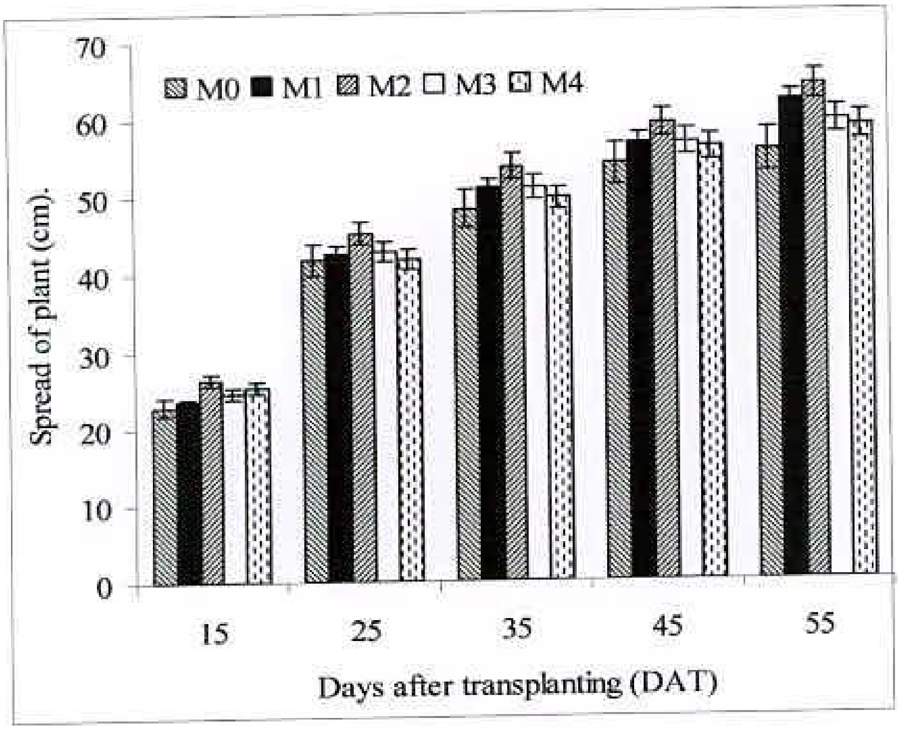

Fig. 10. Effect of moisture management techniques on spread of plant of kohlrabi at different days after transplanting. Mo, Control; M_1, straw; M_2, water hyacinth; M_3, Black plastic; M_4, Irrigation three times

4.2.6 Fresh weight of leaves per plant

A significant variation in fresh weight of leaves per plant at harvest was observed due to application of different moisture management techniques. Highest fresh weight of leaves per plant (104.7g) was obtained when water hyacinth mulch was used, on the other hand the fresh weight was 78.7 g per plant which was obtained from no mulch (Table 2).

4.2.7 Fresh weight of knob per plant

Fresh weight of knob was influenced significantly due to different moisture management techniques. Highest fresh weight of knob per plant (356.4 g) was produced by the water hyacinth mulch treatments and the lowest (257.5 g) was found from control treatment, at 55 DAT (Table 2). Increased weight of individual knob over water hyacinth mulch was probably due to supply soil moisture long time through its conservation mechanism as well as the availability of plant nutrient, which led higher fresh weight of knob.

4.2.8 Fresh weight of root per plant

Fresh weight of root insignificantly varied due to the use of different moisture management techniques in kohlrabi. Water hyacinth mulch (M_2) was found to produce maximum fresh weight of root (5.3 g) and the minimum fresh weight of root was produce by the control treatment (4.0 g) (Table 2).

4.2.9 Diameter of knob

Result of knob diameter was found to be insignificant due to the effect of different moisture management techniques. Highest diameter of knob (8.0 cm) was obtained from the plants grown with water hyacinth (M_2) treatment which is similar M_3 treatment. Lowest diameter (7.1 cm) was found when the plants were raised without mulch (Table 2). Mulching ensured better moisture availability to plants which led to highest number of leaves per plant and ultimately result in the production of maximum diameter of knob.

4.2.10 Thickness of knob

Thickness of kohlrabi knob was non significantly influenced by the treatment of different moisture management techniques. Maximum thickness of knob (7.7 cm) was found with the application of water hyacinth mulch and the minimum (6.6 cm) was recorded in the control treatment (Table 2).

4.2.11 Average length of root per plant

Average length of root per plant was found to be insignificant due to the application of different types of moisture management techniques. Maximum root length (7.2 cm) was found with water hyacinth mulch. Minimum root length (5.3 cm) was recorded with M_0 treatment (Table 2). Such response may be accounted for the physical, chemical and biological properties of soil as improved by mulching. Such improvement might led to increase the microbial activity, water holding capacity and nutrient availability of soil facilitating the normal growth of root.

4.2.12 Number of lateral roots per plant

Number of lateral root per plant varied not significantly with the application of different moisture management techniques. Maximum no. of lateral root (24.9) was observed at black polythene treatment and lowest no. of lateral root (21.8) was obtained from control treatment (Table 2).

4.2.13 Dry weight of leaves

Variation in the percentage of dry weight of leaves due to moisture management techniques was found to be insignificant. The maximum dry weight (11.0 %) was recorded from the treatment of water hyacinth mulch where as the minimum (9.8 %) was produced by the control treatment (Table 2).

Table 2. Effect of moisture management techniques on yield and yield contributing characters of kohlrabi [x]

Treatment [y]	Fresh weight of leaves per plant (gm)	Fresh weight of knob per plant (gm)	Fresh weight of roots per plant (gm)	Diameter of knob per plant (cm)	Thickness of knob per plant (cm)	Average length of roots per plant (cm)	Number of lateral roots per plant	Dry weight of leaves (%)	Dry weight of knob (%)	Dry weight of roots (%)	Gross yield per plot (kg)	Marketable yield per plot (kg)	Marketable yield (t/ha)
M_0	78.7 c	257.5 d	4.0 a	7.1 a	6.6 a	5.3 a	21.8 a	9.8 a	5.5 ab	24.8 a	6.9 b	5.3 c	27.4 b
M_1	96.7 ab	346.0 a	4.0 a	7.7 a	7.5 a	6.9 a	24.1 a	9.9 a	5.8 ab	25.1 a	8.8 ab	6.5 ab	33.7 a
M_2	104.7 a	356.4 a	5.3 a	8.0 a	7.7 a	7.2 a	24.6 a	11.0 a	6.2 a	25.2 a	9.1 a	6.8 a	35.4 a
M_3	89.5 b	323.5 b	4.9 a	8.0 a	7.4 a	6.4 a	24.9 a	11.0 a	5.6 ab	27.9 a	8.8 ab	6.5 ab	33.7 a
M_4	87.4 bc	285.6 c	5.2 a	7.5 a	7.4 a	6.4 a	23.5 a	10.2 a	5.5 b	25.0 a	7.7 ab	5.6 bc	29.4 b
CV (%)	5.0	2.0	22.5	13.7	14.0	20.4	10.5	13.7	19.1	9.9	25.3	26.5	26.7
LSD (0.05)	10.3	13.9	2.4	2.4	2.3	3.0	5.7	3.2	0.6	5.7	2.0	1.0	3.0

[x] means bearing the same letter (s) in a column do not differ significantly at 5% levels of probability

[y] M_0-Control; M_1-straw; M_2-water hyacinth; M_3-Black plastic; M_4-Irrigation three times

4.2.14 Dry weight of knob

Significant influence due to the use of mulch materials was observed for dry weight percentage of knob in kohlrabi. Knob dry weight was the highest (6.17 %) incase of water hyacinth mulch on the other hand the control treatment produced the lowest (5.5 %). As the knob weight and diameter was maximum incase of water hyacinth for that the dry matter percentage was also highest here (Table 2).

4.2.15 Dry weight of root

Effects of different moisture management techniques were found not significant with respect of dry weight of roots of kohlrabi (Table 2). Highest (27.9 %) and lowest (24.8 %) dry weight of roots were observed from the treatments of black polythene and control treatment respectively.

4.2.16 Gross yield per plot

Different moisture management techniques were found to influence significantly the gross yield per plot at harvest. It is apparent from table 2 that the highest gross yield (9.1 kg) per plot was found from water hyacinth mulch (M_2) while the lowest (6.9 kg) per plot was obtained in control treatment.

4.2.17 Marketable yield per plot and per hectare

Variation in yield of kohlrabi was found to be significant due to the application of different moisture management techniques. The treatment M_2 (water hyacinth) gave the highest yield per plot (6.8 kg) and the lowest yield per plot (5.3 kg) was found in the control treatment. In case of yield per hectare a similar trend was also observed where treatment M_2 (water hyacinth) gave the highest yield (35.4 t/ha) which was statistically similar to M_1 and M_3 treatment and the lowest yield (27.4 t/ha) was found from the treatment of nitrogen 0 kg/ha which was statistically similar to M_4 treatment (Table 2). Remarkable effect of mulching in this regard may be attributed to the adequate moisture supply to the growing kohlrabi plants, which ultimately contributed in the formation of heavier knobs.

4.3 Combined effect of nitrogen and moisture management techniques on growth and yield of kohlrabi

4.3.1 Plant height

Combined effect of moisture management techniques and nitrogen was found significant at different days after transplanting. Highest plant height (40.0 cm) was found at 55 DAT from the treatment combination of M_2N_3 (water hyacinth with 240 kg N/ha) which was statistically similar to M_1N_2 treatment combination and the lowest plant height (29.5 cm) from the treatment combination of no moisture management technique and without nitrogen fertilizer (Table 3).

4.3.2 Number of leaves per plant

Combination effect of moisture management techniques and nitrogen fertilizer was significant at different days after transplanting. Maximum number of leaves per plant (19.1) was obtained from the treatment combination of M_2N_3 (water hyacinth with 240 kg N/ha). Minimum number of leaves per plant (11.8) was obtained from the treatment combination of M_0N_0 at 55 DAT (Table 3).

4.3.3 Length of largest leaf per plant

Effect of interaction among different moisture management techniques and nitrogen fertilizer showed significant variation with respect to largest leaf length except 15 DAT. Highest length of largest leaf at 55 DAT (34.0 cm) was recorded when plants were raised with treatment combination of M_2N_3 (water hyacinth with 240 kg N/ha). Lowest leaf length (26.8 cm) was found at M_0N_0 treatment which was statistically similar with treatment combination of M_1N_0 (Table 4).

4.3.4 Breadth of largest leaf per plant

Combination of different moisture management techniques and nitrogen fertilizer was significantly influenced on the breadth of largest leaf at different DAT. Highest breadth of largest leaf (15.2 cm) per plant was observed from the treatment combination M_2N_3 (water hyacinth with 240 kg N/ha) which was statistically similar with treatment combination M_3N_2. Lowest breadth of largest leaf (11.3 cm) per plant was found in treatment combination of M_0N_0 which was statistically similar with treatment combination of M_1N_0 and M_3N_0 at 55 DAT (Table 4).

4.3.5 Spread of plant

From the combined effect of moisture management techniques and nitrogen fertilizer was significant at different DAT. At 55 DAT it was observed that the maximum spread of plant (66.0 cm) with the treatment combination of M_2N_3 (water hyacinth with 240 kg N/ha) and the minimum spread of plant (44.0 cm) was observed from M_0N_0 treatment (Table 5).

4.3.6 Fresh weight of leaves per plant

There was significant interaction effect of different moisture management techniques and nitrogen fertilizer on the fresh weight of leaves. Maximum fresh weight of leaves per plant (129.7 g) was observed from the treatment combination of M_2N_3 (water hyacinth with 240 kg N/ha) which was statistically similar with treatment combination of M_1N_1. Lowest fresh weight of leaves per plant (21.7 g) was found from the treatment combination M_0N_0 (Table 5).

4.3.7 Fresh weight of knob per plant

Interaction effects between moisture management techniques and nitrogen fertilizer treatment were significant on fresh weight of knob at 55 DAT. Highest fresh weight of knob per plant (393.7g) was found the treatment combination M_2N_3 (water hyacinth with 240 kg N/ha). Lowest (129.3g) was obtained from treatment combination of M_0N_0 (Table 5).

Table 3. Effect of nitrogen and moisture management techniques on growth characters of kohlrabi [x]

Treatment [y]	Plant height (cm)					Number of leaves per plant				
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT
M_0N_0	14.9 d	24.1 b	27.7 g	29.0 h	29.5 f	5.7 e	9.5 c	10.5 b	11.4 f	11.8 g
M_0N_1	15.9 cd	28.3 ab	32.1 cdef	35.1 bcdef	37.9 abcd	6.1 bcde	9.7 bc	10.9 ab	11.5 f	12.5 fg
M_0N_2	18.6 ab	25.7 ab	33.4 abcde	35.4 abcdef	36.5 abcd	7.1 abc	11.1 abc	12.3 ab	15.4 abc	18.5 b
M_0N_3	17.3 bc	27.1 ab	30.3 efc	33.2 efg	35.6 bcd	6.5 abcde	10.1 abc	11.7 ab	13.4 bcdef	15.7 abcdef
M_1N_0	18.8 ab	27.8 ab	29.4 fg	29.8 h	30.0 f	6.0 cde	10.1 abc	11.3 ab	12.1 ef	12.8 fg
M_1N_1	17.6 abc	30.7 a	36.4 a	38.5 ab	39.3 ab	6.3 bcde	10.1 abc	12.2 ab	14.3 abcde	15.7 abcdef
M_1N_2	17.8 abc	29.2 ab	35.5 abc	38.4 ab	39.6 a	6.3 bcde	10.4 abc	12.8 a	14.3 abcde	15.4 bcdef
M_1N_3	18.7 ab	31.2 a	36.2 a	38.2 ab	39.3 ab	6.7 abcde	10.6 abc	12.7 ab	14.5 abcde	15.6 bcdef
M_2N_0	19.0 ab	30.3 ab	32.7 bcdef	34.7 cdef	37.9 abcd	7.3 ab	11.2 abc	12.4 ab	13.8 abcdef	14.9 cdefg
M_2N_1	19.4 ab	30.3 ab	34.9 abcd	36.7 abcde	37.2 abcd	7.2 abc	11.4 ab	12.5 ab	13.7 abcdef	16.5 abcde
M_2N_2	19.0 ab	30.7 a	35.5 abc	36.1 abcdef	37.7 abcd	7.0 abcd	11.1 abc	13.1 a	16.0 ab	18.1 abc
M_2N_3	19.6 a	31.5 a	36.5 a	38.7 a	40.0 a	7.6 a	11.6 a	13.1 a	16.2 a	19.1 a
M_3N_0	17.3 bc	27.0 ab	29.5 fg	30.6 gh	31.6 ef	5.8 de	11.1 abc	11.9 ab	12.5 def	13.2 efg
M_3N_1	17.7 abc	29.7 ab	35.9 ab	38.1 abc	38.9 abc	6.1 cde	10.8 abc	12.9 a	14.6 abcde	16.5 abcde
M_3N_2	17.3 bc	28.2 ab	34.3 abcd	37.0 abcd	37.9 abcd	6.9 abcd	10.3 abc	11.3 ab	12.7 cdef	13.2 defg
M_3N_3	18.6 ab	30.7 a	34.5 abcd	35.6 abcdef	36.4 abcd	6.9 abcd	11.5 ab	12.9 a	15.1 abcd	16.6 abcd
M_4N_0	18.5 ab	27.9 ab	31.7 def	33.1 fg	34.6 de	6.7 abcde	10.4 abc	11.4 ab	12.6 def	13.3 defg
M_4N_1	17.6 abc	28.0 ab	34.6 abcd	36.3 abcdef	39.2 ab	6.9 abcde	10.7 abc	12.4 ab	13.9 abcdef	17.1 abc
M_4N_2	17.6 abc	27.6 ab	31.7 def	33.8 defg	35.1 cd	7.1 abc	10.1 abc	12.4 ab	15.8 ab	17.7 abc
M_4N_3	17.8 abc	28.0 ab	31.8 def	34.2 def	35.6 bcd	6.7 abcde	10.5 abc	12.8 a	15.9 ab	18.0 abc
CV (%)	5.9	11.3	5.4	5.2	5.5	9.1	8.7	9.3	10.0	11.2
LSD (0.05)	1.8	5.4	3.0	3.0	3.3	1.0	1.5	1.9	2.3	2.9

[x] means bearing the same letter (s) in a column do not differ significantly at 5% levels of probability

[y] N_0, 0 kg N/ha; N_1, 80 kg N/ha; N_2, 160 kg N/ha; N_3, 240 kg N/ha; M_0, Control; M_1, straw; M_2, water hyacinth; M_3, Black plastic; M_4, Irrigation three times

Table 4. Combined effect of nitrogen and moisture management techniques on growth characters of kohlrabi [x]

Treatment [y]	Length of largest leaf per plant (cm)					Breadth of largest leaf per plant (cm)				
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT
M_0N_0	10.9 b	23.2 c	25.2 e	26.1 c	26.8 e	4.6 c	9.7 c	10.5 c	11.0 d	11.3 b
M_0N_1	14.4 a	26.7 ab	29.6 abcde	30.4 abc	31.2 abcd	5.7 abc	11.9 ab	12.9 abc	13.8 abcd	14.3 ab
M_0N_2	15.8 a	27.4 ab	29.4 abcde	30.1 abc	31.4 abcd	6.3 ab	11.2 abc	12.0 abc	12.9 abcd	13.9 ab
M_0N_3	15.1 a	24.4 bc	26.7 bcde	27.6 abc	28.6 cde	5.7 abc	10.4 abc	11.2 abc	12.7 abcd	13.3 ab
M_1N_0	16.1 a	25.1 abc	25.7 de	26.3 bc	26.9 e	6.1 abc	10.1 abc	11.0 abc	11.4 bcd	11.7 b
M_1N_1	14.2 a	27.1 ab	30.4 abc	32.0 a	32.9 ab	5.7 abc	11.1 abc	13.1 ab	13.5 abcd	14.1 ab
M_1N_2	14.1 a	25.1 abc	30.7 abc	31.7 ab	32.6 ab	5.3 abc	10.4 abc	12.1 abc	12.9 abcd	13.8 ab
M_1N_3	15.6 a	27.2 ab	31.3 a	31.2 abc	32.9 ab	5.8 abc	11.1 abc	12.9 abc	13.4 abcd	13.7 ab
M_2N_0	16.6 a	26.8 ab	28.3 abcde	29.5 abc	30.7 abcd	6.1 ab	10.9 abc	11.8 abc	12.5 abcd	13.0 ab
M_2N_1	15.2 a	27.3 ab	30.8 abc	31.8 ab	32.2 abc	6.1 ab	11.4 abc	13.0 abc	13.6 abcd	14.2 ab
M_2N_2	16.5 a	27.5 ab	31.2 ab	32.0 a	32.7 ab	6.0 abc	11.9 a	12.1 abc	14.2 ab	14.0 ab
M_2N_3	16.7 a	27.8 a	31.4 a	32.2 a	34.0 a	6.4 a	12.0 a	13.3 a	14.2 a	15.2 a
M_3N_0	13.9 a	24.5 abc	26.6 cde	27.2 abc	27.8 de	6.2 ab	9.8 bc	10.6 bc	11.2 cd	11.6 b
M_3N_1	14.9 a	26.1 abc	30.0 abcd	31.5 abc	32.4 abc	4.8 bc	10.4 abc	12.4 abc	13.2 abcd	13.8 ab
M_3N_2	14.6 a	25.2 abc	30.1 abcd	31.6 abc	32.3 abc	5.3 abc	10.9 abc	12.9 abc	12.9 abcd	14.9 a
M_3N_3	15.9 a	26.3 abc	29.6 abcde	30.3 abc	31.0 abcd	6.0 abc	10.7 abc	13.2 ab	13.9 abc	14.5 ab
M_4N_0	15.5 a	24.4 bc	28.1 abcde	28.0 abc	29.7 bcde	6.1 ab	10.4 abc	11.1 abc	11.6 abcd	12.4 ab
M_4N_1	14.6 a	25.1 abc	29.3 abcde	27.3 abc	31.5 abcd	5.0 abc	10.8 abc	11.8 abc	12.7 abcd	13.9 ab
M_4N_2	15.0 a	25.2 abc	28.5 abcde	30.0 abc	31.1 abcd	5.6 abc	9.9 abc	11.2 abc	12.3 abcd	13.4 ab
M_4N_3	15.4 a	25.0 abc	28.7 abcde	29.5 abc	30.9 abcd	6.3 a	10.7 abc	12.2 abc	13.0 abcd	13.9 ab
CV (%)	10.2	6.4	7.8	7.7	6.4	12.9	9.9	10.9	10.9	11.8
LSD (0.05)	2.5	2.8	3.8	4.6	3.3	1.2	1.8	2.2	2.3	2.6

[x] means bearing the same letter (s) in a column do not differ significantly at 5% levels of probability

[y] N_o-0 kg N/ha; N_1-80 kg N/ha; N_2-160 kg N/ha; N_3-240 kg N/ha; M_o-Control; M_1-straw; M_2-water hyacinth; M_3-Black plastic; M_4-Irrigation three times

Table 5. Combined effect of nitrogen and moisture management techniques on growth and yield characters of kohlrabi [x]

Treatment [y]	Spread of plant (cm)					Fresh weight of leaves per plant (gm)	Fresh weight of knob per plant (gm)
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT		
M_0N_0	19.5 g	37.2 h	42.6 g	47.1 g	44.0 f	21.7 k	129.3 o
M_0N_1	21.3 fg	41.0 efgh	48.2 def	58.1 abcd	62.6 abc	103.7 cde	342.7 g
M_0N_2	26.4 abc	46.8 abc	54.6 ab	57.6 abcd	60.1 bcd	95.1 fg	301.7 ij
M_0N_3	23.9 bcdef	42.7 cdefg	47.9 def	53.5 def	56.2 de	94.3 fg	256.3 m
M_1N_0	22.9 cdefg	40.9 fgh	45.5 fg	47.4 g	56.2 de	49.9 j	356.3 ef
M_1N_1	23.0 cdefg	45.3 abcde	54.5 ab	61.4 a	65.5 ab	127.9 a	374.7 bc
M_1N_2	22.4 defg	41.8 defg	50.5 cde	58.0 abcd	63.6 abc	97.6 ef	306.3 i
M_1N_3	25.2 abcde	42.9 cdefg	53.9 abc	60.3 abc	62.8 abc	111.3 bc	346.7 fg
M_2N_0	26.2 abcd	43.5 bcdefg	50.4 cde	55.5 cdef	64.0 abc	77.8 h	285.0 kl
M_2N_1	26.7 abc	46.1 abcd	54.7 ab	60.0 abc	62.8 abc	97.3 ef	284.0 kl
M_2N_2	23.9 bcdef	47.4 ab	53.9 abc	60.5 abc	63.6 abc	113.9 b	367.3 cd
M_2N_3	28.3 a	47.9 a	55.8 a	61.5 a	66.0 a	129.7 a	393.7 a
M_3N_0	26.7 abc	37.4 h	46.7 ef	51.0 fg	53.9 e	46.7 j	293.3 jk
M_3N_1	23.2 bcdef	44.1 abcdef	55.7 a	60.9 ab	62.1 abc	109.1 bc	357.7 de
M_3N_2	22.1 efg	42.1 defg	51.2 bcd	59.1 abc	62.5 abc	95.9 ef	358.0 de
M_3N_3	26.2 abcd	44.1 abcdef	50.9 bcd	56.1 bcde	59.9 cd	106.1 bcd	380.7 b
M_4N_0	25.7 abcde	39.3 gh	47.8 def	51.6 efg	53.9 e	62.5 i	211.3 n
M_4N_1	22.5 defg	42.1 defg	51.3 bcd	58.7 abc	61.1 abcd	99.3 def	324.0 h
M_4N_2	25.7 abcde	44.1 abcdef	51.8 abcd	57.2 abcd	60.0 cd	87.3 g	276.7 l
M_4N_3	27.1 ab	42.2 defg	47.9 def	56.9 abcd	59.9 cd	100.4 def	330.3 h
CV (%)	8.08	5.2	4.2	4.6	4.6	5.0	2.0
LSD (0.05)	3.267	3.7	3.5	4.3	4.6	7.5	10.1

[x] means bearing the same letter (s) in a column do not differ significantly at 5% levels of probability

[y] N_0, 0 kg N/ha; N_1, 80 kg N/ha; N_2, 160 kg N/ha; N_3, 240 kg N/ha; M_0, Control; M_1, straw; M_2, water hyacinth; M_3, Black plastic; M_4, Irrigation three times

4.3.8 Fresh weight of root per plant

Interaction effect of moisture management techniques and nitrogen fertilizer was found to be statistically significant. Maximum fresh weight of root per plant (6.4 g) was found with the treatment combination M_2N_3 (water hyacinth with 240 kg N/ha). The minimum (3.0 g) was observed from treatment combination M_0N_0 (Table 6).

4.3.9 Diameter of knob

Statistically analysis showed that the interaction effect between moisture management techniques and nitrogen fertilizer had significant effect on diameter of knob of kohlrabi. Maximum diameter of knob (8.4 cm) was observed from M_2N_3 (water hyacinth with 240 kg N/ha) treatment which was statistically similar with treatment combination of M_0N_1, M_0N_2, M_1N_0, M_1N_1, M_1N_2, M_1N_3, M_2N_0, M_2N_1, M_2N_2, M_3N_1, M_3N_0, M_3N_2, M_3N_3, M_4N_1 and M_4N_3. The minimum diameter of knob (5.4 cm) was observed from M_0N_0 (Table 6).

4.3.10 Thickness of knob per plant

Interaction of moisture management techniques and nitrogen fertilizer was found to be significant in respect of thickness of knob. Maximum thickness of knob (8.5 cm) was obtained from the treatment combination of M_2N_3 (water hyacinth with 240 kg N/ha). Minimum thickness of knob (5.0 cm) was obtained from M_0N_0 (control) treatment (Table 6).

4.3.11 Average length of root per plant

Treatment combination of different moisture management techniques and nitrogen fertilizer was significantly influenced on the average length of root. Maximum average root length (8.3 cm) was found from the treatment combination of M_2N_3 (water hyacinth mulch with 240 kg N/ha). Minimum average length of root (3.4 cm) was obtained from M_0N_0 (no moisture management techniques and no nitrogen) at 55 DAT (Table 6).

Plate 1. An overall view of experiment area

Plate 2. A view of typical plant with knob

4.3.12 Number of lateral roots per plant

Number of lateral root per plant was significant due to interaction effect of moisture management techniques and nitrogen fertilizer. Number of lateral root (27.9) was the highest when M_2N_3 (water hyacinth with 240 kg N/ha) treatment combination were applied which was statistically similar with treatment combination of M_1N_1. On the other hand the lowest number of lateral root (18.0) was found with M_0N_0 (no moisture management techniques with no nitrogen) (Table 6).

4.3.13 Dry weight of leaves

Percent dry weight of leaf had significant due to the combined effect of moisture management techniques and nitrogen fertilizer. Treatment M_2N_3 (water hyacinth mulch with 240 kg N/ha) produced the highest percentage (12.7%) of dry weight. On the other hand lowest percentage (9.0%) of dry weight was produced by treatment M_0N_0 which was statistically similar with treatment combination of M_0N_2, M_0N_3, M_1N_1, M_2N_0, M_2N_1, M_2N_3 and M_3N_2 (Table 6).

4.3.14 Dry weight of knob

Influence of moisture management techniques and nitrogen fertilizer on the dry weight percentage of knob in kohlrabi significant. Water hyacinth mulch with 240 kg N/ha (M_2N_3) resulted in the highest percentage (6.8%) which was statistically similar with treatment combination of M_2N_2, M_1N_0, and M_0N_1. Lowest percentage dry weight (4.0%) was produced by treatment M_0N_0 (Table 6).

4.3.15 Dry weight of root

Interaction and combined effects of both treatment of moisture management techniques and nitrogen fertilizer were statistically significant. Maximum (33.5%) dry weight of roots was recorded from the treatment combination of water hyacinth mulch and 240 kg N/ha nitrogen (M_2N_3) and the minimum (21.3%) dry weight of root was recorded from the treatment combination of M_0N_0 which was statistically similar with treatment combination of M_1N_3 (Table 6).

Table 6. Combined effect of nitrogen and moisture management techniques on yield and yield contributing characters of kohlrabi [x]

Treatment [y]	Fresh weight of roots per plant (gm)	Diameter of knob per plant (cm)	Thickness of knob per plant (cm)	Average length of roots per plant (cm)	Number of lateral roots per plant	Dry weight of leaves (%)	Dry weight of knob (%)	Dry weight of roots (%)	Gross yield per plot (kg)	Marketable yield per plot (kg)	Marketable yield (t/ha)
M_0N_0	3.0 f	5.4 b	5.0 c	3.4 d	18.0 e	9.0 b	4.0 b	21.3 e	3.1 c	2.5 c	12.9 c
M_0N_1	5.2 abcde	8.3 a	6.4 bc	5.6 bcd	26.5 ab	10.5 ab	6.7 a	26.0 bcde	8.1 ab	6.5 ab	33.8 ab
M_0N_2	4.5 abcdef	7.4 a	8.1 ab	7.9 ab	26.2 abc	9.3 b	6.2 ab	22.0 de	8.7 ab	6.6 ab	34.4 ab
M_0N_3	4.8 abcdef	7.3 ab	6.9 ab	6.9 abc	23.7 abcd	9.5 b	5.3 ab	27.3 bc	7.7 ab	5.5 ab	28.7 ab
M_1N_0	3.9 cdef	8.1 a	7.2 ab	5.8 abcd	22.2 bcde	11.3 ab	6.5 a	29.0 b	7.3 ab	6.1 ab	31.8 ab
M_1N_1	6.2 ab	7.9 a	7.8 ab	6.8 abc	27.8 a	9.8 b	6.2 ab	21.3 d	9.1 a	6.6 ab	34.4 ab
M_1N_2	5.5 abcd	8.0 a	7.0 ab	6.5 abc	23.2 abcd	11.5 ab	5.8 ab	28.8 b	9.7 a	7.0 a	35.8 ab
M_1N_3	5.2 abcde	8.0 a	7.7 ab	7.9 ab	25.3 abcd	11.5 ab	4.8 ab	25.3 bcde	9.0 ab	6.3 ab	33.0 ab
M_2N_0	5.5 abcd	7.5 a	7.6 ab	6.9 abc	20.7 de	9.8 b	5.2 ab	27.3 bc	7.3 ab	5.3 abc	27.5 abc
M_2N_1	4.9 abcdef	7.4 a	7.3 ab	7.5 abc	24.8 abcd	9.2 b	6.0 ab	23.2 cde	7.9 ab	5.6 ab	29.1 ab
M_2N_2	5.8 abc	7.9 a	8.1 ab	6.6 abc	24.7 abcd	10.2 ab	6.7 a	25.0 bcde	10.4 a	7.5 a	39.4 a
M_2N_3	6.4 a	8.4 a	8.5 a	8.3 a	27.9 a	12.7 a	6.8 a	33.5 a	10.7 a	7.9 a	41.3 a
M_3N_0	3.3 ef	7.7 a	7.0 ab	5.0 cd	21.5 cde	11.0 ab	6.2 ab	23.7 cde	7.1 ab	6.0 ab	31.2 ab
M_3N_1	4.5 abcdef	8.0 a	8.1 ab	6.0 abc	24.1 abcd	10.5 ab	5.0 ab	26.3 bcde	8.6 ab	6.6 ab	34.2 ab
M_3N_2	4.1 cdef	8.0 a	7.2 ab	6.0 abc	21.1 de	9.8 b	5.2 ab	26.0 bcde	9.2 a	6.7 ab	34.9 ab
M_3N_3	4.2 bcdef	8.0 a	7.4 ab	5.8 abcd	24.1 abcd	9.8 b	6.0 ab	25.8 bcde	10.4 a	7.6 a	38.9 a
M_4N_0	3.5 def	6.6 ab	6.5 bc	6.4 abc	22.1 bcde	10.7 ab	5.2 ab	25.0 bcde	4.9 bc	3.7 bc	19.3 bc
M_4N_1	3.5 def	7.9 a	7.7 ab	6.3 abc	23.3 abcd	10.3 ab	5.5 ab	26.5 bcd	8.6 ab	6.2 ab	32.5 ab
M_4N_2	3.9 cdef	7.2 ab	7.1 ab	5.7 abcd	25.1 abcd	10.2 ab	5.5 ab	25.3 bcde	8.5 ab	6.0 ab	31.4 ab
M_4N_3	5.1 abcde	8.3 a	8.0 ab	7.3 abc	23.6 abcd	10.8 ab	5.7 ab	23.0 cde	9.0 a	6.6 ab	34.2 ab
CV (%)	22.5	13.7	14.0	20.4	10.5	13.7	19.1	9.9	25.3	26.5	26.7
LSD (0.05)	1.7	1.7	1.7	2.2	4.1	2.4	1.8	4.2	3.5	2.7	14.1

[x] means bearing the same letter (s) in a column do not differ significantly at 5% levels of probability

[y] N_0, 0 kg N/ha; N_1, 80 kg N/ha; N_2, 160 kg N/ha; N_3, 240 kg N/ha; M_0, Control; M_1, straw; M_2, water hyacinth; M_3, Black plastic; M_4, Irrigation three times

4.3.16 Gross yield per plot

Combined effects of moisture management techniques and nitrogen fertilizer were found to be significant for gross yield of kohlrabi per plot. It was found that M_2N_3 (water hyacinth mulch with 240 kg N/ha) treatment produced the maximum gross yield per plot (10.7 kg) which was statistically similar with treatment combination of M_1N_1, M_1N_3, M_2N_2, M_3N_2, M_3N_3 and M_4N_3. Minimum gross yield per plot (3.1 kg) was obtained from the M_0N_0 (control) treatment combination (Table 6).

4.3.17 Marketable yield per plot and per hectare

It was observed that the interaction effect of moisture management techniques and nitrogen fertilizer on marketable yield per plot was statistically significant. M_2N_3 (water hyacinth mulch with 240 kg N/ha) produced the highest marketable yield per plot (7.9 kg) which was statistically similar with treatment combination of M_1N_2, M_2N_2 and M_3N_3. Lowest yield per plot (2.5 kg) was found from M_0N_0 treatment combination. In case of yield per hectare a similar trend was also observed where treatment M_2N_3 (water hyacinth mulch with 240 kg N/ha) gave the highest yield (41.3 t/ha) which was statistically similar to M_2N_2 and M_3N_3 treatment and the lowest yield (12.9 t/ha) was found from the treatment of nitrogen 0 kg/ha (Table 6).

4.4 Economic analysis

Total cost of production under different treatment ranged between Tk. 75906.5 to 96868.5/ha (Table 7). Among the treatment combinations, the variation was due to the cost of different mulch materials and application of different doses of nitrogen fertilizer. Highest cost of production (Tk. 96868.5/ha) was involved in the treatment combination of black plastic and 240 kg N/ha treatment. While it was the lowest (Tk. 75906.5/ha) produced by M_0N_0 treatment combination. Highest gross return (Tk. 330400/ha) was obtained from the water hyacinth with 240 kg N/ha. The lowest gross return (Tk. 102880/ha) was obtained from M_0N_0 (control) treatment. Gross return was the total income through sale of knob @ 8000 taka/ton at harvest. The maximum net return was Tk. 245350.5/ha having a benefit cost ratio of 3.9 in the treatment combination of water hyacinth with 240 kg N/ha. On the other hand the lowest net return (Tk. 26973.5/ha) and benefit cost ratio (1.4) were obtained from the M_0N_0 (no moisture management techniques and no nitrogen fertilizer) treatment (Appendix VI).Thus, it was clear that the treatment combination of water hyacinth and application of 240 kg N/ha gave the highest net return in kohlrabi cultivation.

Table 7. Cost and return analysis in kohlrabi production as influenced by moisture management techniques and nitrogen fertilizer.

Treatment[x]	Marketable yield (t/ha)	Gross return (Tk./ha)	Total cost of production (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio (BCR)
M_0N_0	12.86	102880	75906.5	26973.5	1.4
M_0N_1	33.85	270800	78136.5	192663.5	3.5
M_0N_2	34.38	275040	80366.5	194673.5	3.4
M_0N_3	28.49	227520	82819.5	144700.5	2.7
M_1N_0	31.77	254160	84826.5	169333.5	3.0
M_1N_1	34.38	275040	87056.5	187983.5	3.2
M_1N_2	36.30	290400	89286.5	201113.5	3.3
M_1N_3	32.97	263760	91739.5	172020.5	2.9
M_2N_0	27.45	219600	78136.5	141463.5	2.8
M_2N_1	29.17	233360	80366.5	152993.5	2.9
M_2N_2	38.91	311280	82596.5	228683.5	3.8
M_2N_3	41.30	330400	85049.5	245350.5	3.9
M_3N_0	31.25	250000	89955.5	160044.5	2.8
M_3N_1	34.22	273760	92185.5	181574.5	3.0
M_3N_2	34.90	279200	94415.5	184784.5	3.0
M_3N_3	39.43	315440	96868.5	218571.5	3.3
M_4N_0	19.27	154160	80478.0	73682.0	1.9
M_4N_1	32.45	259600	82708.0	176892.0	3.1
M_4N_2	31.41	251280	84938.0	166342.0	3.0
M_4N_3	34.22	273760	87391.0	186369.0	3.1

Price of kohlrabi @ Tk. 8000/ton
Gross return = Marketable yield x Tk. 8000/t

[x] N_o, 0 kg N/ha; N_1, 80 kg N/ha; N_2, 160 kg N/ha; N_3, 240 kg N/ha; M_o, Control; M_1, straw; M_2, water hyacinth; M_3, Black plastic; M_4, Irrigation three times

CHAPTER V

SUMMARY AND CONCLUSION

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Experiment was carried out at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2007 to January 2008 to evaluate the performance of moisture management techniques and nitrogen fertilizer on the growth and yield of kohlrabi. The experiment comprised of two factor such as (a) five techniques of moisture management viz. M_0 (no mulch); M_1 (straw); M_2 (water hyacinth); M_3 (black polythene); M_4 (irrigation three times) and (b) four levels of nitrogen fertilizer viz. F_0 (0 kg N fertilizer); F_2 (80 kg N/ha); F_3 (160 kg N/ha); F_4 (240 kg N/ha). Experiment was laid out in Randomized Complete Block Design (RCBD) with three replication. Size of each unit plot was 1.6m x 1.2m 32 plants were accommodated in each plot following a spacing of 30cm x 20cm. From each plot, 10 plants were randomly selected and identified with stick for collection of data. Yield per hectare was estimated on the basis of yield per plot. Data were collected on growth parameters and the yield was estimated on the basis of per plot yield. Collected data were analyzed and the differences between the means were evaluated by Duncans Multiple Range Test (DMRT).

Result of the experiment revealed that the application of different doses of nitrogen fertilizer had insignificant effect on plant height except at 55 DAT. Highest plant height (38.5 cm) was recorded from 240 kg N/ha treatment and the lowest plant height (32.71 cm) was recorded from 0 kg N/ha treatment. Water hyacinth mulch caused the highest plant height (38.2 cm) and the minimum plant height (34.88 cm) was recorded in plant grown without moisture management techniques at 55 DAT. Interaction effect of moisture management techniques and nitrogen was found significant at different days after transplanting. Different moisture management technique treatments insignificantly influenced the number of leaves per plant. On an average, 17.16 leaves were found with M_2 (water hyacinth mulch) and the minimum number of leaves (14.62) were recorded without any moisture management techniques. Maximum number of leaves (17.0) were produced per plant when plant receiving 240 kg N/ha and the minimum (13.35) was obtained by control treatment (N_0). Interaction effect of moisture management techniques and nitrogen fertilizer was found to be significant at 55 DAT.

Maximum spread of plants (66.0) was observed at 55 DAT when water hyacinth mulch with 240 kg N/ha was applied and the minimum (44.0) was observed in the treatment combination of control (M_0N_0) where no moisture management techniques and no nitrogen fertilizer was used.

Maximum breadth and length of largest leaf were 14.1 cm and 32.4 cm were found in plants with water hyacinth mulch and the minimum breadth and length of largest leaf (13.2 cm and 29.5 cm) were found on the control treatment. In case of nitrogen fertilizer the highest breadth and length of largest leaf per plant (14.3 cm and 32.4 cm) was observed when 240 kg N/ha treatment was used. Highest breadth and length of largest leaf per plant (15.2 cm and 34.0 cm) was observed at 55 DAT when treatment combination of water hyacinth with 240 kg N/ha was applied and minimum (11.3 cm and 26.8 cm) was observed in the treatment combination of control (M_0N_0).

Other parameter like fresh weight of leaves, knob and root, diameter and thickness of knob, average length and number of roots were significantly influenced by the treatment combination of the experiment. Maximum dry matter of leaves and knob (12.7 % and 6.8 %) were come from treatment combination of 240 kg N/ha with water hyacinth mulch.

Application of different moisture management techniques and different levels of nitrogen fertilizer was found to be statistically insignificant on gross yield of kohlrabi. Maximum gross yield (9.1 kg per plot) was obtained with water hyacinth mulch and the lowest (6.9 kg per plot) from the plant grown without moisture management technique. On the other hand maximum gross yield (9.4 kg per plot) was observed from the plants fertilized with 240 kg N/ha and the minimum (6.0 kg per plot) from the plant receiving no nitrogen fertilizer. Treatment combination of M_2N_3 (water hyacinth with 240 kg N/ha) gave the maximum gross yield (10.7 kg per plot) which was statistically similar with treatment combination of M_1N_1, M_1N_3, M_2N_2, M_3N_3 and M_4N_3.

Different moisture management techniques played important role on yield of kohlrabi. The maximum marketable yield (6.8 kg/plot) and (35.4 t/ha) were obtained from water hyacinth mulch. While the lowest marketable yield (5.3 kg/plot) and (27.4 t/ha) was found in control plot. Again maximum marketable yield (6.8 kg/plot) and (35.9 t/ha) were obtained by 240 kg N/ha treatment. The minimum marketable yield (4.7 kg/plot) and (24.5 t/ha) were in the control plot. Both moisture management technique and nitrogen fertilizer showed statistically significant effect of marketable yield. Highest marketable yield (7.9 kg/plot) and (41.3 t/ha) were obtained from water hyacinth mulch with 240 kg N/ha which was statistically similar with treatment combination of M_1N_1, M_2N_2 and M_2N_3.

From the economic point of view it was evident that highest gross return was obtained from the combined effect of water hyacinth mulch with 240 kg N/ha (330400 Tk./ha) and also the maximum net return (245350.5 Tk./ha). Highest benefit cost ratio (3.9) was found from the treatment combination of water hyacinth mulch with 240 kg N/ha and the lowest (1.4) was recorded in no moisture management technique and no nitrogen fertilizer treatment.

Results of the present study reveals that application of water hyacinth as well as optimum supply of nitrogen fertilizer helped to increase yield of kohlrabi. It was observed that the yield was maximum with the water hyacinth and 240 kg N/ha. Considering the situation of the present study, further studies in the following areas may be suggested.

i. From the present experiment it may be concluded that application of water hyacinth mulch as moisture management technique may be suggested where precipitation is scanty and irrigation is costly. From the point of yield economics it may be suggested that higher yield could be obtained by cultivating the kohlrabi with the adoption of water hyacinth practice with 240 kg N/ha under the Madhupur tract (AEZ No-28) of Bangladesh.

ii. Further investigation may be carried out in different agro ecological zones of Bangladesh before giving final recommendation.

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APPENDICES

APPENDICES

Appendix I: Soil characteristics of horticulture farm of Sher-e-Bangla Agricultural University are analyzed by soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture garden, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	N/A

B. Physical and chemical properties of the initial soil

Characteristics	Value
Practical size analysis	
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	6.06
Organic carbon (%)	0.45
Organic matter (%)	0.90
Total N (%)	0.10
Available P (µgm/gm soil)	43.87
Available K (me/100g soil)	0.13
Available S (mlgm/100gm soil)	11.45

Appendix II. Monthly air temperature, Rainfall and Relative humidity of the experimental site during the study period (October, 2007 to January, 2008)

Year	Month	Air temperature (^0C)			Rainfall**	* Relative
		Max.	Min.	Mean	(mm)	humidity (%)
2007	October	35.6	19.5	27.5	320.0	64.5
	November	31.8	16.8	24.3	14.0	67.0
	December	28.2	11.3	19.8	0.0	63.0
2008	January	29.0	10.5	19.8	23.0	61.5

* Monthly average

** Monthly total

Source: The Meteorological Department (Weather division) of Bangladesh, Agargoan, Dhaka

Appendix III. Mean square values of analysis of variance of the data on growth of kohlrabi as influenced by moisture management techniques and nitrogen fertilizer.

Sources of variation	Degrees of freedom (df)	Mean sum square														
		Plant height at					Number of leaves per plant					Length of largest leaf per plant (cm)				
		15 DAT	25 DAT	35 DAT	45 DAT	55 DAT (at harvest)	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT (at harvest)	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT (at harvest)
Replication	2	1.1	51.8	7.1	6.3	10.6	1.5	2.0	1.5	0.1	0.1	5.3	4.3	6.7	20.2	10.5
Factor A (Moisture management)	4	8.8^{NS}	34.7^{NS}	30.8^{NS}	23.2^{NS}	18.2^{NS}	2.1^{NS}	2.8^{NS}	3.0^{NS}	7.4^{NS}	15.8^{NS}	3.7^{NS}	7.4^{NS}	10.9^{NS}	15.6^{NS}	13.0^{NS}
Factor B (Nitrogen)	3	1.3^{NS}	14.6^{NS}	63.7^{NS}	94.8**	99.0**	0.4^{NS}	0.5^{NS}	3.4^{NS}	21.1^{NS}	39.8^{NS}	1.3^{NS}	8.0^{NS}	38.2^{NS}	40.2^{NS}	50.4^{NS}
A x B	12	3.0**	2.8**	6.3**	8.7**	14.2**	0.5**	0.6**	1.0**	3.0**	7.8**	1.8**	3.8**	3.2**	4.5**	3.3**
Error	38	1.1	10.5	3.3	3.3	4.0	0.4	0.9	1.3	2.0	3.1	2.4	2.8	5.2	5.3	4.0

**: Significant at 5% level of significance, NS: Not significant, DAT: Days after transplanting.

Appendix IV. Mean square values of analysis of variance of the data on growth and yield of kohlrabi as influenced by moisture management techniques and nitrogen fertilizer.

Sources of variation	Degrees of freedom (df)	Mean sum square												
		Breadth of largest leaf per plant (cm)					Spread of plant (cm)					Fresh weight of leaves per plant (gm)	Fresh weight of knob per plant (gm)	Fresh weight of roots per plant (gm)
		15 DAT	25 DAT	35 DAT	45 DAT	55 DAT (at harvest)	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT (at harvest)			
Replication	2	0.5	1.9	3.3	4.0	3.0	9.7	13.2	4.6	15.2	8.9	18.1	67.2	9.5
Factor A (Moisture management)	4	1.6 NS	0.9 NS	2.4 NS	1.7 NS	1.6 NS	24.1 NS	22.6 NS	47.6**	43.1 NS	122.5**	1152.8**	20738.9**	4.6 NS
Factor B (Nitrogen)	3	0.7 NS	2.5 NS	8.0 NS	11.3 NS	16.2 NS	11.5 NS	74.2 NS	129.6**	260.4**	220.4**	10800.2**	24192.3**	4.9 NS
A x B	12	0.5**	1.2**	1.1**	0.9**	0.8**	14.3**	15.8**	16.2**	11.7**	29.4**	475.4**	6275.5**	1.7**
Error	38	0.5	1.1	1.7	1.7	2.6	4.0	4.5	4.5	6.7	7.6	20.5	37.3	1.1

**: Significant at 5% level of significance, NS: Not significant, DAT: Days after transplanting.

Appendix V. Mean square values of analysis of variance of the data on yield contributing parameters of kohlrabi as influenced by moisture management techniques and nitrogen fertilizer.

Sources of variation	Degrees of freedom (df)	Diameter of knob per plant (cm)	Thickness of knob per plant (cm)	Average length of roots per plant (cm)	Number of lateral roots per plant	Dry weight of leaves (%)	Dry weight of knob (%)	Dry weight of roots (%)	Gross yield per plot (kg)	Marketable yield per plot (kg)	Marketable yield (t/ha)
Replication	2	1.8	3.2	3.1	5.9	1.0	1.1	54.4	5.5	7.2	194.6
Factor A (Moisture management)	4	1.9 NS	2.1 NS	6.2 NS	18.3 NS	4.5 NS	0.1**	20.5 NS	0.8 **	0.2 **	136.4**
Factor B (Nitrogen)	3	2.6 NS	3.2 NS	6.3 NS	57.7 NS	2.8 NS	0.1 NS	43.4 NS	1.0 **	0.6**	384.2**
A x B	12	1.0**	1.4**	2.3**	7.8**	1.8**	1.3**	22.0**	2.5**	2.2**	60.1**
Error	38	1.1	1.1	1.7	6.2	2.0	1.3	6.4	4.4	2.6	72.7

**: Significant at 5% level of significance, NS: Not significant, DAT: Days after transplanting.

Appendix VI. Production cost of kohlrabi per hectare

A. **Input cost (Tk.)**

a. **Material cost (Tk.)**

Treatment	Seed	Manures and fertilizers				Moisture management cost	Chatai and bamboo	Insecticide	Water for seedling establishment	Subtotal (a)
		Cowdung	Urea	TSP	MP					
M_0N_0	3000	3000	-	6000	6100	-	500	2000	1000	21600
M_0N_1	3000	3000	2000	6000	6100	-	500	2000	1000	23600
M_0N_2	3000	3000	4000	6000	6100	-	500	2000	1000	25600
M_0N_3	3000	3000	6200	6000	6100	-	500	2000	1000	27800
M_1N_0	3000	3000	-	6000	6100	7800	500	2000	1000	29400
M_1N_1	3000	3000	2000	6000	6100	7800	500	2000	1000	31400
M_1N_2	3000	3000	4000	6000	6100	7800	500	2000	1000	33400
M_1N_3	3000	3000	6200	6000	6100	7800	500	2000	1000	35600
M_2N_0	3000	3000	-	6000	6100	1800	500	2000	1000	23400
M_2N_1	3000	3000	2000	6000	6100	1800	500	2000	1000	25400
M_2N_2	3000	3000	4000	6000	6100	1800	500	2000	1000	27400
M_2N_3	3000	3000	6200	6000	6100	1800	500	2000	1000	29600
M_3N_0	3000	3000	-	6000	6100	12000	500	2000	1000	33600
M_3N_1	3000	3000	2000	6000	6100	12000	500	2000	1000	35600
M_3N_2	3000	3000	4000	6000	6100	12000	500	2000	1000	37600
M_3N_3	3000	3000	6200	6000	6100	12000	500	2000	1000	39800
M_4N_0	3000	3000	-	6000	6100	3000	500	2000	1000	24600
M_4N_1	3000	3000	2000	6000	6100	3000	500	2000	1000	26600
M_4N_2	3000	3000	4000	6000	6100	3000	500	2000	1000	28600
M_4N_3	3000	3000	6200	6000	6100	3000	500	2000	1000	30800

Cowdung: 10 ton/ha @ 300 Tk./ton
Urea : 12 Tk./kg
TSP : 150 kg/ha @ 40 Tk./kg
MP : 175 kg/ha @ 35 Tk./kg

Straw: 3 ton/ha @ 2600 Tk./ton
Water hyacinth: 1800 Tk./ha
Black polythene: 1200 m/ha @ 10 Tk./m

Appendix VI (Contd.)

b. Non material cost (Tk.)

Treatment	Seed bed preparation	Land preparation	Moisture management and transplanting cost	Cost of intercultural operation	Bird driving	Cost of harvesting	Subtotal (b)	Input cost A (a + b)
M_0N_0	400	3000	1200	1200	1200	4500	11500	33100
M_0N_1	400	3000	1200	1200	1200	4500	11500	35100
M_0N_2	400	3000	1200	1200	1200	4500	11500	37100
M_0N_3	400	3000	1200	1200	1200	4500	11500	39300
M_1N_0	400	3000	2000	600	1200	4500	11700	41100
M_1N_1	400	3000	2000	600	1200	4500	11700	43100
M_1N_2	400	3000	2000	600	1200	4500	11700	45100
M_1N_3	400	3000	2000	600	1200	4500	11700	47300
M_2N_0	400	3000	2000	600	1200	4500	11700	35100
M_2N_1	400	3000	2000	600	1200	4500	11700	37100
M_2N_2	400	3000	2000	600	1200	4500	11700	39100
M_2N_3	400	3000	2000	600	1200	4500	11700	41300
M_3N_0	400	3000	2400	600	1200	4500	12100	45700
M_3N_1	400	3000	2400	600	1200	4500	12100	47700
M_3N_2	400	3000	2400	600	1200	4500	12100	49700
M_3N_3	400	3000	2400	600	1200	4500	12100	51900
M_4N_0	400	3000	2000	1500	1200	4500	12600	37200
M_4N_1	400	3000	2000	1500	1200	4500	12600	39200
M_4N_2	400	3000	2000	1500	1200	4500	12600	41200
M_4N_3	400	3000	2000	1500	1200	4500	12600	43400

Labour cost @ Tk. 80/day/capital

Appendix VI (Contd.)

B. Overhead cost (Tk.)

Treatment	Cost of lease of land for 6 month (13% of value of land Tk. 600000/year)	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 month (Tk. 13% of cost/year)	Sub total (Tk.) (B)	Total cost (Tk.) of production [Input cost (A) + overhead cost (B)]
M_0N_0	39000	1655	2151.5	42806.5	75906.5
M_0N_1	39000	1755	2281.5	43036.5	78136.5
M_0N_2	39000	1855	2411.5	43266.5	80366.5
M_0N_3	39000	1965	2554.5	43519.5	82819.5
M_1N_0	39000	2055	2671.5	43726.5	84826.5
M_1N_1	39000	2155	2801.5	43956.5	87056.5
M_1N_2	39000	2255	2931.5	44186.5	89286.5
M_1N_3	39000	2365	3074.5	44439.5	91739.5
M_2N_0	39000	1755	2281.5	43036.5	78136.5
M_2N_1	39000	1855	2411.5	43266.5	80366.5
M_2N_2	39000	1955	2541.5	43496.5	82596.5
M_2N_3	39000	2065	2684.5	43749.5	85049.5
M_3N_0	39000	2285	2970.5	44255.5	89955.5
M_3N_1	39000	2385	3100.5	44485.5	92185.5
M_3N_2	39000	2485	3230.5	44715.5	94415.5
M_3N_3	39000	2595	3373.5	44968.5	96868.5
M_4N_0	39000	1860	2418.0	43278.0	80478.0
M_4N_1	39000	1960	2548.0	43508.0	82708.0
M_4N_2	39000	2060	2678.0	43738.0	84938.0
M_4N_3	39000	2170	2821.0	43991.0	87391.0

Appendix VII. Layout of the experimental plot