PERFORMANCE OF DIFFERENT VARIETIES AND FERTILIZER MANAGEMENT PRACTICES ON THE GROWTH AND YIELD OF KNOL-KHOL

BY

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CERTIFICATE

This is to certify that the thesis entitled "***PERFORMANCE OF DIFFERENT VARIETIES AND FERTILIZER MANAGEMENT PRACTICES ON THE GROWTH AND YIELD OF KNOL-KHOL***" submitted to the Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE*** in ***HORTICULTURE,*** embodies the result of a piece of *bona fide* research work carried out by ***ABU SHAMA MD. ASIF IQBAL, REGISTRATION NO. 03-01150,*** under my supervision and guidance. No part of this 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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Beloved Parents

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ABSTRACT

A field experiment was carried out to investigate the performance of different varieties and different fertilizer management practices on the growth and yield of Knol-khol at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2007 to January, 2008. The experiment consisted of five varieties, viz. V_1: White vienna; V_2: Quick star; V_3: Sufala-14; V_4: UFO; V_5: Early 005 and four kinds of fertilizer management practices, viz. F_0: Control; F_1: Organic Manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer. The experiment was carried out in randomized complete block design with three replications. Both variety and fertilizer management practices had significant influence on growth and yield. In case of varieties, V_1 showed highest marketable yield (29.39 t/ha) and V_5 the lowest (22.43 t/ha). For fertilizer, the maximum marketable yield (31.78 t/ha) was found in F_3 and the lowest (18.99 t/ha) in F_0. For combined effect, the highest marketable yield (37.51 t/ha) was obtained from V_1F_3 and the lowest (16.31 t/ha) from V_5F_0. Maximum net return (200730.62 Tk./ha) and benefit cost ratio (3.02) were found from V_1F_3 and the lowest from V_5F_0. So, higher yield could be obtained by cultivating the White vienna of Knol-khol with both organic and inorganic fertilizers under the Madhupur tract of Bangladesh.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-ecological Zone
AIS	=	Agricultural Information Service
BARI	=	Bangladesh Agricultural Research Institute
BARC	=	Bangladesh Agricultural Research Council
BCR	=	Benefit Cost Ratio
CV%	=	Percentage of Coefficient of Variance
DAT	=	Days after Transplanting
DMRT	=	Duncan's Multiple Range Test
et al.	=	And others
FAO	=	Food and Agriculture Organization
ha	=	Hectare
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
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

CHAPTER I

INTRODUCTION

Knol-khol or Kohlrabi (*Brassica oleracea* var. *gongylodes*) belongs to the family Cruciferae and is closely related to cabbage. It is also known as "Ol-copi". It is often called "Turnip rooted cabbage". The name comes from the German "kohl" (cabbage) plus "rabi" (turnip), because the spherical swollen stem resembles the latter. It is of North-European origin and is one of the winter vegetable of Bangladesh. It is also a short duration vegetable crop. Generally, above-ground modified stem is the main edible portion, but the young leaves also may be cooked in various ways (Baloch, 1994).

Knol-khol is a member of the cole crops and is an excellent vegetable if used before it becomes tough and fibrous. It is high in minerals and vitamins A and C. It contains adequate amount of water (90.3 g), calories (29 g), protein (2 g), carbohydrate (6.6 g), fibre (1 g), and ash (1 g) per 100 g of edible stem. It also contains satisfactory amount of calcium (41 mg), phosphorus (51 mg), iron (0.5 mg), sodium (8 mg), potassium (372 mg), vitamin A (20 mg), thiamin (0.06 mg), riboflavin (0.04 mg), niacin (0.03 mg), and vitamin C (66 mg) per 100 g of above ground stem (Duke and Ayensu, 1985).

Production of knol-khol depends on many factors such as quality of seed, variety, plant spacing, fertilizer and proper management practices. The actual yield of knol-khol is very low against the potential yield and has not been extended much beyond the agricultural farms in Bangladesh. This is due to lack of awareness regarding its nutritive value and method of production. This can be bridged up by adopting modern agronomic techniques like planting methods, controlled irrigation, hybrid variety and increased nutritional status of the soil through balanced fertilizer application. Knol-khol responds greatly to major essential nutrients like N, P and K in respect of 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 NPK. Nitrogen is a part of chlorophyll molecule, amino acid, proteins, nucleic acid and pigments. Adequate supply of nitrogen

favours 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). Phosphorus plays a vital role in several key physiological processes, viz. photosynthesis, respiration, energy storage and transfer, cell division and cell enlargement. It is an important structural component of many biochemical, viz., nucleic acids (DNA, RNA), co-enzymes, nucleotides, phospholipids and sugar phosphate. It stimulates root growth, blooming, fruit setting and seed formation (Memon, 1996). Potassium is considered essential in photoslynthesis, sugar translocation, nitrogen metabolism, enzyme activation, stomatal opening, water relation and growth of meristematic tissue. It acts as chemical traffic policeman, root booster, stalk strengtheners, protein builder, breathing regulator and retard the diseases, but it is not effective without its co-efficient such as N and P (Chandra, 1989).

Again use of organic matter in crop production may have many advantages over inorganic fertilizer. Organic matter reduced soil erosion, increased water holding capacity, physiochemical and biological conditions of the soil. Besides nitrogen, phosphorus, potassium and sulfur, a considerable amount of micronutrients is also present in organic matter. Knol-khol is a short duration crop so easily soluble organic manure should be applied for its cultivation. Organic manure helps to conservation of soil moisture. Available soil moisture also helps taking other nutrients for the plants. With the available soil moisture nitrogen fertilizer also may be available to the plants. In this way organic manure helps uptaking of nitrogen fertilizer (Anon., 1992).

Crop yield varies from variety to variety due to internal and external factors of the plant. Most of the seed companies of the world developed crop varieties suitable for varied climatic conditions, and if the varieties are used without adaptability test, the growers may face economic losses. Those varieties which possess high yield potential and less disease incidence, and are dwarf in size with short crop duration are preferred by the growers. Therefore, it is necessary to find out a suitable variety for higher yield and economic return as well. The seed of the plant used in the present experiment are mainly hybrid varieties.

The present study was undertaken with the following objectives:

- to find out the suitable variety/varieties for the commercial production of Knol-khol in Bangladesh condition.
- to observe the performance of organic or inorganic fertilizers.
- to observe the combined effect of different fertilizers and the varieties for maximum production of Knol-khol.

Chapter II

Review of literature

CHAPTER II

REVIEW OF LITERATURE

Knol-khol is a thinly scattered vegetable crop of Bangladesh which grown during the cold winter months. Its growth, yield and storability are remarkably influenced by variety and nutrient supply from organic and inorganic fertilizer sources. The requirement is varied with soil and cultural conditions. Growth, yield and storability of knol-khol have been studied in various parts of the world. But a limited number of published reports are available on the variety and nutrients requirement of knol-khol. However, available information relevant to this study is reviewed under the following headings.

2.1 Effect of variety on growth and yield of knol-khol

Cebula (2004) compared yielding and commercial quality of heads of 13 late cultivar of white cabbage (*Brassica oleracea* var. *capitata*; Galaxy F_1, Donar F_1, Kronos F_1, Balaton F_1, Lennox F_1, Bently F_1, Saratoga F_1, Amtak F_1, Brutus F_1, Marathon F_1, Hamilton F_1, Robustor F_1 and Junior F_1) during 1999-2001 in Poland. High total and marketable yields of cabbage cultivars (>100 t/ha in general) were obtained. The highest yields were recorded in Donar F_1, Galaxy F_1 and Balaton F_1. The cultivars were characteristerized by good mean weight of heads (3-4 kg) and a high percentage of first-grade total yields.

In a field trial Marsic and Osvald (2004) was studied the effect of fertigation and broadcast mineral fertilizer application on yield and quality of 4 cabbage (B. oleracea var. capitata) cultivars in Ljubljana, Slovenia. Five treatments were formed: K=classical fertilization with 150 kg N/ha (broadcast incorporated); DNPK=All nutrients (NPK) were applied via fertigation; FN=P and K were added by classical methods and total N by fertigation; FNPK/30%=30% of total N were applied via fertigation; FN/30%=total P and K and 30% of total N were incorporated before transplanting, the remaining N was applied via fertigation. During the harvest, the height and width of the cabbage, length of stalk, weight of head with leaves and without leaves, height width of cleaned head, firmness of head and core length were measured and the number of external trimmed leaves was counted. The highest average marketable yield was achieved by fertigation

with soluble nutrients, combined with pre- plant as follows: Hermes F1 (38.7 t/ha), Paral F_1 (71.7 t/ha) and Tropicana F_1 (70.7 t/ha) and the lowest by fertigation with N incorporation, with cultivars as follows: Hermes F_1 (20.9 t/ha), Paral F_1 (50.4 t/ha), Tropicana F_1 (63.0 t/ha) and Fieldwinner F_1 (66.1 t/ha). The firmness of cabbage heads was also affected by the method of nutrient application.

Trautwein (2004) reported that the German "Bundessortenamt" in Bamberg tested 10 cultivars during 2000-03 for their ability to be cultivated in greenhouses. The cultivars were All Star, Express Forcer, Korrodor, Korvit, Oasis, Olivia, Pheres, Picaro, Printako and Spurt Forcer (also called Korist). These cultivars were selected by the growers.Each cultivar was tested over two years in six to eight locations. Planting was usually done in February with harvesting in April or early May. The criteria for marketability were a tuber diameter of at least 80 mm, no splitting or stringy plants. The number of leaves and plant structure are important for packaging, and the length and firmness of the stems is important to avoid contact with the soil. The best results were obtained by cv. Express Forcer, followed by Oasis, Picaro, Olivia, Korrodor and Korvit. Cultivars All Star, Spurt Forces and Printako showed intermediate results, while Pheres was the least marketable.

Arin *et al.* (2003) carried out a research to determine the yield and quality of kohlrabi (*Brassica oleracea* var. *gongylodes*) under unheated the yield and glasshouse conditions during the spring and autumn growing periods in 2000. In each period, three kohlrabi cultivars, two seedling ages and three planting dates, with respect to yield and quality characteristics, were evaluated. The autumn cultivar "Express Forcer" and the spring cultivar "Lahn" were more suitable than other cultivars.

Basir *et al.* (2002) conducted an experiment to introduce exotic to introduce exotic cabbage (cultivars Golden Acre, Stand By, Atlas, First of June, and Derby Day) as an off-season vegetable was conducted at the Hilkot watershed, Mansehra, Pakistan. During 2000, Golden Acre took maximum days to head formation (59.33) while Atlas took minimum days (46.67) to head formation. The highest number of leaves (15.33) head-1 was produced by Golden Acre. Minimum insect attack (6.80%) was noted in Golden Acre followed by Atlas (23.40%) while maximum insect attack (51.0%) was noted in Golden Acre. Maximum head diameter was recorded from first of June (32.77cm)

followed by Atlas (31.77 cm). Maximum head weight (332.5 gm) was recorded from Atlas. The highest yield (24220 kg/ha) was produced by Atlas. Atlas is considered the best cultivar for the farmers of the Hilkot watershed.

Thakur and Thakur (2002) twenty-five cabbage cultivars, including Golden Acre and Pride of India, grown in Nauni, Solan, Himachal Pradesh, India, were evaluated for yield and other horticultural traits (days to marketable maturity, number of non-wrapper leaves, leaf area index, head shape index, stalk length, head compact heads and bolters). The analysis of variance showed highly significant differences among cultivars for all traits. Total yield per plot was the highest in line 83-5, followed by H-149. Golden Acre, EC-271632, Express Mail, 83-5, and Pusa Mukta performed well in terms of terms of days to marketable maturity, head compact head, respectively.

Singh *et al.* (2001) investigated the effects of N fertilizer rates (0, 50, 100 and 150 kg/ha) on cabbage cultivars Umder, Vishesh, Chaubatia Early and Anuglory in Uttar Pradesh, India, during 1996-96. Vishesh recorded the highest head length (27.6 cm), volume (2031.3 cm) and weight with (3.2 kg/ha) or without (2.3 kg/ha) stalk; whereas Chaubatia Early exhibited the tallest plants (34.8 cm) with the highest number of open leaves (30.3) and largest head (27.6 cm). All N treatments significantly improved the growth and yield of the cabbage cultivars compared with the control (no N application). Tallest plants (34.5 cm) with the highest head periphery (67.5 cm) and volume (1884.4 cm) were obtained with N at 100 kg/ha, while N at 150 kg/ha resulted in the highest head weight with (3.0 kg/ha) or without (2.1 kg/ha) stalk. The head yield increased with increase in N level; corresponding increases were 30.8, 43.3 and 43.8% for 50, 100 and 150 kg N/ha. Interactions between the cultivar and N treatment weight (4.1 kg) and yield (162 t/ha) were highest in Vishesh with 150 kg N/ha. Chaubatia Early applied with 150 kg N/ha produced cabbage with thickest stems (4.3 cm).

Rooster (1997) conduted a trial with 10 white, 9 red and 6 Savoy cabbage varieties in Balgium, and observed that among the white cabbage varieties, Parel and Elisa were the earliest, followed by Farao and Balbaro, among the red cabbage varieties, Pancas, Intro and Primero were the earliest among the Savoy cabbage varieties, Kilosa, Comparsa and Protovoy were the earliest.

While working with a new early maturing sping cabbage variety "Yanchun" at Shanghai, China, Weijun *et al.* (1996) observed that the variety matured early, was high yielding, had a compact head and scarce premature bolting and was of good quality. The variety yield 10% more than the variety Zhengchun (37.5-48.0 t/ha). It was adapted to winter cultivation in the vast area south of the Yellow River, and along the middle and lower parts of the Yongtze River in China.

Yahua *et al.* (1996) carried out an experiment in China with a new early spring cabbage F_1 variety Hybrid Chunbao. They observed that the variety is early maturing, 3-5 days earlier than the popular variety Niuxin, and had a 60% higher yield, producing 30-52.5 t/ha. The heads were pointed, resistant to bolting and of good quality.

Zhiyuan *et al.* (1996) conducted an experiment with an early spring cabbage F_1 hybrid 8398 in China, and found that it had good quality, early maturity and high productivity. They also stated that, the variety could be harvested 50 days after transplanting, giving a yields of 49.5-57.0 t/ha. The variety was found better than Zhonggan 11 in respect of yield, commercial quality and seed germination.

Shiru *et al.* (1995) reported that, the variety Xiyuan 4 was a high quality, high yielding autumn cabbage. The F_1 hybrid variety was bred in the Sichman province of China from a cross between a self incompatible line introduced from Japan (7817-5-10-3-3-3) and a self incompatible line selected from a local variety (83281-3-1-8-9-1). The variety is resistant to *Xanthomonas campestris* and turnip mosaic potyvirus, which out-yielded the local varieties by 20.5-27.1% in regional trials. The heads of the variety were of good quality, crisp and sweet, and contained 33.2 mg ascorbic acid, 4.9 g soluble solids, 0.74-0.79 g cellulose and 3.96 g total sugar per 100 g fresh leaf. The variety is grown in Sichuan, Yunnan, Hubei and Fujian probices.

Dave and Bambhaniya (1993) conducted an experiment with cabbage under South Gujarat condition. They planted three cabbage varieties, namely, Express, Pride of India and Golden Acre at 5 spacing (30 X 30, 45 X 30, 60 X 30, 45 X 45 and 60 X 45 cm). They reported that Pride of India produced the greatest plan spread and head diameter (11.1 cm), the highest head weight/plant (599 g) and highest yield (32.3 t/ha).

Gong (1991) conducted an experiment to study the brief introduction of new vegetages Zhong Gan 11, X; Yuan 3 and Dong Nong 607 are F1 hybrids, the first and last early and the second an autumn-winter type. Zhong Gan 11 gives good- quality heads weighing 0.8-1 kg and yields 42-52 t/ha. Xi Yuan 3 gives a mean yield of 67.5 t/ha and is resistant to turnip mosaic potyvirus and *Xanthomonas campestris*, as is Dong Nong 607, which has a growth period of 105 days, produces heads weighing 0.6-0.7 kg and containing 43 mg AA/100 g, and yields 37.7 t/ha. The cabbage Dong Nong 606, with a growth period of 108- 110 days, is resistant to turnip mosaic potyvirus and *X. campestris* and produces heads weighing 0.6 kg.

In a trial with 8 varieties of cabbage at 13 locations of Norway, Heradstveit (1988) observed that the most promising varieties were Marner Julico, followed by Grenadier. Both varieties showed good resistance to splitting and produced heads with an average weight of 930 g.

In Brazil, Muniz (1988) conducted an experiment with 3 open pollinated and 8 hybrid varieties of cabbage to compare the commercial yields, average head weight, mean number of external leaves and head compactness. He observed that, the hybrid varieties Sooshu, Gloria and Shutiku were the most productive with yields of 38.0, 37.9 and 32.8 t/ha. The variety Chato do Brunswick gave the lowest yield of 23.5 t/ha.

Synnevag and Guttormsen (1988) conducted a trial at 13 sites throughout Norway, initially with 41 varieties from which 8 were selected for further trials in 1986-87. In the south, sowing time was 1st April and planting out was on 1st May; and in the north, sowing and planting were slightly later. They observed that, Marner Julico and Grenadier were the best cabbage varieties; the former being more susceptible to splitting; but both gave higher yields than the standard variety Delikatesse at all 13 sites. They also stated that, Marner Julico, Grenadier and J. Sommerkal had the highest head weight and Delikatesse and Libra had the lowest head weight. Head shape varied from flat-round in Delight to round in Hermes; other varieties having elongated round heads. The varieties J. Sommerkal, Libra and Fry had the highest heads. The varieties Marner Julico was recommended as the best, while the variety Grenadier was the second best. The variety Delikatesse was with drawn from the recommended list.

Espinosa *et al.* (1987) reported that the varieties CO-Cross (from Japan) and Army Foldi (from Hungry) significantly out-yielded the other varieties, producing mean yields of 65.6 and 60.5 t/ha, respectively, while working with 4 varieties of cabbage at 4 localities in Cuba.

Al-Amin and Hussain (1983) while working with five cabbage varieties at Bangladesh Agricultural University and found that Titan produced heavier head- weight as well as the highest gross yield per plant (5 kg) followed by Big Cropper (3.8 kg) and Hercules (3.33 kg).Titan produced 14.95 outer leaves and head diameter (23.81 cm). Hervules and Titan produced larger plants with plant spread of 85.60 cm and 83.06 cm respectively.

A regional trial was conducted by the Vegetable Section, BARI (Anonymous, 1983) to investigate the adaptability and performance of twenty five exotic varieties of cabbage. The results showed that K-K Cross and Safe Guard performed better at Joydebpur, Atlas-70 and K-K Cross at Jessore, whereas Golden Acre and Y-R Summer at Hathazari.

Iqbal (1981) conducting an experiment with 13 exotic cabbage varieties at Joydebpur conditions, stated that Morishogun gave the highest yield (2.75 kg/plant) followed by Green Cross (2.54 kg/plant), Ogosho (2.49 kg/plant) and N-S Cross (2.26 kg/plant).

Christian Reformed World Relief Committee (Anonymous, 1980), while evaluating the performance of four late varieties (Y-R Summer 50, Atlas-70, K-K Cross and K-Y Cross) observed that both Y-R Summer and K-Y Cross were potentially high yielder.

2.2 Effect of organic fertilizer on growth and yield of knol-khol

To evaluate the response of Chinese cabbage (*Brassica pekinensis*) to different forms of organic fertilizer an experiment was conducted by Thy and Buntha (2005) over the period May through August 2004. The four treatments were: raw cattle manure solids, composted cattle manure solids (in piles of 0.5 or 1.0 m^3 volume) and the effluent from a mixing indigested (20 days retention time) charged with the liquid and small particles from raw cattle manure. The fertilizers were applied at the same level of nitrogen (150 kg N/ha) at 7 days interval with increasing quantities equivalent to 10, 20, 30, and 40% of

the total amount over the first 28 days. A basal fertilization of 2 kg per m^2 of fresh cattle manure was directly in the field and the plots were protected with plastic sheet against the rain, biomass yield of the cabbage showed a 100% increase for use of indigested effluent (34 t/ha) compared with composted manure (14 to 17 t/ha), with lowest results for fresh manure solids (9 t/ha).

Felczynski (2004) investigate with Chinese cabbage (*Brassica rapa* subsp. *Pekininsis*) were carried out in a long-term, state fertilization experiment, which was established in Skierniewice (Poland) on 1922 and continued up to the present. Chinese cabbage cv. Bilko F1 (Bejo Zaden) was cultivated from potted transplants for autumn crop at density of 9 plants/m^2. The crop responded very strongly to increasing rates of organic fertilizer. The highest marketable yield (76.1 t/ha) was the highest rate of farmyard manure (FYM; 60 t/ha) plus 2^{nd} level of mineral fertilizers (M-2), i.e. 150 kg N, 100 kg P_2O_5 and 200 kg K_2O/ha. This yield, however, did not differ statistically from the yields obtained with 40 t FYM + M-2 and with FYM at 60 t/ha alone. In the case of mineral fertilizer application without FYM, the total and marketable yields decreased along with increasing NPK rates, but the differences were not statistically proved and the yields were similar to those obtained with FYM at 40 t/ha. Application of Mg had no marked effect on yield but application with combination of 2 elements (NP, NK or PK) significantly decreased the marketable yields of Chinese cabbage compared to NPK treatment. The lowest marketable yield (25.2 t/ha) was obtained from the control plots (without fertilizer application) and it was over 3 times lower than the best treatment. Increasing rates of FYM alone tended to increase nitrates and decreased dry matter content in heads of Chinese cabbage. Application of mineral fertilizer and combined mineral- organic fertilizers increased both the matter contents in the heads of Chinese cabbage at harvest time. The lowest nitrate content and the highest dry matter were noted from the control and PK treatments.

To study the effects of the combined application of organic manure and chemical fertilizer on the yield and quality of Chinese cabbage an experiment was conducted by Ye *et al.* (2004) in China and found that the combined application of organic manure and fertilizer improved the yield quality of Chinese cabbage. Greater yield and quality were

obtained when organic manure was applied at 3750 kg/667 m^2 and when chemical fertilizer was applied at 30 kg/667 m^2.

Zhang *et al.* (2004) conducted an experiment to found the effects of organic-inorganic compound fertilizers and inorganic nitrogen fertilizers on the quality and yields of *Chinese cabbage* cv. *Luxing*. The results show that application of organic-inorganic compound fertilizer produced the highest yield among all treatments; the yield was higher by 14.4, 6.3, 10.6 and 33.6% compared with the treatments of ammonium nitrate, ammonium sulfate, urea and the control, respectively.

To examine the effect of organic amendment application on the fate of inorganic-N accumulated in a vegetable field soil during conversion from inorganic input, a pot experiment using 15N- labeled soil was conducted by Choi *et al.* (2004) and the soil was labeled with 15N through addition of urea-15N (98 atom% 15N) and was then incubated for 1year resulting in inorganic soil-N concentration and 15N abundance of 211 mg kg^{-1} soil and 4.950 atom%, respectively. Chinese cabbage plants were grown in the labeled soil for 30 and 60 days after application of organic amendment at the rates of 0 (control), 200, 400, and 600 mg N kg^{-1} soil. Although organic amendment application did not show any significant effect on the uptake efficiency of inorganic-N by Chinese cabbage, it significantly increased inorganic-N uptake efficiency as well as and dry matter yield.

The effects of GFT compost (vegetable, fruit and garden waste), Humotex (anaerobically digested GFT) and Groencompost (garden waste), applied at 15 t dry matter/ha in early cauliflowers followed by leeks. Total crop yields increased by 10 percent (GFT and Humotex) and 6 percent (Groencompost) compared with no compost use. Another field study with leeks investigated the effects of compost application (25 t dry matter/ha) and mineral fertilization. A soil analysis was carried out and showed no differences in soil nitrate concentrations in plots with and without compost application. Extra fertilizer was applied and crop yields were 3 to 4 percent higher in plots treated with compost (Rooster and Devliegher, 1998).

Dixit (1997) investigated the effects of N (0, 40, 80, 120 or 160 kg/ha) and farmyard manure (FYM) (0 or 20 t/ha) on the growth of cabbages (cv. Pride of India) in

Himalachal Pradesh, India, in 1994. The yield increased with increasing N rate (from 136.8 to 175.1 q/ha after addition of 0 and 160 kg N/ha, respectively) and increasing FYM rate (from 129.5 to 144 q/ha). Addition of FYM to N treatments further increased yield (yield of 1761 q/ha in presence of FYM + 160 kg N/ha).

The effects of compost and inorganic fertilizer on the growth, yield and pest damage on cabbage intercropped with tomatoes were investigated by Busayong (1996). He observed no significant differences in yield, growth and pest damage of cabbage applied only or inorganic fertilizers only or mixture of compost and inorganic fertilizers.

Flynn. *et al.* (1995) carried out an experiment to evaluate the stability of composed broiler chicken manure as a potting substrate using lettuce plants. They mentioned that the broiler manure containing peanut hulls as breeding material was composed and then combined with a commercially available potting substrate. The highest fresh weight yield was obtained when broiler chicken litter compost was mixed with commercially available potting substrate at 3 : 1 ratio. There was no evidence of physiological disorders resulting from excessive nutrient concentration.

An experiment carried out by Gaweda *et al.* (1995) in a pot trial, lettuce and carrot seedlings were grown in soil containing 0, 3 or 8% organic manure (peat) and 0, 300 or 600 mg Pb dm^3 (as lead acetate). The inclusion of organic manure in the soil reduced the Pb content of lettuce leaves and carrot roots in the Pb treatments. In the experimental conditions, no external symptoms of the Pb toxicity were observe but differences in the mineral and organic composition of lettuce leaves and roots retarding Pb contamination was found, particularly in the soil with no organic manure.

Abedin *et al.* (1994) tried to find out a sustainable practice, using data collected from 85 selected farmers in the Cameron, involved pest (insect, disease, weed) control, fertilization and soil erosion and inorganic fertilizers were of more sustainable practices and did not suffer yield sacrifices. A strategy to help farmers for spread adoption and sustainable practices was the most effective approach for sustainability.

Krupkin *et al.* (1994) made an investigation using proultry manure, a mixture of poultry manure plus hydrolysis lignin, and a compost of poultry manure plus hydrolysis lignin as organic fertilizers for potatoes, carrots, cabbage etc. with and without irrigation. The result should that these organic fertilizers improved the yield and quality of the crop, especially on soil having a low content of nitrate N, but had only litter effect on soils well supplied with nitrate N. The lignin based fertilizers i.e. mixture of poultry manure and hydrolysis lignin based fertilizers i.e. mixture of poultry manure and hydrolysis lignin and a compost of poultry manure plus hydrolysis lignin were similar in their effect to poultry manure.

Steffen *et al.* (1994) carried out an experiment, on short- term and long-term impact of an initial large scale spent mushroom soil (SMS) amendment on vegetable crop productivity and resource use efficiency at Pennsylvania University, USA. They observed the effect of organic matter (spend mushroom compost at 64 mt/ha + rotten cattle manure at 57 mt/ha) applied in spring 1990 on growth and yield of broccoli. No fertilizer or other amendments were added to previously amended treatments, but 100 percent recommended NPK was added to all control treatments in all years. Broccoli yield and curd diameter were greater in the amended treatment.

Vogtmann *et al.* (1993) pointed out that as a general trend, compost positively affected food quality, improved storage performance and yielded a somewhat superior sensory quality of tomato in particular. Compost significantly reduced nitrates and improved the nitrate to vitamin C ratio of vegetables.

Kao (1991) found from a field trials, 0 or 25 t conventional pig compost and/or 0, 25, t sawdust-swine waste (SSW) compost was applied to an acid silt loam soil (pH 4.8) and to a neutral sandy loam soil (pH 7.5) in Taiwan. One year after SSW application, Zn and Cu content in the acidic soil increased from 15.1 p.p.m.with no compost to 22.8 p.p.m. and from 14.5 to 26.7 p.p.m., resp. In the neutral soil, Zn content increased from 5.7 to 6.3 p.p.m. and Cu content from 6.5 to 7.0 p.p.m. SSW compost had no effect on the soil microbial system but increased CEC and OM content of the soil. In the acidic soil, yields of Chinese cabbages were 2.00, 2.22, 2.36 and 2.38 t/ha with no compost, conventional compost, 25 and 50 t SSW compost, resp. Leaf Zn and Cu content was 28-43% greater

with compost application than with no compost. In the neutral soil, Chinese cabbage yields ranged from 4.34 with no compost to 4.54 t with 50 t SSW compost. There was no significant difference in leaf Zn and Cu content between no compost and compost treatments.

In a 3 years field experiment, Suchorska (1991) tested the sustainability of some unconventional fertilizers, obtained from brown coal ash as well as poultry manure, cattle manure and fertilizer made from mushroom substrate. The yield and content of P, K, Ca and Mg in cabbages, carrots and spinach was obtained from plots fertilized with brown coal ash. The mineral organrc fertilizers tested increased the P content of vegetables.

Sumiati (1988) stated that seedlings of broccoli cultivars Green King and Mikado were transplanted into Jiffy pots or into a 1 : 1mixture of stable manure and soil supplemented or not supplemented with NPK compound fertilizer (15 : 15 : 15) and/or Metalik. There were no differences between cultivars in plant height, root length, LAI, NAR and RGR at 2, 3 or 4 weeks after transplanting. These factors were all maxmum at all stages in plants grown in manure + soil supplemented with NPK + Metalik and were generally minimum in plants grown in Jiffy pots. Interactions between cultivars and treatments on LAI, NAR and K uptake at 4 weeks after transplanting were noted.

Silva (1986) planted cabbage in hydromorphic soil and treated with 100 kg N/ha, 100 kg P_2O_5/ha or 50 t/ha cattle manure, alone or in combination. Nitrogen increased the total yield but decreased commercial to total yield ratio. K_2O alone decreased total yields. Cattle manure increased commercial and total yields but decreased total yield ratio. The highest commercial yield (49 t/ha) was obtained with cattle manure or N + K_2O but there was no response to P_2O_5.

Edmond *et al.* (1977) reported that organic matter increased the pore space of the soil and thus improved the rate of gas exchange. Application of compost to the soil increased water-holding capacity, reduced soil erosion and improved the physio-chemical and condition of the soil besides providing the plant nutrients.

Cavazza and Bianco (1975) applied composed townrefuge, FYM and inorganic fertilizer at similar N rates after sowing or transplanting radish, Swiss chard, spinach, cauliflower, Florence fennel and lettuce. They obtained highest yield with inorganic fertilizer whereas yields of crop receiving no fertilizer or the 2 organic did not usually differ significantly, althodgh fennel yielded better with composted town refuge. After hot dry weather crusting occurred on the surface of control plots and inorganic fertilizer plots but not on those receiving organic fertilizer, so radish roots were not damaged on such plots.

Organic manures increase the yield of crop. Application of 10 t/acre of fresh cattle manure increased the yield of pimento, egg plant and Chinese cabbage but reduced the yield of cucumber and tomato compared with normal (rate unspecified) applications. Fresh chicken manure at the rate of 5-10 t/acre could be used for pimento, eggplant and Chinese cabbage without deleterious effect. In the field cultivation without irrigation, organic fertilization and liming increased total and marketable yield of cabbage cv. Salva at the optimum level of mineral fertization (Omori *et al.*, 1972).

Gaur *et al.* (1971) found that FYM and organic residues were effective in increasing the level of organic matter even under tropical conditions.

Cutcliffe *et al.* (1968) during three successive cropping seasons investigated the effects of nitrogen, phosphorus, potassium and manure on the yield and maturity of broccoli [*Brassica oleracea* L. var. *italic Plenck.*]. Terminal (central inflorescence), lateral (axillary stalk) and total yields were substantially increased by the applications of nitrogen and phosphorus. For maximum yields, rates of 175 to 250 kg/ha of N and 100 to 150 kg/ha P were necessary. Increases in lateral yields and total yields from high rates of nitrogen were obtained only when nitrogen was accompanied by adequate phosphorus. Yields of terminals were increased in only one of three seasons by added potassium. A manure treatment increased lateral and total yields in two seasons and terminal yields in one season. Maturity was delayed by increasing the rates of nitrogen and where no phosphorus was applied.

Wright (1960) studied that Horse and cow manure contains approximately 0.5% N, 0.55% K and 0.25% Phosphoric acid. It thus supplies three of main elements needed by fruit plants.

2.3 Effect of inorganic fertilizer on growth and yield of knol-khol

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). The 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 inorganic fertilizer on growth, yield and storability of knol-khol are reviewed here.

XiSheng et al. (2004) conducted a field trial in China to investigate the effects of N and K rates on the nutrient uptake and partitioning of cabbage. Sole N, K, Ca, Mg, Cu, and Fe. Sole K increased the contents. Application of N and K increased nutrient proportion in heads and leaves, which increased growth, yield, quality and nutritional value of cabbage.

The 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 as 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 (25850 kg/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 (30 x 15, 30 x 20 or 30 x 30 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 (30 x 50 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 (272.21 quintal/ha).

Rai *et al.* (2003) observed the effects of spacing (25 cm x 25 cm, 30 cm x 25 cm and 30 cm x 30 cm) and NPK level (80 : 60 : 60, 100 : 80 : 80, 120 : 100 : 100 and 140 : 120 : 120 kg/ha) on the growth and yield of knol-khol (*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 knol-khol.

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).

Dutta (2001) conducted an exprement during the rabi seasons of 1995-98, in Assam, India, to study the effect of potash on growth, yield and quality of knolkhol (*Brassica caulorapa* [*B.okracea* var, *gongylodes*]) and minimize the cracking intensity of the knob. There were seven levels of potash (0, 20, 40, 60, 80, 100, and 120 kg/ha) with uniniform doses of urea (80 kg/ ha), superphosphate (60 kg/ha) and borax (8 kg/ha). Data reveal that the growth and yield of knol-khol was increased by potash application. Plant height, number of leaves, size, weigh and marketable yield were increased due to potash and this increase was greater with the rise in potash level and vise-versa. NPK dose of 80: 60: 100 kg/ha. Produced the maximum marketable yield of 328.89/h associated with the highest knob weight of 380.20 g. Potash application also reduced the intensity of cracking and the maxmimum cracking intensity (10.2%) was recorded in two highest levels of potash, i.e., NPK at 80 : 60 : 100 and 80 : 60 : 120 kg/ha, while the maximum cracking intensity of 40.3% was observed in the control. Hence, the NPK level of 80 : 60 : 100 kg/ha was optimum for minimizing the cracking intensity and for obtaining the highest marketable yield in knolkhol.

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 (45 x 45, 60 x 45 and 60 x 60 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 60 x 60 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.

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.

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.

Fink *et al.* (1996) conducted a field experiment in Germany to assess the consideration of nitrogen mineralization from harvest residues in the calculation of fertilizer recommendations. An experiment was conducted on a sandy soil to test if N mineralization of harvest residues reflected accurately the fertilizer recommendations given the decision support system, N-expert. Kohlrabi was grown with 4 levels of mineral N (0, 50, 150 and 250 kg N/ha) and 4 levels of lettuce harvest residues (0, 26, 50 and 73.7 t/ha). As the amount of harvest residue increased, recommendation N fertilizer decreased from 200 to 100 kg N/ha. Calculation of N blanch showed that the amount of N mineralized from harvest residues was less than that estimated my N-expert resulted in significant yield losses.

An experiment was conducted by Pant *et al.* (1996) during 1991 at Kunaon hills, India to evaluate the influence of N (40, 60, 80, 120, 160, 180 or 200 kg/ha on the marketable head yield of cabbage. Yield increased to 49.83 t/ha with increasing rates on N up to 180 t/ha with increasing rates. Yield decreased with the further increased with the further increase in N rates.

Fink (1995) carried out a field experiment at Germany where kohlrabi was grown after different amount of lettuce crop residue had been ploughed in optimum rates of N fertilizer application was determined by expert computer program. According to N-expert, mineral N requirements decreased as the amount of crop residues ploughed in increased. In practice, maximum were obtained in all classes, confirming that crop residues can substitute for fertilizer. Where a large amount of crop residue is available for instance when a sole crops had to be ploughed then the N-fertilizer dose can be reduced by up to 100 kg N/ha without affecting yield.

Baylan and Joginder (1994) conducted a field trial with cauliflower and reported that increasing Zn application increased leaf curd ratio compared with no Zn, but there was no effect on number of leaves/plant and days to 50% curd maturity.

Farag *et al.* (1994) reported that the application of B (2.5 kg borax/fedder) or Mo (500 g ammonium molybdate/fedder) to cauliflower plants of the cultivars 'Soltany' and 'Amsheery' significantly enganced curd yield and quality in both cultivars. (1 fedder = 0.42 ha).

Halim *et al.* (1994) carried out an experient on different doses of NPK on the growth and yield of cabbage at Jamalpur. They mentioned that gross yield and marketable head per plant were the highest with 150 kg N + 100 kg P_2O_5 + 150 kg K_2O or 200 kg N + 100 kg P_2O_5 + 150 kg K_2O/ha.

Samant *et al.* (1993) investigated the balance fertilizer use for cabbage in acid clay loam soils of Orissa, India. It was found that nitrogen 75 kg/ha, phosphorus 80 kg/ha and potassium 150 kg/ha gave the highest yield (17.42 t/ha) and it was the most economic dose.

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.

In another study (Anonymous, 1991) was found that fertilizer at the rate of 240 kg N/ha, 60 kg P/ha and 120 kg K/ha along with 10 t/ha cowdung gave the highest head yield (75 t/ha) of cabbage var. Atlas-70.

In a field trial conducted by Singh *et al.* (1991) in 1988-89 and 1989-90, Cauliflower cv. Improved Japanese received a spray application of Zn (as $ZnSO_4$) at 0.3, 0.6, 0.9, 1.2 or

1.5%, 40 days after transplanting in the field. Highest curd yields (111.21 and 158.38 q/ha) in the 1st and 2nd season, respectively were obtained with 1.2% Zn.

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.

Farooque and Islam (1989) studied the effect of different fertilizer management practices on the growth and yield of cabbage in Bangladesh. They reported that the highest marketable yield produced when 8.3 t FYM, 200 kg Moc, 326 kg urea, 125 kg TSP and 200 kg MP/ha were applied.

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.

Baylan *et al.* (1988) reported that N was applied at 0-160 kg/ha, P_2O_5 at 0 or 50 kg/ha and $ZnSO_4$ at 0-30 kg/ha and maximum curd yield (238 q/ha) was obtained with 160 kg N + 50 kg P_2O_5 + 20 kg $ZnSO_4$/ha.

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 NH4NO3 + 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.

Will and Handel (1986) studied the effect of slow release fertilizer NPK permanent (15 N + 9 P + 15 K + 2 Ca). They were compared with those of the liquid fertilizer kohlrabi. Broad strip application of NPK increased the yields much more whole area application.

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 (Anonymous, 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.

A 2-year field trials was conducted by Samant *et al.* (1981) and showed that the economically best fertilizer combination was 75 : 80 : 150 kg/ha. N, P_2O_5, K_2O for kohlrabi cultivation.

Krieg (1978) studied in Germany to assess the supply of slow release fertilizers to vegetables under plastic. Investigations over a 3-years period on the use of slow and quick release fertilizers for kohlrabi forced under polythene sheets (0.05 mm thick, 6-10 m wide with 500 perforations/m^2) for 60 days, revealed that NPK permanent (15 N + 9 P + 2 Mg, containing 40% of slow release N) gave highest yield and was most profitable.

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.

Polach (1970) carried out an experiment in USA to assess a contribution to the preparation of nutrient solution from mineral fertilizers. Commercial calcium ammonium nitrate, super phosphate and muriate of potash were found suitable for replicating sulutions of pure nutrients in kohlrabi growing. Kohlrabi grown in the autum with 18.0 g N, 13.5 g P_2O_5 and 36.0 g K_2O in 100 liters produced among as high yields as the pure salt sulation.

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.

Chapter III

Materials and methods

CHAPTER III

MATERIALS AND METHODS

This chapter includes the informations regarding materials and methods that were used in conducting the experiment. It consists a short description of locations of the experimental site, characteristics of soil, climate, materials used for the experiment, raising of seedlings, treatments of the investigation, layout and design, land preparation, manuring and fertilizing, transplanting of seedlings, intercultural operations, harvesting, data collection procedure, economic and statistical analyses.

3.1 Experimental site

Field experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from October, 2007 to January, 2008 to study the effect of organic and inorganic fertilizer on the growth and yield of five knol-khol varieties. 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). Land was in Agro-Ecological Zone of Madhupur tract (AEZ No-28). Soil was sandy loam in texture having pH 5.56. 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 knol-khol 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

The varieties of knol-khol selected for the experiment were, White Vienna, Quick star, UFO, Early 005, Sufala-14. All the varieties were hybrid. Seeds of the varieties were collected from Siddique Bazar, Dhaka.

3.4 Raising of Seedlings

Seedlings of knol-khol were raised at the Horticulture Farm, SAU, Dhaka under special care in five seed beds each measuring 3 m x 1 m. Soil of the seed bed was ploughed and covered into loose friable and 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 5 t/ha. Ten grams of seeds of each varieties were sown in each seed bed on 07 October, 2007. The seeds were covered with fine light soil after sowing and to protect the young seedlings from scorching sunshine and heavy rainfall; shading was given by bamboo mat (chatai). Weeding, mulching and light watering were done from time to time for maintaining an favorable environmental condition for raising healthy seedlings.

3.5 Treatments of the experiment

Five different varieties and four different types of fertilizers were used in this experiment. The treatments are described below:

Factor A: Five varieties of knol-khol

V_1: White vienna

V_2: Quick star

V_3: Sufala-14

V_4: UFO

V_5: Early 005

Factor B: Different kinds of fertilizers

F_0: Control (No fertilizer)

F_1: Organic manure (Cowdung)

F_2: Inorganic fertilizer (Urea, TSP, MP)

F_3: Organic fertilizer + Inorganic fertilizer (Cowdung, Urea, TSP, MP)

3.6 Layout and design of the experiment

Two factors experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. Whole experimental area (32.4 m x 6.8 m) was first divided into three blocks, each block was divided into 20 unit plots were total 60 (3 x 20) unit plots.

The size of a unit plot was 1.2 m x 1.6 m. The distance between two plots was 40 cm and between two blocks was 50 cm. Total area used for the experiment was 220.32 square meter.

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 few days to kill insects. It was subsequently ploughed several times with a power tiller to bring about a good tilth and suitable for growing knol-khol. 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 manures and fertilizers

Entire amount of well decomposed cowdung @ 20 t/ha for treatment F_1 & @10 t/ha for treatment F_3 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 laying out of the plot and 4 days before transplanting. Again half of rest amount of Urea was applied 20 days after transplanting and rest half was applied 30 days after transplanting. Applied fertilizers were mixed properly with the soil of the plot using a spade.

The following doses of manure and fertilizers were used in this experiment.

Treatments	Dose (per hectare)	Dose (per plot)
F_0	0 kg Cowdung + 0 kg Urea + 0 kg TSP + 0 kg MP	0 kg Cowdung + 0 kg Urea + 0 kg TSP + 0 kg MP
F_1	20 ton Cowdung	3.84 kg Cowdung
F_2	300 kg Urea + 300 kg TSP +250 kg MP	57.6 g Urea + 57.6 g TSP + 48 g MP
F_3	10 ton Cowdung + 200 kg Urea + 150 kg TSP + 175 kg MP	1.92 kg Cowdung + 38.4 g Urea + 28.8 g TSP + 33.6 g MP

F_0: Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer

Unit plot = 1.2 m x 1.6 m Cowdung contains 0.5-1.5% N, 0.4-0.8% P, 0.5-1.5% K

(AIS, Krishi diary, 2008)

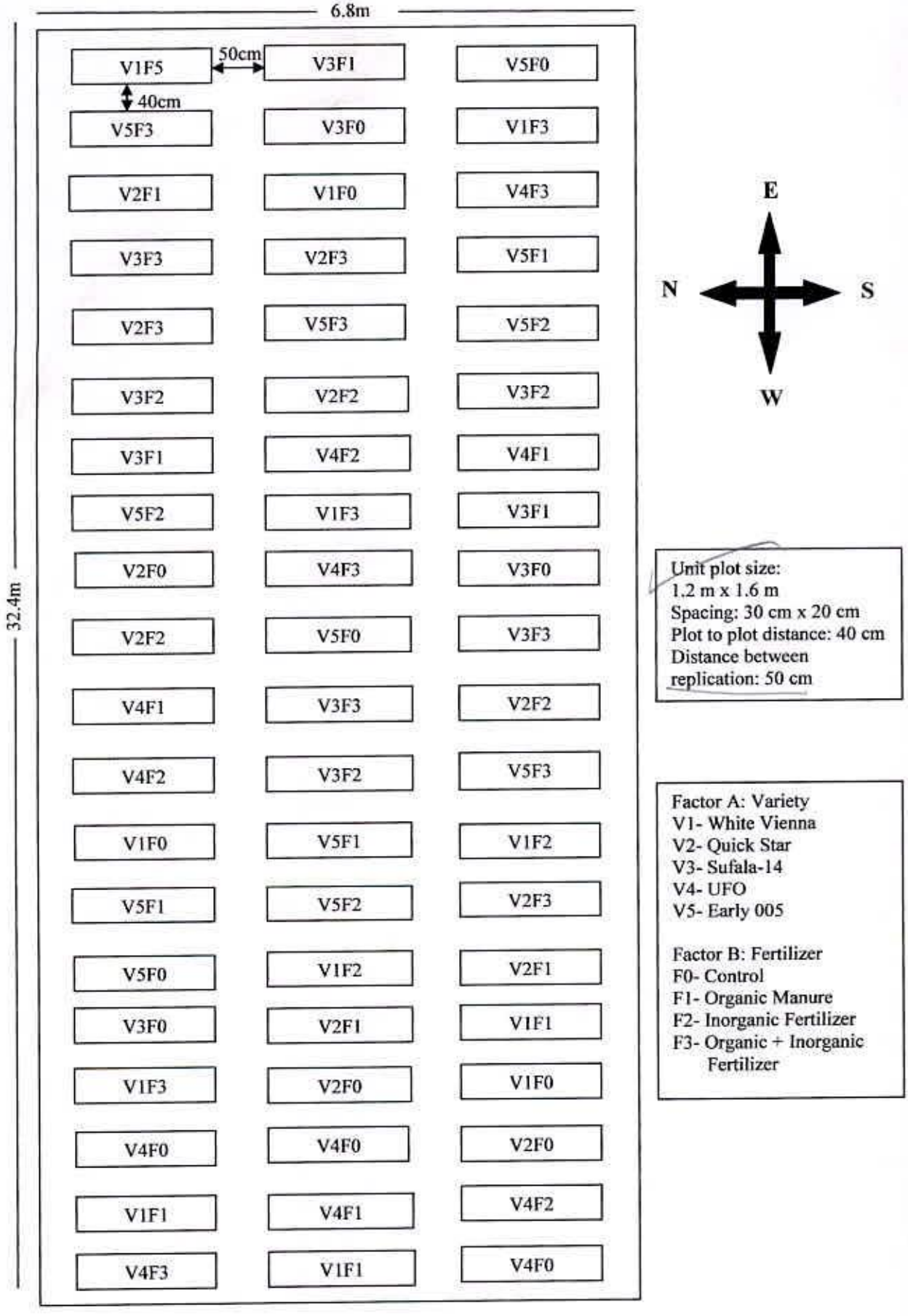


Fig. 1. Layout and design of the experimental plot

3.9 Transplanting of seedlings

Seedlings were transplanted in the experimental plots on November 06, 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 30 cm x 20 cm 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 for 5 days. To fill the gap when required, a number of seedlings were also planted in the border of the experimental plots.

3.10 Intercultural operations

3.10.1 Gap filling

Seedlings were kept under careful observation after transplanting. Very few seedlings were damaged and those seedlings were replaced. Replacement was done with healthy seedlings through the border plants of the plots. Gap filling was done according to necessary.

3.10.2 Weeding

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

3.10.3 Irrigation

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. 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.

3.10.4 Pest management

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

3.11 Harvesting

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

3.12 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. Data on following parameters were recorded.

3.12.1 Plant height

Height of plant was recorded at 15, 25, 35, 45 and 55 days after transplanting (DAT) using meter scale. 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.

3.12.2 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.

3.12.3 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.

3.12.4 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.

3.12.5 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.

3.12.6 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.

3.12.7 Fresh weight of knob per plant

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

3.12.8 Fresh weight of roots per plant

Fresh weight of root was measured at harvest in gram.

3.12.9 Diameter of knob per plant

Selected ten knobs were sectioned in the middle vertically with a sharp knife. The 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.

3.12.10 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 and expressed in gram.

3.12.11 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.

3.12.12 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.

3.12.13 Dry matter content of leaves per plant

At first the fresh weight of leaves per plant was recorded then one hundred grams an oven at 70^0C for 72 hours.

3.12.14 Dry matter content of knob per plant

A sample at 100 g 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.

3.12.15 Dry weight of roots per plant

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

3.12.16 Gross yield per hectare

Gross yield of a knol-khol was measured as the whole plant weight including the leaves of all the plant of a plot and gross yield per hectare was calculated by converting the weight of the knol-khol plant of plot into hectare and expressed in t/ha.

3.12.17 Marketable yields per hectare

Weight of edible parts of all the plants in a plot was taken and marketable yield per hectare was calculated by converting the weight of edible plants parts of a plot into hectare and was expressed in t/ha. Marketable yield included only weight of knob.

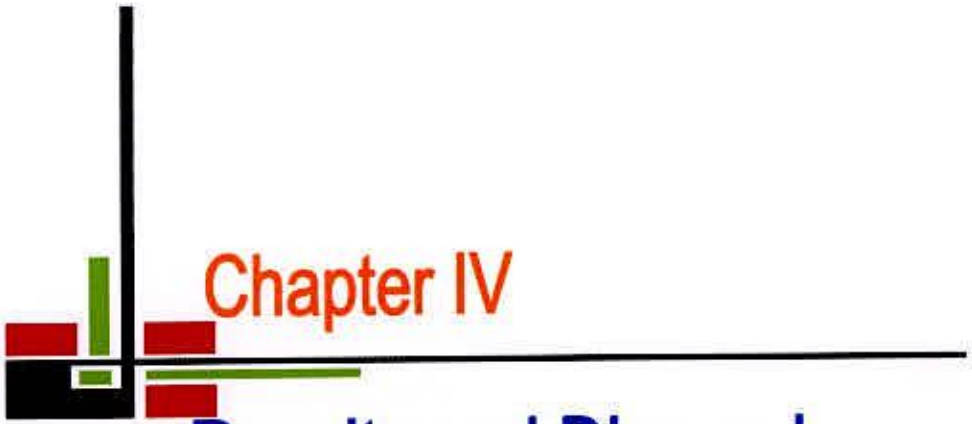
3.12.18 Economic analysis

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 @ 12% per year for 6 month. The cost and return analyses were done in details according to the procedure followed by Alam *et al.* (1989). The Benefit Cost Ratio (BCR) was calculated as follows:

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

3.12.19 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' test. Significance of differences between pairs of treatment means were evaluated by Duncan's Multiple Range Test (Gomez and Gomez, 1984).



Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to investigate the effects of different varieties and fertilizer management practices on the growth and yield of knol-khol. The analysis of variance (ANOVA) of the data on different yield contributing characters and yield of knol-khol as influenced by different varieties and fertilizer management practices presented in **Appendix III-V**. Results on main and combined effect of different varieties and fertilizer management practices and their interactions have been presented and discussed in this chapter.

4.1 Plant height

Main effects of varieties on plant height have been presented in (Fig. 2). Maximum plant height (32.78 cm) was recorded in White vienna, at 55 DAT which was statistically similar by UFO (32.50 cm) and Sufala-14 (32.48 cm) and the minimum plant height (23.21 cm) was recorded a with variety Early 005 at the same DAT.

Different fertilizers significantly influenced the plant height of knol-khol (Fig. 3). Maximum plant height (34.27 cm) was recorded from the fertilizer treatment, F_3 (Organic fertilizer + Inorganic fertilizer) at 55 DAT and minimum plant height (23.60 cm) was obtained from the F_0 (control) treatment at the same DAT.

From the result, it was found that the interaction effects of different varieties and different fertilizers were significant on plant height of knol-khol. Highest plant height (40.17 cm) was recorded from the treatment combination of V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) at 55 DAT and the lowest plant height (50.25 cm) was found in the treatment combination of V_5F_0 (Early 005 with control treatment) at the same DAT (Table 1).

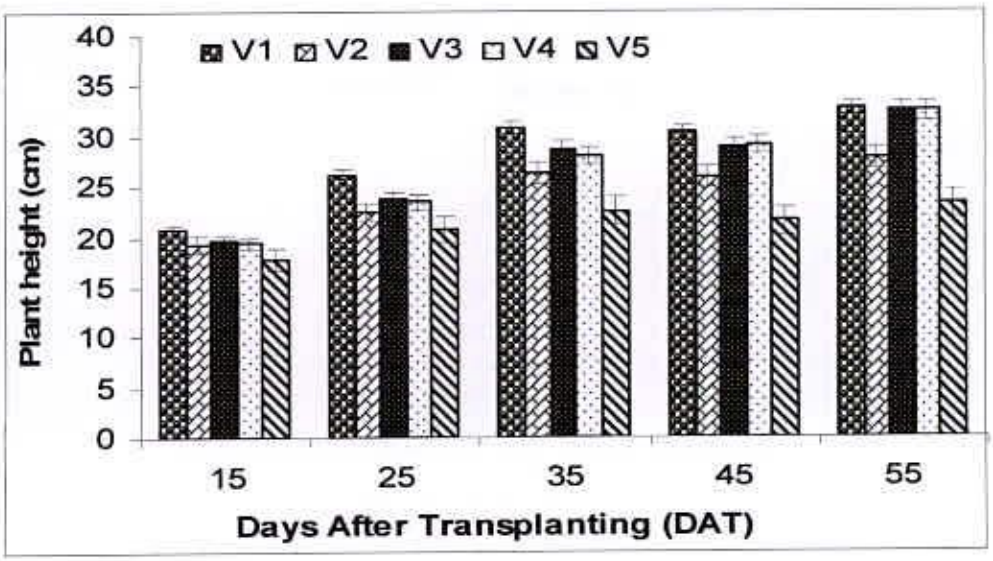


Fig. 2. Effect of varieties on plant height of Knol-khol at different days after transplanting.

V_1: White vienna; V_2: Quick star; V_3: Sufala-14; V_4: UFO; V_5: Early 005.

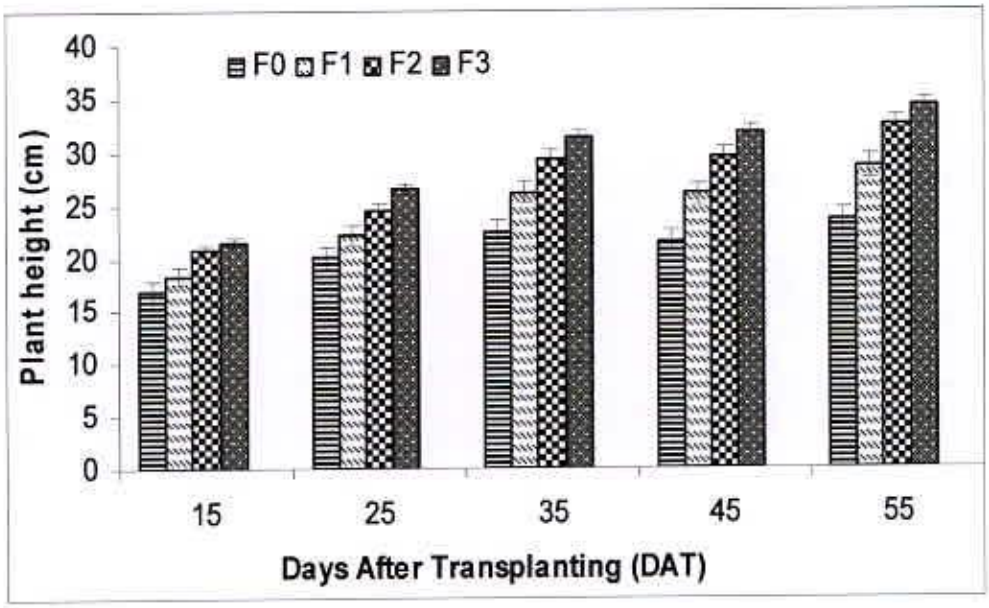


Fig. 3. Effect of different fertilizers on Plant height of Knol-khol at different days after transplanting.

F_0: Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer.

4.2 Number of leaves per plant

Variation in number of leaves per plant was significant due to the effect of varieties (Fig. 4). The maximum number of leaves (15.50) was obtained from the variety White vienna at 55 DAT and the lowest (11.08) was found from the variety Early 005 which was statistically similar by Quick star (11.79) at the same DAT.

The number of leaves produced per plant under different fertilizers was statistically significant (Fig. 5). The maximum number of leaves per plant (16.40) was found from the F_3 (Organic fertilizer + Inorganic fertilizer) treatment of fertilizers at 55 DAT and the lowest (23.60 cm) was found from the F_0 (control) treatment at the same DAT.

Interaction effects of varieties and different fertilizers were found significant in respect of number of leaves per plant (Table 1). Minimum number of leaves (19.83) was obtained from the treatment combination of V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) at 55 DAT and the minimum number of leaves (8.50) was found in the treatment combination of V_5F_0 (Early 005 with control treatment) at the same DAT. Increased number of leaves per plant may be due to balanced fertilization of the crop.

4.3 Length of largest leaf per plant

Results on effects of variety showed that varieties of knol-khol had significant effect on length of largest leaf (Fig. 6). Variety White vienna gave the maximum length of largest leaf (28.00 cm) at 55 DAT which was statistically similar by UFO (27.75 cm) and Sufala-14 (27.38 cm). Early 005 gave minimum (20.04 cm) length of largest leaf at the same DAT.

Length of largest leaf was significantly influenced by different treatments of fertilizer application. F_3 (Organic fertilizer + Inorganic fertilizer) treatment of fertilizers gave the length of largest leaf (29.50 cm) at 55 DAT and the lowest leaf length (20.20 cm) was recorded from the treatment of F_0 (control) treatment at the same DAT (Fig. 7).

Interaction effects of varieties and different fertilizers had significant influence on the length of the largest leaf. The highest length of largest leaf (34.50 cm) was obtained from the treatment combination of V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) at 55 DAT and the minimum length of largest leaf (18.17 cm) was found in the treatment combination of V_5F_0 (Early 005 with control treatment) at the same DAT (Table 2).

4.4 Breadth of largest leaf per plant

Effects of varieties were significant in this regard (Fig. 8). UFO variety produced the widest (12.33 cm) leaf and Early 005 produced narrowest leaf (7.88 cm) at 55 DAT.

Breadth of the largest leaf was found to be significant due to the application of different fertilizers (Fig. 9). Maximum breadth of leaf largest (11.23 cm) was obtained from the treatment F_3 (Organic fertilizer + Inorganic fertilizer) at 55 DAT which was statistically similar by F_2 (Inorganic fertilizer) treatment (11.13 cm) and the minimum breadth of largest leaf (9.70 cm) was found in F_0 (control) fertilizer treatment at the same DAT.

Interaction effects of different varieties and different fertilizers were found significant in respect of breadth of largest leaf (Table 4). Numerically the highest breadth if largest leaf (13.17 cm) per plant was obtained from the treatment combination of V_4F_3 (UFO with organic fertilizer + inorganic fertilizer) at 55 DAT and the minimum breadth of largest leaf (7.33 cm) was found in the treatment combination of V_5F_0 (Early 005 with control treatment) at the same DAT (Table 2).

4.5 Spread of plant

There was a significant difference among the five varieties on spread of plant canopy (Fig. 10). At 55 DAT, the maximum spread of plant canopy (50.21 cm) was found from the variety White vienna which was statistically similar by UFO (48.27 cm) and Sufala-14 (47.71 cm) and the minimum (35.74 cm) spread of plant canopy were observed in the variety Early 005 at the same DAT.

It revealed that the spread of plant canopy was increased gradually with the advance of time (Fig. 11). At 55 DAT, maximum spread of plant (51.78 cm) was found from the treatment F_3 (Organic fertilizer + Inorganic fertilizer) at 55 DAT and the lowest (35.91 cm) was found from the F_0 (control) fertilizer treatment at the same DAT.

It was observed that the interaction effects of different varieties and different fertilizers were significant on spread of plant canopy (Table 3). Maximum spread of plant canopy (60.50 cm) was found in the treatment combination of V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) at 55 DAT and Minimum spread (32.50 cm) was found in the treatment combination of V_5F_0 (Early 005 with control treatment) at the same DAT. This was due to the increasing vegetative growth of plants as influenced by balanced application of fertilizers.

4.6 Fresh weight of leaves per plant

Variety significantly influenced the fresh weight of leaves per plant (Table 4). Maximum weight of fresh leaves per plant (64.62 g) was observed in the variety White vienna and the minimum weight (30.53 g) was found in the variety Early 005, respectively at 55 DAT.

Fresh weight of leaves varied significantly by the application of different fertilizers. Maximum fresh weight of leaves (66.33 g) was recorded when the plants treated with F_3 (Organic fertilizer + Inorganic fertilizer) at 55 DAT and the minimum fresh weight (29.93 g) was found from the F_0 (control) treatment at the same DAT (Table 5).

Interaction effects of different varieties and different fertilizers were significant in respect of fresh weight of leaves per plant (Table 3). The highest (87.87 g) and lowest (20.33 g) weight of fresh leaves per plant were observed in the treatment combination V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) and V_5F_0 (Early 005 with control treatment) at 55 DAT, respectively.

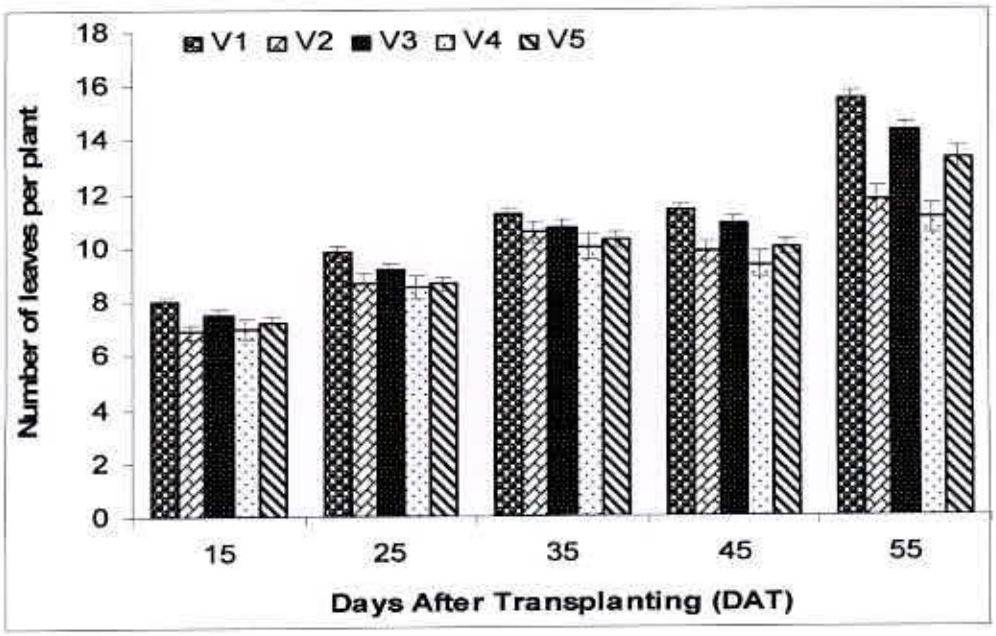


Fig. 4. Effect of varieties on number of leaves per plant of Knol-khol at different days after transplanting.

V_1: White vienna; V_2: Quick star; V_3: Sufala-14; V_4: UFO; V_5: Early 005.

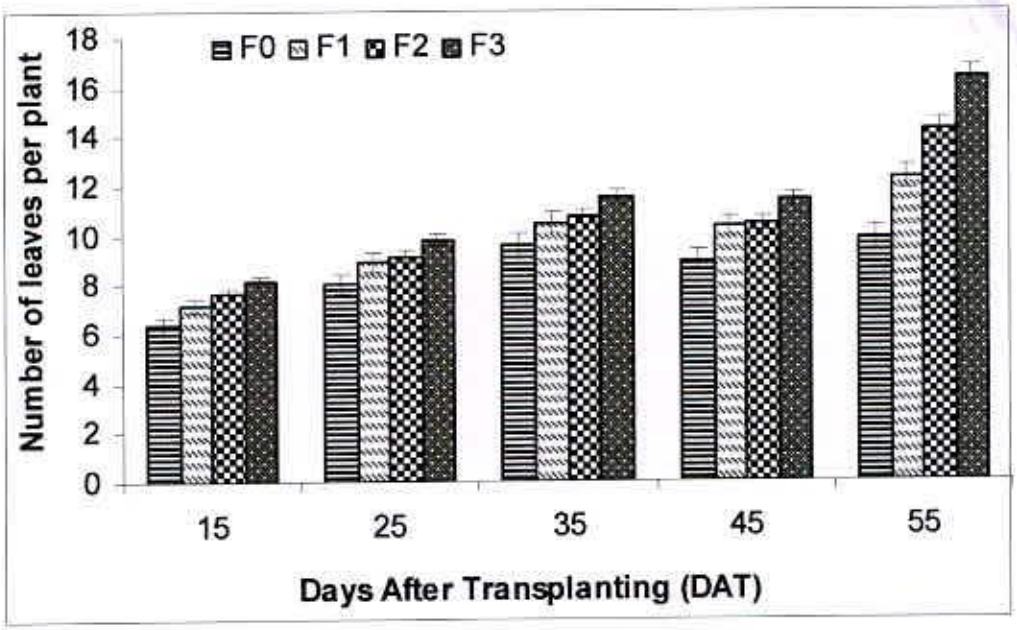


Fig.5. Effect of different fertilizers on number of leaves per plant of Knol-khol at different days after transplanting.

F_0: Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer.

Table 1. Effect of varieties and different fertilizers combination on growth characters of Knol-khol[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	
V_1F_0	18.03	de	21.17	ghij	24.60	gh	23.73	ef	25.13	gh	6.71	fgh	8.41	fgh	9.93	fgh	9.60	fgh	10.83	ghi
V_1F_1	20.60	abc	25.50	bcde	30.87	bcd	28.07	d	28.67	f	8.13	bc	10.07	abc	10.73	cdef	11.40	bcd	14.50	cdef
V_1F_2	21.60	ab	26.47	bc	31.53	bcd	32.73	bc	37.17	b	8.07	bc	10.00	bc	11.80	ab	11.87	abc	16.83	abc
V_1F_3	22.83	a	31.33	a	36.20	a	37.20	a	40.17	a	9.07	a	10.87	a	12.60	a	12.73	a	19.83	a
V_2F_0	17.14	def	20.23	hij	22.60	hi	21.27	fgh	24.60	ghi	6.40	ghi	8.13	fgh	9.67	gh	9.00	ghi	10.17	hi
V_2F_1	17.67	def	20.13	hij	23.53	ghi	22.90	ef	23.00	hij	6.37	hi	8.50	fg	10.80	cdef	9.87	efg	9.50	hi
V_2F_2	20.97	abc	23.53	def	28.37	def	27.80	d	29.33	ef	6.93	efgh	8.40	fgh	10.47	defg	9.47	gh	12.33	defgh
V_2F_3	21.30	abc	25.80	bcd	30.67	bcd	31.73	bc	34.17	c	7.83	bcd	9.73	bcd	11.27	bcd	11.00	cde	15.17	bcde
V_3F_0	17.43	def	20.67	hij	23.53	ghi	22.57	efg	25.10	gh	6.53	ghi	8.20	fgh	9.67	gh	9.33	ghi	10.67	hi
V_3F_1	17.27	def	21.30	fghi	26.53	efg	27.33	d	31.50	de	6.90	efgh	8.27	fgh	10.07	fgh	10.27	defg	12.00	efghi
V_3F_2	21.43	ab	25.90	bcd	31.00	bcd	31.73	bc	35.67	bc	8.07	bc	9.93	bc	11.47	bc	11.60	abc	16.00	bc
V_3F_3	22.33	a	27.20	b	33.73	ab	34.13	b	37.67	b	8.57	ab	10.27	ab	11.80	ab	12.40	ab	18.50	ab
V_4F_0	16.62	ef	19.27	ij	20.80	i	20.20	gh	22.33	ij	6.23	hi	7.87	gh	9.40	h	8.53	hi	9.17	hi
V_4F_1	19.22	bcde	24.70	cde	28.87	cde	31.73	bc	37.50	b	6.80	fgh	8.40	fgh	10.13	efgh	9.47	gh	9.67	hi
V_4F_2	20.67	abc	24.80	cde	31.93	bc	33.43	bc	36.67	b	7.20	defg	8.33	fgh	9.47	h	8.53	hi	11.33	fghi
V_4F_3	21.03	abc	25.17	bcde	30.47	bcd	31.23	c	33.50	cd	7.66	cde	9.47	bcde	11.07	bcde	10.87	cde	14.17	cdefg
V_5F_0	15.43	f	18.80	j	20.27	i	20.00	h	20.83	j	5.90	i	7.53	h	9.27	h	8.20	i	8.50	i
V_5F_1	17.17	def	19.07	ij	20.70	i	20.00	h	22.50	hij	7.69	cde	9.33	cde	10.67	cdef	10.80	cdef	15.67	bcd
V_5F_2	18.79	cde	21.73	fgh	23.60	ghi	21.67	fgh	23.67	ghi	7.80	bcd	9.00	def	10.53	cdefg	10.73	cdef	14.83	cde
V_5F_3	19.70	bcd	23.27	efg	25.47	fgh	24.33	e	25.83	g	7.37	cdef	8.73	efg	10.73	cdef	10.27	defg	14.33	cdef
CV (%)	6.97		5.40		6.84		4.96		4.80		5.83		5.14		4.62		6.49		8.88	
LSD (0.05)	2.23		2.08		3.08		2.23		2.36		0.71		0.76		0.81		1.11		3.03	

[y] V_1: White vienna; V_2: Quick star; V_3: Sufala-14 ; V_4: UFO; V_5: Early 005; F_0 : Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer

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

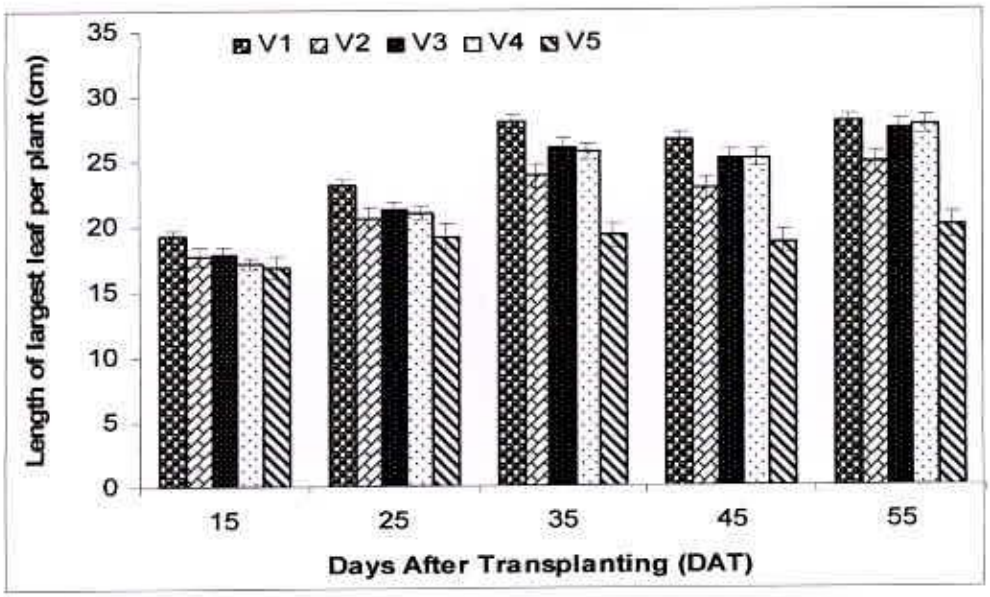


Fig. 6. Effect of varieties on length of largest leaf per plant of Knol-khol at different days after transplanting.

V_1: White vienna; V_2: Quick star; V_3: Sufala-14; V_4: UFO; V_5: Early 005.

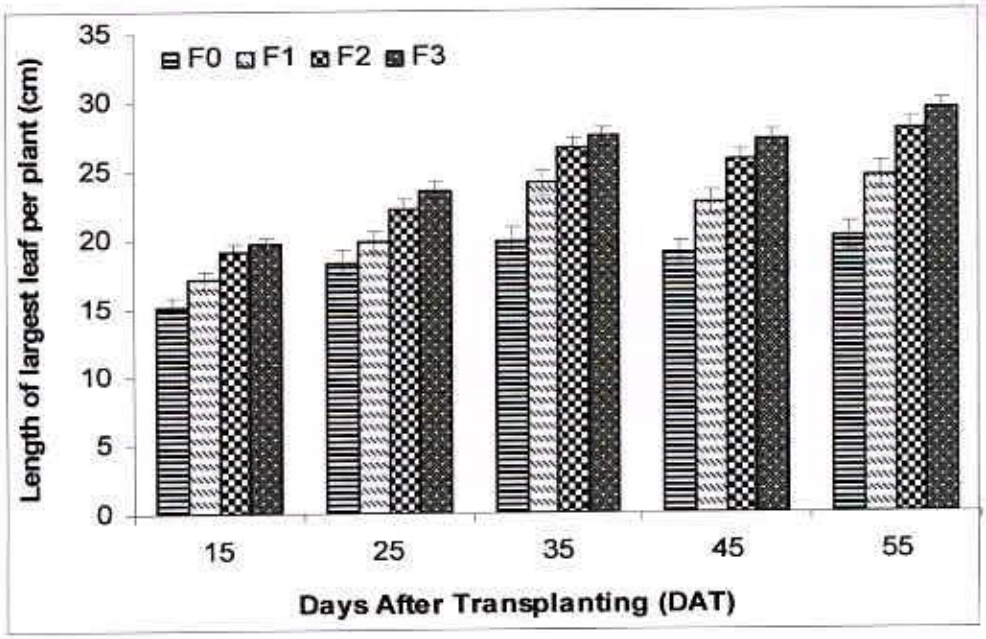


Fig. 7. Effect of different fertilizers on length of largest leaf per plant of Knol-khol at different days after transplanting.

F_0: Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer.

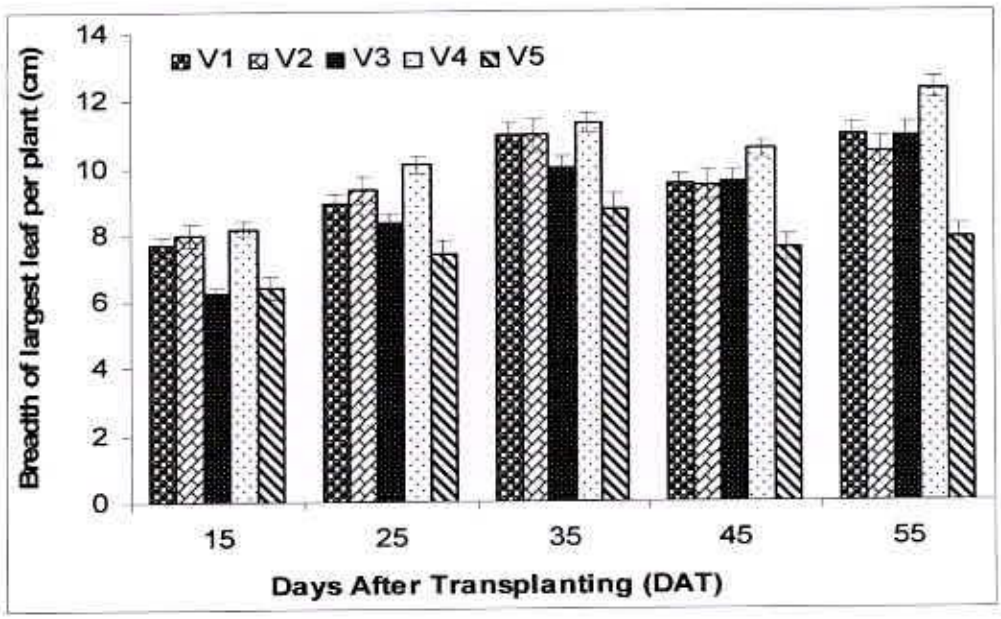


Fig. 8. Effect of varieties on breadth of largest leaf per plant of Knol-khol at different days after transplanting.

V_1: White vienna; V_2: Quick star; V_3: Sufala-14; V_4: UFO; V_5: Early 005.

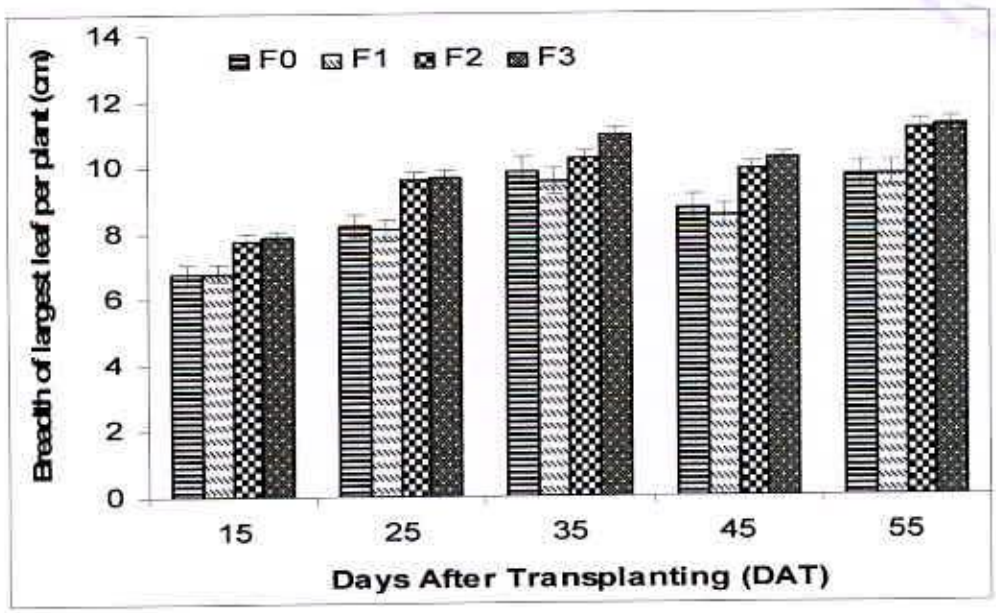


Fig. 9. Effect of different fertilizers on breadth of largest leaf per plant of Knol-khol at different days after transplanting.

F_0: Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer.

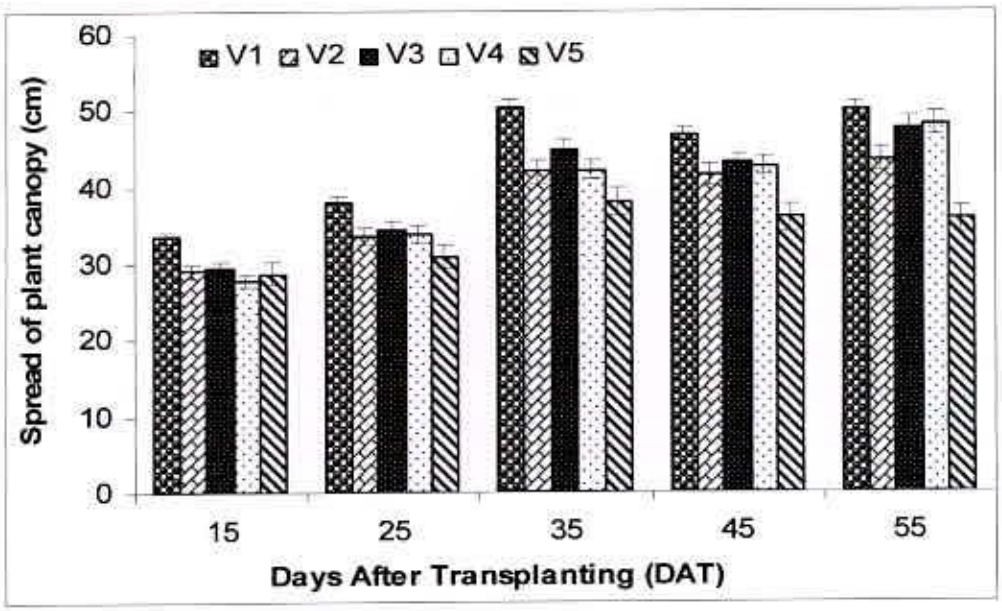


Fig. 10. Effect of varieties on spread of plant canopy of Knol-khol at different days after transplanting.

V_1: White vienna; V_2: Quick star; V_3: Sufala-14; V_4: UFO; V_5: Early 005.

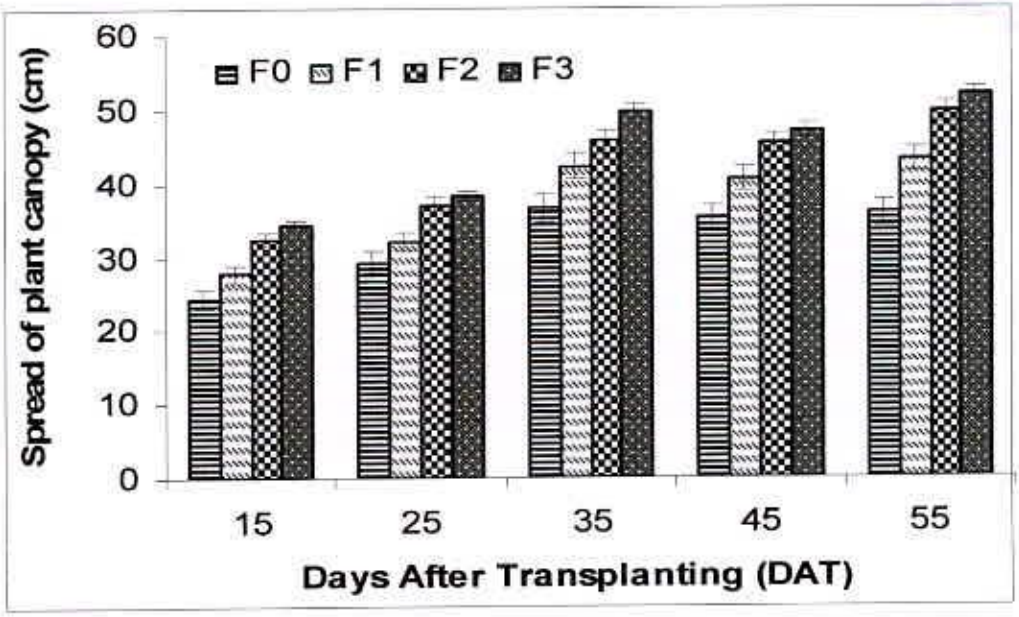


Fig. 11. Effect of different fertilizers on spread of plant of Knol-khol at different days after transplanting.

F_0: Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer.

Table 2. Effect of varieties and different fertilizers combination on growth characters of Knol-khol[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	
V_1F_0	15.78	ef	19.27	efgh	22.40	de	20.87	gh	22.17	f	6.90	abc	8.43	bcde	10.17	a-g	8.57	defg	10.00	cdefg
V_1F_1	20.27	ab	23.43	bc	28.73	ab	24.87	ef	24.33	e	7.87	a	8.70	bcde	10.57	a-f	9.20	bcde	9.50	cdefg
V_1F_2	19.92	ab	23.50	bc	28.07	bc	28.33	bcd	31.00	bc	7.93	a	9.27	abcd	11.77	ab	10.00	abcd	11.83	abcd
V_1F_3	21.15	a	26.43	a	33.07	a	32.20	a	34.50	a	8.07	a	9.37	abcd	11.40	abcd	10.33	abc	11.33	abcd
V_2F_0	14.97	ef	18.63	gh	19.93	ef	18.93	hij	20.67	fg	7.43	ab	8.97	bcd	10.77	abcde	9.00	cdef	9.17	defg
V_2F_1	16.67	cde	18.50	gh	21.80	e	20.40	gh	21.83	f	7.00	abc	7.97	cde	9.73	b-h	8.47	efg	10.17	bcdef
V_2F_2	19.78	ab	22.17	bcd	26.37	bcd	25.00	ef	26.83	d	8.80	a	10.53	ab	11.80	ab	10.00	abcd	11.67	abcd
V_2F_3	19.33	ab	23.03	bc	27.20	bc	27.13	cd	29.83	bc	8.70	a	9.87	abc	11.50	abc	10.40	abc	10.83	abcde
V_3F_0	16.05	def	18.83	fgh	21.67	e	19.87	ghi	20.83	fg	5.33	c	7.87	cde	9.63	c-h	8.73	def	10.00	cdefg
V_3F_1	15.28	ef	18.37	gh	23.67	cde	23.60	f	27.17	d	5.73	bc	7.63	de	8.67	fgh	8.40	efg	9.83	cdefg
V_3F_2	19.77	ab	23.13	bc	27.80	bc	27.47	bcd	29.83	bc	6.97	abc	9.13	abcd	11.00	abcde	10.47	abc	11.67	abcd
V_3F_3	20.47	ab	24.67	ab	30.80	ab	29.40	b	31.67	bc	6.83	abc	8.80	bcde	10.67	abcdef	10.67	ab	12.17	abc
V_4F_0	14.48	ef	17.93	gh	19.63	ef	18.07	ij	19.17	gh	8.43	a	9.16	abcd	10.70	abcdef	10.20	abc	12.00	abc
V_4F_1	16.75	cde	21.23	cdef	26.73	bcd	27.07	cd	30.67	bc	7.47	ab	9.40	abcd	10.47	abcdef	9.43	bcde	11.33	abcd
V_4F_2	18.12	bcd	22.17	bcd	29.27	ab	29.00	bc	31.83	b	8.37	a	11.13	a	12.17	a	11.33	a	12.83	ab
V_4F_3	19.00	ab	22.63	bcd	27.00	bc	26.67	de	29.33	c	8.40	a	10.60	ab	11.93	a	11.20	a	13.17	a
V_5F_0	14.02	f	17.07	h	16.20	f	17.27	j	18.17	h	5.67	bc	6.67	e	7.97	h	7.13	gh	7.33	g
V_5F_1	16.53	cde	17.80	gh	19.73	ef	17.73	j	19.17	gh	5.87	bc	6.70	e	8.27	gh	6.93	h	7.83	fg
V_5F_2	18.40	bc	20.40	defg	21.53	e	19.13	ghij	20.67	fg	6.80	abc	7.97	cde	9.37	d-h	7.67	fgh	8.17	efg
V_5F_3	18.70	bc	21.50	cde	19.40	ef	21.00	g	22.17	ef	7.30	abc	8.23	cde	9.30	efgh	8.53	defg	8.17	efg
CV (%)	6.88		6.51		9.98		7.64		5.06		8.96		9.56		10.30		8.29		7.63	
LSD (0.05)	2.02		2.26		4.05		1.82		2.14		1.68		1.83		1.77		1.28		2.35	

[y] V_1: White vienna; V_2: Quick star; V_3: Sufala-14 ; V_4: UFO; V_5: Early 005; F_0 : Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer

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

Table 3. Effect of varieties and different fertilizers combination on growth characters of Knol-khol[x]

Treatment [y]	Spread of plant canopy (cm)										Fresh weight of leaves per plant (gm)		Fresh weight of knob per plant (gm)	
	15 DAT		25 DAT		35DAT		45 DAT		55 DAT					
V_1F_0	26.85	defg	30.48	cdef	38.20	ghi	37.53	def	39.33	fg	37.87	hi	131.80	ijk
V_1F_1	34.50	ab	39.13	b	52.40	b	46.00	bc	46.67	de	54.67	d	202.70	cd
V_1F_2	34.37	ab	39.53	ab	51.33	bc	49.60	b	54.33	bc	78.07	b	219.90	b
V_1F_3	38.18	a	42.97	a	59.60	a	54.20	a	60.50	a	87.87	a	256.50	a
V_2F_0	24.57	fg	29.60	cdef	36.87	ghi	36.67	def	36.33	gh	31.80	jk	118.30	l
V_2F_1	26.63	defg	29.80	cdef	38.67	fghi	38.03	de	38.40	gh	49.27	e	148.30	gh
V_2F_2	32.37	bc	37.37	b	45.33	cdef	44.23	c	47.50	de	44.87	efg	192.70	de
V_2F_3	32.60	bc	37.53	b	47.13	bcde	47.27	bc	52.17	bcd	47.93	ef	195.80	cde
V_3F_0	25.10	efg	30.00	cdef	37.43	ghi	36.23	def	37.17	gh	33.00	ij	123.40	kl
V_3F_1	23.33	fg	29.07	def	40.53	efghi	39.17	d	44.50	ef	42.77	fgh	126.30	jkl
V_3F_2	33.62	abc	38.07	b	48.93	bcd	47.67	bc	52.50	bcd	76.00	b	204.90	c
V_3F_3	35.80	ab	40.47	ab	52.90	b	49.40	b	56.67	ab	80.07	b	227.60	b
V_4F_0	23.25	fg	28.93	ef	35.77	i	33.63	ef	34.23	gh	26.67	k	116.00	l
V_4F_1	26.27	defg	31.90	cde	43.67	defg	44.13	c	52.00	bcd	66.80	c	120.70	l
V_4F_2	31.03	bcd	37.23	b	42.97	defgh	46.73	bc	56.50	ab	74.80	b	156.10	g
V_4F_3	30.95	bcd	37.37	b	46.47	bcde	46.53	bc	50.33	cde	74.87	b	185.70	e
V_5F_0	22.23	g	27.67	f	35.00	i	32.57	f	32.50	h	20.33	l	96.00	m
V_5F_1	28.15	cdef	30.43	cdef	36.13	hi	34.83	def	34.23	gh	28.80	jk	139.30	hi
V_5F_2	30.40	bcde	32.93	c	39.47	fghi	38.40	de	37.00	gh	32.07	jk	135.30	ij
V_5F_3	34.10	ab	32.80	cd	41.80	efghi	38.07	de	39.23	fg	40.93	gh	173.90	f
CV (%)	9.94		5.82		8.28		6.49		7.28		13.70		11.68	
LSD (0.05)	4.88		3.29		5.96		4.51		5.43		5.16		9.80	

[y] V_1: White vienna; V_2: Quick star; V_3: Sufala-14 ; V_4: UFO; V_5: Early 005; F_0 : Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer

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

4.7 Fresh weight of knob per plant

Effects of varieties were found statistically significant in respect of fresh weight of knob per plant (Table 4). The highest (202.80 g) and lowest (136.10 g) weight of knob were found from the variety White vienna and Early 005, respectively at 55 DAT.

Different fertilizers had significant effect on fresh weight of knob per plant (Table 5). Maximum fresh weight of knob plant (207.90 g) was obtained from the treatment F_3 (Organic fertilizer + Inorganic fertilizer) at 55 DAT and the lowest weight (117.10 g) was found from F_0 (control) treatment at the same DAT. The maximum weight of single tuber might be due to balanced fertization because normal metabolic processes can continue only in the presence of an optimum level of nitrogen, phosphorus, potassium plays its role in the promotion of growth and meristematic tissues.

Interaction effects of different varieties and different fertilizers treatment were significant on fresh weight of knob. Highest fresh weight of knob per plant (256.50 g) was found the treatment combination V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) at 55 DAT. Lowest (96.00 g) was obtained from treatment combination of V_5F_0 (Early 005 with control treatment) at the same DAT (Table 3).

4.8 Fresh weight of roots per plant

Variety significantly influenced the fresh weight of roots per plant (Table 4).Maximum fresh weight of roots per plant (4.55 g) was measured from White vienna, while the minimum fresh weight of roots per plant (2.84 g) was recorded from Early 005 at 55 DAT.

There was a significant effect of different fertilizers on the fresh weight of roots per plant (Table 5). Highest fresh weight of roots (4.84 g) was recorded from the treatment F_3 (Organic fertilizer + Inorganic fertilizer) at 55 DAT and the lowest (2.15 g) was found from F_0 (control) treatment at the same DAT. This was due to the balanced application of fertilizers, which significantly influenced the root growth of Knol-khol.

Interaction effects of different varieties and different fertilizers treatment were significant in this regard. Highest fresh weight of roots per plant (6.50 g) was found the treatment combination V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) at 55 DAT. Lowest (1.57 g) was obtained from treatment combination of V_5F_0 (Early 005 with control treatment) at the same DAT (Table 6).

4.9 Diameter of knob

Different varieties significantly influenced the diameter of knob (Table 4). The maximum (7.38 cm) and minimum (6.36 cm) diameters were observed in the varieties White vienna and Early 005, respectively at 55 DAT.

Effect of different fertilizers had significant influence on the diameter of knob (Table 5). The maximum diameter of knob (7.66 cm) was found with the F_3 (Organic fertilizer + Inorganic fertilizer) treatment and the minimum diameter of knob (5.93 cm) was obtained from F_0 (control) treatment. This may be due to the fact that the presence of all the three major elements in a suitable combination enhanced the vegetative growth of the plants. Plants growing in this treatment had maximum number of leaves (16.40) that might have enhanced the photosynthetic activities and prepared sufficient food for the growth and tuber enlargement.

Interaction effects of different varieties and different fertilizers treatment were significant in this regard. Maximum diameter of knob (8.67cm) was observed from V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) at 55 DAT. Minimum diameter of knob (5.40 cm) was observed from V_5F_0 (Early 005 with control treatment) at the same DAT (Table 6).

4.10 Thickness of knob

It was observed that the effects of varieties on thickness of knob were statistically significant (Table 4). White vienna produced the maximum (7.16 cm) and Early 005 produced the minimum (5.93 cm) thickness of knob at 55 DAT.

Different fertilizers had significant effect on the thickness of knob (Table 5). Maximum thickness (7.57 cm) was obtained when plants produced with F_3 (Organic fertilizer + Inorganic fertilizer) treatment. Minimum thickness (5.17 cm) was found in the F_0 (control) treatment.

Interaction effects of different varieties and different fertilizers treatment were significant in respect of thickness of knob per plant. Maximum thickness of knob (8.87 cm) was observed from V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) at 55 DAT. Minimum thickness of knob (4.93 cm) was observed from V_5F_0 (Early 005 with control treatment) at the same DAT (Table 6).

4.11 Average length of roots per plant

Effect of variety revealed that there was a significant difference among the varieties in respect of average length of root. Longest root (8.03 cm) was recorded on the variety White vienna which was statistically similar by Sufala-14 (7.38 cm) and shortest (5.58 cm) from the variety Early 005 (Table 4).

Different fertilizers had significant influence on average length of root of knol-khol plant (Table 5). Maximum length of root (8.60 cm) was recorded from the F_3 (Organic fertilizer + Inorganic fertilizer) treatment. Minimum thickness (5.17 cm) was found in the F_0 (control) treatment. Balanced fertilizers increased the root growth of knol-khol.

Interaction effects of different varieties and different fertilizers treatment were significantly influenced on the average length of root. Maximum average root length (10.77 cm) was found from the treatment combination of V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) at 55 DAT. Minimum average length of root (4.10 cm) was obtained from V_5F_0 (Early 005 with control treatment) which was statistically similar with V_4F_0 (UFO with control treatment) at the same DAT (Table 6).

4.12 Number of lateral roots per plant

There was observed significant interaction among varieties of Knol-khol in respect of number of lateral roots per plant. Highest (21.59) and the lowest (14.58) number of lateral roots were found in the variety White vienna and Early 005, respectively (Table 4).

Effect of different fertilizers had significant influence on the production on lateral roots. Maximum number of lateral roots (22.69) was obtained when the F_3 (Organic fertilizer + Inorganic fertilizer) treatment and minimum (12.32) was recorded with F_0 (control) treatment (Table 5). Number of lateral roots increased gradually with balanced nutrient supply.

Number of lateral root per plant was significant due to interaction effect of different varieties and different fertilizers treatment. Number of lateral roots (29.97) was the highest when V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) at 55 DAT. On the other hand the lowest number of lateral roots (7.47) was found when V_5F_0 (Early 005 with control treatment) at the same DAT (Table 6).

4.13 Dry weight of leaves

Variation in relation to dry weight of leaves among different varieties was significant. Maximum dry weight of leaves (13.58%) was recorded from the White vienna and the minimum dry weight of leaves (12.00%) was found the Early 005 (Table 4).

Effects of different fertilizers were found significant in respect of dry weight of leaves per plant. Highest dry weight (14.04%) was recorded with the F_3 (Organic fertilizer + Inorganic fertilizer) treatment and minimum weight (11.10%) was found from F_0 (control) treatment (Table 5).

Percent dry weight of leaf had significant due to the interaction effect of different varieties and different fertilizers treatment. Treatment V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) produced the highest percentage (14.83%) of dry weight.

minimum dry weight of roots (16.67%) was recorded in the F_0 (control) treatment (Table 2).

Interaction effects of different varieties and different fertilizers treatment were statistically significant. Maximum (19.83%) dry weight of roots was recorded from the treatment combination of White vienna with organic fertilizer + inorganic fertilizer (V_1F_3) which was statistically similar with treatment combination of V_3F_3 (Sufala-14 with organic fertilizer + inorganic fertilizer) and Minimum (15.00%) dry weight of roots was recorded from the treatment combination of V_5F_0 (Early 005 with control treatment) (Table 6).

4.16 Gross yield per hectare

Results of different varieties showed significant effect on gross yield of knol-khol per hectare. Maximum gross yield per hectare (38.44 ton) was recorded from the variety White Vienna while the lowest gross yield per hectare (28.39 ton) was observed from Early 005 variety (Table 4).

Gross yield per hectare was significantly influenced by the application of different fertilizers. Maximum gross yield per hectare (41.36 ton) was produced by the plants grown under the treatment F_3 (Organic fertilizer + Inorganic fertilizer) while the lowest yield per hectare (24.88 ton) was found from F_0 (control) treatment (Table 5). It was observed that the combination of organic and inorganic fertilizers gave the better result than the single fertilizer treatment. Study of Zhang *et al.* (2004) supports this result.

Interaction effects of different varieties and different fertilizers treatment were found to be significant for gross yield of knol-khol per hectare. It was found that V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) treatment produced the maximum gross yield per hectare (49.48 ton). Minimum gross yield per hectare (21.18 ton) was obtained from the V_5F_0 (Early 005 with control treatment) treatment combination (Table 6).

On the other hand lowest percentage (10.50%) of dry weight was produced by treatment V_5F_0 (Early 005 with control treatment) was used (Table 6).

4.14 Dry weight of knob

Production of dry matter of knol-khol knob varied significantly due to the effect of different varieties. Highest percent dry weight of knob (4.92%) was recorded from White vienna. The lowest dry matter production (4.58%) was found from Early 005 (Table 4).

Application of different fertilizers showed significant effect on the dry matter production of knol-khol. Maximum dry weight of knol-khol knob (5.10%) was obtained from the F_3 (Organic fertilizer + Inorganic fertilizer) treatment and minimum dry matter weight of knol-khol knob (4.30%) was found from F_0 (control) treatment (Table 5).

Interaction effects of different varieties and different fertilizers treatment were significantly influenced on the dry weight percentage of knob in knol-khol. White vienna with organic fertilizer + inorganic fertilizer (V_1F_3) resulted the highest percentage (5.33%) which was statistically similar with treatment combination of V_3F_3 (Sufala-14 with organic fertilizer + inorganic fertilizer). Lowest percentage dry weight (4.17%) was produced by treatment V_5F_0 (Early 005 with control treatment) which was statistically similar with treatment combination of V_4F_0, V_3F_0 and V_2F_0 (Table 6).

4.15 Dry weight of roots

It was observed that the dry weight of roots as influenced by the varieties was significant. The highest dry weight (18.46%) of knol-khol roots was recorded from White Vienna which was statistically similar by Sufala-14 (18.17%) and the lowest dry weight (17.00%) of knol-khol roots was obtained from variety Early 005 (Table 4).

Variation due to the effect of application of different fertilizers in relation to percent dry weight of roots was found significant (Table 5). Maximum percent dry weight (18.73 %) of roots was recorded in the treatment F_3 (Organic fertilizer + Inorganic fertilizer) and

4.17 Marketable yield per hectare

Variety remarkably influenced the marketable yield of knol-khol per hectare. Maximum (29.39 ton/ha) and mimimum (22.43 ton/ha) marketable yields of knol-knol were obtained from the variety White vienna and Early 005, respectively (Table 4).

Effects of different fertilizers on marketable yields of knol-khol per hectare revealed that variation among different fertilizers were statistically significant. It is obvious from the present study that the maximum marketable yield resulted from proper supply of nutrients. Highest marketable yield (31.78 ton/ha) was found from treatment F_3 (Organic fertilizer + Inorganic fertilizer) and minimum marketable yield (18.99 ton/ha) was found from F_0 (control) treatment (Table 5). It was observed that the combination of organic and inorganic fertilizers were better than a single fertilizer treatment for knol-khol production.

It was observed that the interaction effect of different varieties and different fertilizers treatment on marketable yield per hectare was statistically significant. V_1F_3 (White vienna with organic fertilizer + inorganic fertilizer) treatment produced the maximum marketable yield per hectare (37.51 ton). The lowest marketable yield per hectare (16.31 ton) was found from V_5F_0 (Early 005 with control treatment) treatment combination (Table 6).

Table 5. Effect of different fertilizers combination on yield and yield contributing characters of Knol-khol[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/ hectare (ton)	Marketable yield/ hectare (ton)
F_0	29.93 d	117.10 d	2.15 d	5.93 d	5.17 d	4.61 d	12.32 d	11.10 c	4.30 d	16.47 d	24.88 d	18.99 d
F_1	48.46 c	147.50 c	3.14 c	6.61 c	6.15 c	5.93 c	16.76 c	12.23 b	4.57 c	17.67 c	32.60 c	23.79 c
F_2	61.16 b	181.80 b	4.45 b	7.24 b	7.12 b	7.72 b	20.12 b	13.83 a	4.90 b	18.27 b	37.55 b	29.06 b
F_3	66.33 a	207.90 a	4.95 a	7.66 a	7.57 a	8.60 a	22.69 a	14.07 a	5.10 a	18.73 a	41.36 a	31.78 a
CV (%)	13.70	11.68	7.06	8.8	4.03	11.92	9.47	7.81	9.18	7.93	7.11	5.61
LSD (0.05)	2.31	4.39	0.19	0.19	0.19	0.59	1.92	0.27	0.15	0.39	1.67	1.10

[y] F_0: Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer

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

Table 4. Effect of varieties on yield and yield contributing characters of Knol-khol[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/ hectare (ton)	Marketable yield/ hectare (ton)
V_1	64.62 a	202.80 a	4.55 a	7.38 a	7.16 a	8.03 a	21.59 a	13.58 a	4.92 a	18.46 a	38.44 a	29.39 a
V_2	43.47 d	163.80 c	3.57 c	6.82 c	6.43 c	6.53 b	17.60 b	12.71 c	4.67 bc	17.71 b	35.82 b	25.43 c
V_3	57.96 c	170.60 b	4.04 b	7.11 b	6.74 b	7.38 a	19.17 b	13.17 b	4.79 ab	18.17 a	36.63 ab	28.17 b
V_4	60.78 b	144.60 d	3.37 c	6.64 c	6.24 c	6.05 bc	16.92 b	12.58 c	4.63 bc	17.58 b	31.21 c	24.09 d
V_5	30.53 e	136.10 e	2.84 d	6.36 d	5.93 d	5.58 c	14.58 c	12.00 d	4.58 c	17.00 c	28.39 d	22.43 e
CV (%)	13.70	11.68	7.06	8.75	4.03	11.92	9.47	7.81	9.18	7.93	7.11	5.61
LSD (0.05)	2.58	4.91	0.21	0.21	0.22	0.66	2.15	0.30	0.16	0.43	1.84	1.20

[y] V_1: White vienna; V_2: Quick star; V_3: Sufala-14 ; V_4: UFO; V_5: Early 005

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

V_1F_3 Treatment

V_5F_0 Treatment

White vienna, variety

Fig.12. Photographs of different treatments of Knol-khol

Table 6. Effect of varieties and different fertilizers combination on yield and yield contributing characters of Knol-khol[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/ hectare (ton)		Marketable yield/hectare (ton)	
V_1F_0	2.43	klm	6.27	ijk	5.47	jk	5.13	fghi	15.20	fghi	11.50	fg	4.50	cd	17.00	efgh	27.26	ghi	21.18	ij
V_1F_1	3.97	fg	6.90	efgh	6.43	fgh	6.67	de	18.53	bcdefg	13.50	cd	4.83	bc	18.00	cde	32.48	efgh	26.22	efg
V_1F_2	5.30	bc	7.67	bc	7.87	bc	9.53	ab	22.67	bc	14.50	ab	5.00	ab	19.00	ab	44.53	abc	32.64	b
V_1F_3	6.50	a	8.67	a	8.87	a	10.77	a	29.97	a	14.83	a	5.33	a	19.83	a	49.48	a	37.51	a
V_2F_0	2.30	m	6.03	kl	5.23	kl	4.67	hi	12.80	hi	11.17	fg	4.33	d	16.83	fgh	25.26	ghi	19.10	jk
V_2F_1	2.97	ij	6.57	ghij	6.17	ghi	5.93	efgh	16.67	efgh	11.83	f	4.50	cd	17.67	cdefg	41.08	bcd	23.96	gh
V_2F_2	4.40	ef	7.17	def	7.07	de	7.03	de	19.60	bcdef	13.83	bc	4.83	bc	18.00	cde	36.11	def	28.12	de
V_2F_3	4.60	de	7.50	bcd	7.27	d	8.50	bc	21.33	bcde	14.00	bc	5.00	ab	18.33	bcd	40.82	bcd	30.56	bcd
V_3F_0	2.33	lm	6.20	jk	5.23	kl	4.90	ghi	14.47	ghi	11.33	fg	4.33	d	16.83	gh	26.73	ghi	21.01	ij
V_3F_1	3.20	hij	6.70	fghi	6.27	ghi	6.00	defgh	16.73	efgh	12.50	e	4.50	cd	17.83	cdef	30.91	efgh	24.31	fgh
V_3F_2	5.00	cd	7.63	bc	7.50	cd	8.80	bc	22.13	bcd	14.33	ab	5.00	ab	18.50	bc	41.84	abcd	31.95	bc
V_3F_3	5.63	b	7.90	b	7.97	b	9.83	ab	23.33	b	14.50	ab	5.33	a	19.50	a	47.05	ab	35.42	a
V_4F_0	2.10	m	5.73	lm	4.97	l	4.23	i	11.67	ij	11.00	gh	4.17	d	16.67	h	23.96	hi	17.36	kl
V_4F_1	2.77	jkl	6.50	hijk	6.07	hi	5.53	efghi	16.33	efghi	11.67	fg	4.50	cd	17.50	c-h	29.69	efgh	22.57	hi
V_4F_2	4.17	ef	7.00	efg	6.77	ef	6.97	de	19.00	bcdefg	13.67	c	4.83	bc	18.00	cde	33.68	defg	26.74	ef
V_4F_3	4.43	e	7.33	cde	7.17	de	7.47	cd	20.67	bcde	14.00	bc	5.00	ab	18.17	bcd	37.50	cde	29.70	cd
V_5F_0	1.57	n	5.40	m	4.93	l	4.10	i	7.47	j	10.50	h	4.17	d	15.00	i	21.18	i	16.31	l
V_5F_1	2.80	jk	6.40	ijk	5.83	ij	5.53	efghi	15.53	fghi	11.67	fg	4.50	cd	17.33	defgh	28.82	fghi	21.88	hi
V_5F_2	3.40	hi	6.73	fghi	6.40	fgh	6.27	defg	17.20	defgh	12.83	e	4.83	bc	17.83	cdef	31.60	efgh	25.85	efg
V_5F_3	3.60	gh	6.90	efgh	6.57	fg	6.43	def	18.13	cdefg	13.00	de	4.83	bc	17.83	cdef	31.95	efgh	25.70	efg
CV (%)	7.06		8.75		4.03		11.92		9.47		7.81		9.18		7.93		7.11		5.61	
LSD (0.05)	0.43		0.42		0.43		1.32		4.30		0.60		0.33		0.86		7.39		2.40	

[y] V_1: White vienna; V_2: Quick star; V_3: Sufala-14 ; V_4: UFO; V_5: Early 005; F_0 : Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer

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

4.18 Economic analysis

Details of economic analyses have been shown in Table 7 and Appendix VI. The input and overhead costs were recorded for all the treatments and calculated on per hectare basis. The total cost of production under different treatments ranged between Tk. 78694.00 to Tk. 115879.25 per hectare (Table 7). Among the treatment combinations, the variation was due to the cost of different varieties and application of different fertilizers (Organic, Inorganic and Organic-Inorganic combination). Highest cost of production (Tk. 115879.25/ha) was involved in the treatment combination of Early 005 with inorganic fertilizer treatment and the lowest (Tk. 78694.00/ha) produced by Sufala-14 with control treatment combination. Gross return from different combinations ranged between Tk. 130480.00 to Tk. 300080.00 per hectare. Gross return was the total income through the sale of knol-khol knob @ 8000/t at harvest. The highest gross return (Tk. 300080.00/ha) was obtained from the White vienna with organic fertilizer + inorganic fertilizer. The lowest gross return (Tk. 130480.00/ha) was obtained from Early 005 with control treatment combination. Maximum net return was Tk. 200730.62/ha having a benefit cost ratio of 3.02 in the treatment combination of White vienna with organic fertilizer + inorganic fertilizer. On the other hand the lowest net return (Tk. 41451.00/ha) and benefit cost ratio (1.47) were obtained from the Early 005 with control treatment combination (Appendix VI).

Thus, it was clear that the treatment combination of White vienna with application of organic fertilizer + inorganic fertilizer gave the highest net return in knol-khol cultivation.

There was a wide gap between the lowest and the highest benefit cost ratio (BCR). However, the cost and return analysis was based on the crop yield as well as factor such as cost of inputs and market price of the harvested materials, which may vary from year to year. Therefore, the cost and return analysis for a crop grown in a particular year may not represent exactly the same with crop grown in another year.

Table 7. Cost and return analysis in knol-khol production as influenced by different varieties and fertilizer management practices.

Treatment	Marketable yield (t/ha)	Gross return (Tk./ha)	Total cost of production (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio (BCR)
V_1F_0	21.18	169440	79809.00	89631.00	2.12
V_1F_1	26.22	209760	86499.00	123261.00	2.42
V_1F_2	32.64	261120	106959.25	154160.75	2.44
V_1F_3	37.51	300080	99349.38	200730.62	3.02
V_2F_0	19.10	152800	86499.00	66301.00	1.77
V_2F_1	23.96	191680	93189.00	98491.00	2.06
V_2F_2	28.12	224960	113649.25	111310.75	1.98
V_2F_3	30.56	244480	106039.38	138440.62	2.31
V_3F_0	21.01	168080	78694.00	89386.00	2.14
V_3F_1	24.31	194480	85384.00	109096.00	2.28
V_3F_2	31.95	255660	105844.25	149815.75	2.42
V_3F_3	35.42	283360	98234.38	185125.62	2.88
V_4F_0	17.36	138880	86499.00	52381.00	1.61
V_4F_1	22.57	180560	93189.00	87371.00	1.94
V_4F_2	26.74	213920	113649.25	100270.75	1.88
V_4F_3	29.70	237600	106039.38	131560.62	2.24
V_5F_0	16.31	130480	89029.00	41451.00	1.47
V_5F_1	21.88	175040	95419.00	79621.00	1.83
V_5F_2	25.85	206800	115879.25	90920.75	1.78
V_5F_3	25.70	205600	108269.38	97330.62	1.90

V_1: White vienna; V_2: Quick star; V_3: Sufala-14; V_4: UFO; V_5: Early 005; F_0: Control; F_1: Organic manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer

Price of knol-khol @ Tk. 8000 per ton; Gross return = Marketable yield x Tk. 8000/t

Chapter V

Summary and conclusion

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted to find out the performance of different varieties and different fertilizer management practices on the growth and yield of knol-khol. The experiment was carried out at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2007 to January 2008. The experiment comprised of two factors such as (a) Five varieties of knol-khol, viz. V_1: White vienna; V_2: Quick star; V_3: Sufala-14; V_4: UFO; V_5: Early 005 (b) Four different types of fertilizers, viz. F_0: Control; F_1: Organic Manure; F_2: Inorganic fertilizer; F_3: Organic fertilizer + Inorganic fertilizer. Thus there were altogether 20 treatment combinations. Experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Size of each unit plot was 1.2 m x 1.6 m. Thirty days old seedlings were transplanted on 06 November, 2007. 32 plants were accommodated in each plot following a spacing of 30 cm x 20 cm and the crops were harvested on 02 January, 2007. From each plot, 10 plants were randomly selected and identified with stick for collection of data. Yield was estimated on the basis of yield per hectare. Observations were made on the height of plant, number of leaves per plant, spread of plant canopy, length of the largest leaf, breadth of the largest leaf (at 15, 25, 35, 45 and 55 DAT), fresh weight of leaves per plant, fresh weight of knob per plant, fresh weight of roots per plant, diameter of knob per plant, thickness of knob per plant, length of root per plant, number of lateral roots per plant, per cent dry weight of leaves, per cent dry weight of knob, per cent dry weight of roots, gross yield per hectare, marketable yields per per hectare. An economic analysis was also done to evaluate the profitability of the crops. Collected data were statistically analyzed and the means were compared with the Duncans Multiple Range Test (DMRT) values.

Different varieties and different types of fertilizers influenced all the characters studied significantly. Different varieties and different types of fertilizers significantly influenced the plant height of knol-khol. Maximum plant height (32.78 cm) and (34.27 cm) were recorded from the variety White vienna and (Organic fertilizer + Inorganic fertilizer), respectively at 55 Days after Transplanting (DAT). In case of combined effect, the treatment combination V_1F_3 (White Vienna X Organic fertilizer + Inorganic fertilizer)

gave the tallest plant (40.17 cm) and V_5F_0 (Early 005 with control treatment) gave the shortest (50.25 cm) plant at 55 DAT. Maximum numbers of leaves per plant were recorded 15.50 and 16.40 from variety White Vienna and F_3 (Organic fertilizer + Inorganic fertilizer), respectively at 55 DAT. Treatment combination V_1F_3 (White vienna X Organic fertilizer + Inorganic fertilizer) gave the height number of leaves per plant (19.83), whereas the lowest number of leaves per plant was obtained from the treatment combination V_5F_0 (Early005, with control fertilizer treatment) gave the shortest (8.50) plant at 55 DAT.

Result showed that effect of different varieties and different sources of NPK fertilizers on spread of plant were also remarkable and statistically significant at 55 DAT. The highest spread of plant (60.50 cm) was observed from the treatment combination of V_1F_3 (White vienna with Organic fertilizer + Inorganic fertilizer) at 55 DAT and minimum spread (32.50 cm) was found in the treatment combination of V_5F_0 (Early 005 with control fertilizer treatment) at the same DAT.

Maximum length and breadth of the largest leaf per plant were significantly influenced by variety and different types of fertilizers. Maximum length and breadth of the largest leaf per plant were recorded 28.00 cm and 12.33 cm from variety White Vienna and UFO at 55 DAT. Minimum length and breadth of the largest leaf per plant were recorded 20.04 cm and 7.88 cm from variety Early 005 at the same DAT. In case of different fertilizers management practices the maximum length and breadth of largest leaf per plant were recorded 29.50 cm and 11.23 cm from the treatment F_3 (Organic fertilizer + Inorganic fertilizer) at 55 DAT and the minimum length and breadth of largest leaf per plant were recorded 20.20 cm and 9.70 cm from control fertilizer treatment. The maximum length (34.50 cm) and breadth (13.17 cm) of largest leaf per plant were observed in the treatment combination V_1F_3 (White vienna with Organic fertilizer + Inorganic fertilizer) and V_4F_3 (UFO with organic fertilizer + inorganic fertilizer), respectively at 55 DAT. The minimum length (18.17 cm) and breadth (7.33 cm) of the largest leaf per plant were found in the treatment combination of V_5F_0 (Early 005 with control fertilizer treatment) at 55 DAT.

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 fresh weight of leaves per plant (87.87 g), maximum fresh weight of knob per plant (256.5 g) and maximum fresh weight of roots per plant (6.50 g) were observed in the treatment combination V_1F_3 (White vienna with Organic fertilizer + Inorganic fertilizer) at 55 DAT, whereas the minimum fresh weight of leaves (20.33 g), minimum fresh weight of knob per plant (96.00 g) and minimum fresh weight of roots per plant (1.57 g) were recorded with the combined effect of V_5F_0 (Early 005 with control fertilizer treatment) at the same DAT.

Maximum diameter of knob per plant (8.67cm) and maximum thickness of knob per plant (8.87 cm) were observed from the treatment combination V_1F_3 (White vienna with Organic fertilizer + Inorganic fertilizer) at 55 DAT, whereas the minimum diameter of knob per plant (5.40 cm) and minimum thickness of knob per plant (4.93 cm) were recorded with the combined effect of V_5F_0 (Early 005 with control fertilizer treatment) at the same DAT.

Highest average length of root per plant (10.77 cm) and the highest number of roots per plant (29.97) was found from the treatment combination of V_1F_3 (White vienna with Organic fertilizer + Inorganic fertilizer) at 55 DAT and the lowest average length of root per plant (4.10 cm) and the lowest number of roots per plant (7.47) was observed from the treatment combination of V_4F_0 (UFO with control fertilizer treatment) and V_5F_0 (Early 005 with control fertilizer treatment), respectively at the same DAT.

Percentage of dry matter content of leaves, knob and roots were significantly influenced by single effect as well as combined effect of the treatments. Maximum dry weight of leaves (14.83%), knob (5.33%) and roots (19.83%) were measured in the treatment combination of V_1F_3 (White vienna with Organic fertilizer + Inorganic fertilizer), whereas the minimum dry weight of leaves (10.50%), dry weight of knob (4.17%), dry weight of roots (15.00%) were recorded with the combined effect of V_5F_0 (Early 005 with control fertilizer treatment).

Gross yield per hectare and marketable yield per hectare were significantly influenced by the different varieties and different fertilizer management practices. The highest gross yield per hectare (49.48 t), marketable yield per hectare (21.18 t) were obtained from the treatment combination of V_1F_3 (White vienna with Organic fertilizer + Inorganic fertilizer). Minimum gross yields per hectare (37.51 t), marketable yield per hectare (16.31 t) were measured from the variety Early 005 with control fertilizer treatment (V_5F_0).

From the economic point view, it was evident that the highest net return (200730.62 Tk./ha) and benefit cost ratio (3.02) were obtained from the treatment combination of V_1F_3 (White vienna with Organic fertilizer + Inorganic fertilizer), while the lowest net return (41451.00 Tk./ha) and benefit cost ratio (1.47) were found from the treatment combination of V_5F_0 (Early 005 with control treatment).

The variety White vienna gave the highest yield and economic return. Different fertilizer management practices had significant influence on growth and yield of Knol-khol, and the use of both organic and inorganic fertilizers in the experiment gave the best result. So for commercial cultivation of Knol-khol under the Dhaka region both organic and inorganic fertilizers (F_3 = Organic fertilizer + Inorganic fertilizer) and variety White vienna might be encouraged.

Considering the result of the present study, following conclution may be drawn:

i. From the point of economic yield, it may be suggested that higher yield could be obtained by cultivating the White Vienna (V_1) of Knol-khol with the application of both organic and inorganic fertilizers (F_3) 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 as 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

Source: SRDI

B. Physical and chemical properties of the initial soil

Characteristics	Value
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
pH	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (µgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40
Available B (µgm/gm soil)	0.13
Available Zn (µgm/gm soil)	0.94
Available Cu (µgm/gm soil)	1.93
Available Fe (µgm/gm soil)	240.9
Available Mn (µgm/gm soil)	50.6

Source: SRDI

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** (mm)	* Relative humidity (%)
		Max.	Min.	Mean		
	October	35.60	19.50	27.46	320.00	64.50
2007	November	31.80	16.80	24.30	14.00	67.00
	December	28.20	11.30	19.75	0.00	63.00
2008	January	29.00	10.50	19.75	23.00	61.50

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

* Monthly average; ** Monthly total

Appendix III. Mean square values of analysis of variance of the data on growth of knol-khol as influenced by different varieties and different fertilizers combination.

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	1.49	0.39	14.38	0.20	14.26	2.27	0.55	0.02	1.15	7.14	1.65	1.46	38.13	1.57	13.68
Factor A (Variety)	4	13.71**	46.87**	116.08**	154.22**	212.79**	2.46**	3.52**	2.69**	8.34**	38.89**	10.50**	24.48**	133.86**	111.75**	135.24**
Factor B (Fertilizer Management)	3	64.75**	120.26**	229.19**	294.84**	335.16**	8.21**	8.14**	9.29**	16.11**	116.80**	68.35**	84.91**	170.37**	200.98**	256.13**
A x B	12	1.35**	6.11**	9.51**	18.71**	35.66**	0.55**	0.83**	0.67**	1.26**	8.11**	2.55**	3.48**	10.46**	11.68**	18.95**
Error	38	1.8	1.59	3.48	1.82	2.04	0.18	0.21	0.24	0.45	3.36	1.50	1.87	6.01	1.21	1.68

**: Significant at 5% level of significance.

DAT: Days after transplanting.

Appendix IV. Mean square values of analysis of variance of the data on growth and yield knol-khol as influenced by different varieties and different fertilizers combination.

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	5.52	0.31	2.85	1.04	0.80	30.35	2.22	81.52	1.86	20.36	434.29	975.56	0.24
Factor A (Variety)	4	10.02**	12.30**	13.34**	14.07**	31.33**	57.09**	77.14**	247.61**	185.33**	398.26**	2412.21**	8086.30**	5.10**
Factor B (Fertilizer management)	3	5.50**	9.18**	10.16**	10.98**	10.78**	301.26**	262.01**	448.83**	419.94**	763.66**	3938.51**	23576.58**	24.31**
A x B	12	0.55**	0.36**	0.28**	0.33**	0.71**	11.95**	12.78**	27.72**	16.70**	48.16**	317.42**	920.94**	0.48**
Error	38	1.04	1.23	1.15	0.60	2.03	8.73	3.96	12.99	7.44	10.79	9.74	35.26	0.07

**: Significant at 5% level of significance.

DAT: Days after transplanting.

Appendix V. Mean square values of analysis of variance of the data on yield contributing parameters of knol-khol as influenced by different varieties and different fertilizers combination.

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/ hectare (ton)	Marketable yield/ hectare (ton)
Replication	2	0.28	0.41	5.39	391.12	0.12	1.43	2.00	179.81	67.97
Factor A (Variety)	4	1.88**	2.65**	11.76**	81.79**	4.33**	0.22**	3.79**	207.58**	98.44**
Factor B (Fertilizer management)	3	8.58**	17.10**	48.10**	301.28**	29.42**	1.88**	14.42**	759.82**	483.69**
A x B	12	0.15**	0.33**	1.44**	8.39**	0.24**	0.03**	0.50**	41.56**	6.36**
Error	38	0.07	0.07	0.64	6.76	0.13	0.04	0.27	19.97	2.11

**: Significant at 5% level of significance.

DAT: Days after transplanting.

Appendix VI. Production cost of knol-khol per hectare

A. Input cost (Tk.)

a. Material cost (Tk.)

Treatment	Seed	Manures and fertilizers				Irrigation	Chatai and bamboo	Insecticide	Water for seedling establishment	Subtotal (a)
		Cowdung	Urea	TSP	MP					
V_1F_0	3000	0	0	0	0	8000	1200	4000	2000	18200
V_1F_1	3000	6000	0	0	0	8000	1200	4000	2000	24200
V_1F_2	3000	0	3600	12000	8750	8000	1200	4000	2000	42550
V_1F_3	3000	3000	2400	6000	6125	8000	1200	4000	2000	35725
V_2F_0	9000	0	0	0	0	8000	1200	4000	2000	24200
V_2F_1	9000	6000	0	0	0	8000	1200	4000	2000	30200
V_2F_2	9000	0	3600	12000	8750	8000	1200	4000	2000	48550
V_2F_3	9000	3000	2400	6000	6125	8000	1200	4000	2000	41725
V_3F_0	2000	0	0	0	0	8000	1200	4000	2000	17200
V_3F_1	2000	6000	0	0	0	8000	1200	4000	2000	23200
V_3F_2	2000	0	3600	12000	8750	8000	1200	4000	2000	41550
V_3F_3	2000	3000	2400	6000	6125	8000	1200	4000	2000	34725
V_4F_0	9000	0	0	0	0	8000	1200	4000	2000	24200
V_4F_1	9000	6000	0	0	0	8000	1200	4000	2000	30200
V_4F_2	9000	0	3600	12000	8750	8000	1200	4000	2000	48550
V_4F_3	9000	3000	2400	6000	6125	8000	1200	4000	2000	41725
V_5F_0	11000	0	0	0	0	8000	1200	4000	2000	26200
V_5F_1	11000	6000	0	0	0	8000	1200	4000	2000	32200
V_5F_2	11000	0	3600	12000	8750	8000	1200	4000	2000	50550
V_5F_3	11000	3000	2400	6000	6125	8000	1200	4000	2000	43725

Cowdung : @ 300 Tk./ton
Urea : @12 Tk./kg
TSP : @ 40 Tk./kg
MP : @ 35 Tk./kg

Appendix VI (Contd.)

b. Non material cost (Tk.)

Treatment	Seed bed preparation	Land preparation	Transplanting cost	Cost of intercultural operation	Bird driving	Cost of harvesting	Subtotal (b)	Input cost A (a + b)
V_1F_0	900	3000	2000	5000	1500	6000	18400	36600
V_1F_1	900	3000	2000	5000	1500	6000	18400	42600
V_1F_2	900	3000	2000	5000	1500	6000	18400	60950
V_1F_3	900	3000	2000	5000	1500	6000	18400	54125
V_2F_0	900	3000	2000	5000	1500	6000	18400	42600
V_2F_1	900	3000	2000	5000	1500	6000	18400	48600
V_2F_2	900	3000	2000	5000	1500	6000	18400	66950
V_2F_3	900	3000	2000	5000	1500	6000	18400	60125
V_3F_0	900	3000	2000	5000	1500	6000	18400	35600
V_3F_1	900	3000	2000	5000	1500	6000	18400	41600
V_3F_2	900	3000	2000	5000	1500	6000	18400	59950
V_3F_3	900	3000	2000	5000	1500	6000	18400	53125
V_4F_0	900	3000	2000	5000	1500	6000	18400	42600
V_4F_1	900	3000	2000	5000	1500	6000	18400	48600
V_4F_2	900	3000	2000	5000	1500	6000	18400	66950
V_4F_3	900	3000	2000	5000	1500	6000	18400	60125
V_5F_0	900	3000	2000	5000	1500	6000	18400	44600
V_5F_1	900	3000	2000	5000	1500	6000	18400	50600
V_5F_2	900	3000	2000	5000	1500	6000	18400	68950
V_5F_3	900	3000	2000	5000	1500	6000	18400	62125

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)]
V_1F_0	39000	1830.00	2379.00	43209.00	79809.00
V_1F_1	39000	2130.00	2769.00	43899.00	86499.00
V_1F_2	39000	3047.50	3961.75	46009.25	106959.25
V_1F_3	39000	2706.25	3518.13	45224.38	99349.38
V_2F_0	39000	2130.00	2769.00	43899.00	86499.00
V_2F_1	39000	2430.00	3159.00	44589.00	93189.00
V_2F_2	39000	3347.50	4351.75	46699.25	113649.25
V_2F_3	39000	3006.25	3908.13	45914.38	106039.38
V_3F_0	39000	1780.00	2314.00	43094.00	78694.00
V_3F_1	39000	2080.00	2704.00	43784.00	85384.00
V_3F_2	39000	2997.50	3896.75	45894.25	105844.25
V_3F_3	39000	2656.25	3453.13	45109.38	98234.38
V_4F_0	39000	2130.00	2769.00	43899.00	86499.00
V_4F_1	39000	2430.00	3159.00	44589.00	93189.00
V_4F_2	39000	3347.50	4351.75	46699.25	113649.25
V_4F_3	39000	3006.25	3908.13	45914.38	106039.38
V_5F_0	39000	2230.00	2899.00	44429.00	89029.00
V_5F_1	39000	2530.00	3289.00	44819.00	95419.00
V_5F_2	39000	3447.50	4481.75	46929.25	115879.25
V_5F_3	39000	3160.25	4038.13	46144.38	108269.38