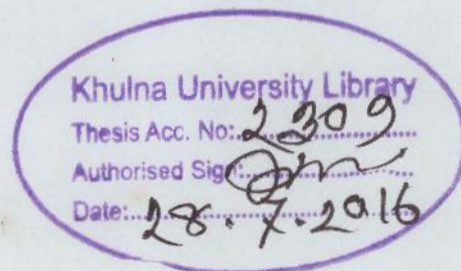


**EFFECT OF DIFFERENT ORGANIC MANURES AND FERTILIZERS
ON GROWTH AND YIELD OF KNOL-KHOL (*Brassica oleracea* var.
gongylodes L.)**



A Thesis

Submitted to

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KHULNA UNIVERSITY

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BANGLADESH

By

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STUDENT ID: MS-120814

In Partial Fulfillment of the Requirements

for the Degree

of

MASTER OF SCIENCE IN HORTICULTURE



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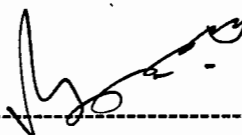
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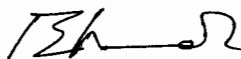
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ABSTRACT

A field experiment was carried out to investigate the effect of different manures and fertilizers on the growth and yield of knol-khol (*Brassica oleracea* var. *gongylodes*) at Dr. Purnendu Gain Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna from November 2014 to February 2015. The single factor experiment comprised of different types of fertilizers and manures viz., T₀ (Control), T₁ (Recommended doses of NPK), T₂ (Cow dung), T₃ (Vermicompost), T₄ (Poultry manure), T₅ (50 % Cow dung + 50 % NPK), T₆ (50% Vermicompost + 50% Cow dung), T₇ (50% Vermicompost + 50 % Poultry manure) and T₈ (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% NPK). The Experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The maximum plant height was obtained from the treatment T₁ (Recommended doses of NPK) at 25, 35 and 45 DAT. The maximum spread of canopy was 36.75 cm, 52.50 cm and 66.05 cm from the treatment T₃ (Vermicompost), T₇ (50% Vermicompost + 50 % Poultry manure) and T₂ (Cow dung), respectively. The maximum economic yield (21.92 t/ha) and biological yield (40.083 t/ha) were found in the treatment T₁ (Recommended doses of NPK) and T₇ (50 % Vermicompost + 50 % Poultry manure), respectively. Highest benefit cost ratio (3.07) was obtained from the treatment T₁ (Recommended doses of NPK) which was statistically similar with the treatment poultry manure (2.89) and Cow dung (2.73). The minimum benefit cost ratio (0.57) was obtained from the treatment T₃ (Vermicompost) which indicates that high cost of vermicompost affect net return severely. Although, recommended doses of NPK produced maximum benefit cost ratio, the treatment T₄ (Poultry manure) and T₂ (Cow dung) are very close to T₁ (Recommended doses of NPK) and also statistically similar. So, we can consider the treatment T₄ (Poultry manure) and T₂ (Cow dung) for our soil health, environmental benefits and ecological safety.

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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%	% Coefficient of Variation
DAT	Days after Transplanting
DMRT	Duncan's Multiple Range Test
FAO	Food and Agriculture Organizations
t/ha	Ton per hectare
LSD	Least Significance Difference
MP	Muriate of Potash
ppm	Parts per million
RH	Relative humidity
SRDI	Soil Resources Development Institute
TSP	Triple Super phosphate

CHAPTER I

INTRODUCTION

Knol-khol (*Brassica oleracea* var. *gongylodes* L.) belongs to the family Brassicaceae that is the German name for cabbage turnip, also called kohlrabi, which resembles an above ground turnip. The fleshy enlargement of the stem develops entirely above the ground, called knob and is used as a vegetable. It is an excellent vegetable if it is used before it becomes tough and fibrous. After boiling the small knobs are cooled and added with salt and vinegar and served as a salad, leaves are used as green. The knol-khol is reported to have originated in the coastal countries of Western Europe (Shanmugavelu, 1989).

Knol-khol is a member of the cole crops and is an excellent vegetable. It is high in minerals and vitamins A and C. It contains adequate amount of water (90.3 g), calories (29.0 g), protein (2.0 g), carbohydrate (6.6 g), fibre (1.0 g), and ash (1.0 g) per 100 g of edible stem. It also contains satisfactory amount of calcium (41.0 mg), phosphorus (51.0 mg), iron (0.5 mg), sodium (8.0 mg), potassium (372.0 mg), vitamin A (20.0 mg), thiamin (0.06 mg), riboflavin (0.04 mg), niacin (0.03 mg), and vitamin C (66.0 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, 2007).

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 (Cavazza and Bianco, 2005).

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 photosynthesis, 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 reduces soil erosion, increases water holding capacity, improves 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).

Organic fertilizers are all forms of organic soil amendments that originate from both livestock waste and crop residues, with the nutrients in them being mineralized by soil microbes and slowly making them available to plants over a long period of time (Lampkin, 2009).

Organic fertilizers contain mineral nutrients in the form of complex organic molecules and the levels of nutrients are much lower than inorganic fertilizers. Organic fertilizers also have a longer residual effect than inorganic fertilizers. Inorganic fertilizers are specially made to provide essential nutrients faster even during unfavourable conditions such as autumn and spring. In other words, inorganic fertilizers do not depend on the activity of microbes to release nutrients. Therefore, inorganic fertilizers are required in smaller amounts and they are easy to store as well as to apply to the soil compared to organic fertilizers. Inorganic fertilizers do not supply humus to the soil, so the nutrient and water holding capacity of the soil may be less than that of organic fertilised soil. This lower capacity as well as high

solubility of inorganic fertilizer leads to faster leaching of nutrients (nitrogen) from the soil (Taiz and Zeiger, 2011).

Bangladesh is a developing country. Most of the people living here are suffering from nutrient deficit ie., malnutrition. Organic knol-khol can be a cheap and safe vegetables with healthy soil, that is our ultimate destination to produce crop. So, cultivation of knol-khol by organic manures deserve great importance.

Therefore, the present study was undertaken with the following objectives:

- To observe the performance of organic and inorganic fertilizers on growth and yield of Knol-khol; and
- To find out best combination(s) of organic manures and inorganic fertilizers for obtaining higher economic yield of knol-khol.

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

Some of the promising varieties available in Bangladesh are Sutton's Earliest Purple (Sutton), Golith White (Sadashiv), Early White Vienna, King of the Market and Early Purple Vienna (Verma, Pocha). Although, research stations and some private seed companies are engaged in testing and maintenance of varieties, no serious attempt has been made for the improvement of the crop as the available introductions are well-suited to our conditions (Basir *et al.*, 2002).

Arin *et al.* (2003) carried out a research to determine the yield and quality of kohlrabi (*Brassica oleracea* var. *gongylodes*) under 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.

Varieties that are susceptible to bolting lack a juvenile phase and become generative without producing knobs if exposed after germination to low temperature. When the low temperature occurs at the knob formation stage, the round and flat round varieties produce long oval-shaped knobs. The low temperature or frost conditions sometimes develop the anthocyanin pigments on knobs or plant parts. These pigments are intensified, if there is lack of N and P in soil, deteriorating the quality of knobs, especially of green types (Trautwein, 2004).

Knol-khol can be grown on all types of soils. A soil rich in manures and fertilizers produces excellent knobs. Sandy loam is ideal for an early crop and clay or silt loam for higher yield and late crop. It does not grow well in highly acidic soil. The optimum pH is 5.5–6.8 (Iqbal, 1981)

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

Organic matter enhances root growth and nutrient uptake of kohlrabi resulting in higher yields. The dark colour of humus absorbs heat, thereafter high specific heat helps to stabilize the soil temperature or warm up the soil especially in spring. Through composting methods, diseases, pests and weed seeds are destroyed by high temperature in the compost heap (AIS, 2008).

By using slow decomposing materials such as compost or leaf mould the chances of over-fertilization is reduced since the availability of minerals will not influence the plant negatively. Organic fertilizers add humus to the soil and this has the ability to hold positively charged ions (cations) and negatively charged ions (anions) and make them available to the plants through the process of exchange capacity. Humus added by organic fertilizers adsorbs large quantities of water and makes it available to plants during drought. This feature as well

as the capacity to hold nutrients is important for sandy soils which retain very few nutrients and water (Scholl and Nieuwenhuis, 2004).

Humus serves as an effective buffer regulating the balance between acid and base in the soil solution, i.e. soil pH (Naramabuye *et al.*, 2007).

Organic fertilizers enrich the soil with organic matter, which improves soil structure or workability (soil tilth), making the soil easier to plough (sand and clay soils). Since clay soil has few macro pores, it inhibits the transport of water and oxygen to plant roots leading to suffocation, plant stress (directly) or susceptibility of plants to diseases and pests (indirectly). Therefore, the application of organic fertilizers assist structuring of clay soil to open and admit air penetration to roots and water drainage, both conditions necessary for satisfactory kholrabi growth (Eimhoit *et al.*, 2005)



Organic fertilizers are derived from different raw materials and that is why they vary in their nutrient composition. Generally, cow dung manure is lowest and poultry manure highest in nutrients. Fresh poultry manure contains two or three times as much nitrogen than cow dung. The composition of manure depends very much on the quality of animal feed. The richer the feed in proteins, the richer the manure is in nitrogen. Similarly, the more phosphorus and potassium in the feed, the more of these constituents there are in organic fertilizer (Lampkin, 2009).

Organic fertilizer composition also varies with its age and the extent to which it is exposed to air. When exposed and allowed to dry out, much of the nitrogen in the organic fertilizer may be lost to the air (volatilisation). Potassium may also be lost from the manure through leaching action of rain water. Because of many factors that affect the chemical composition

of organic fertilizers and also significantly affect knol-khol production (Okalebo and Woomer, 2005).

Over fertilization creates pollution problems such as nitrate leaching especially in poorly drained soils as well as an increase in soil phosphorus content. On the other hand, under fertilization results in slow growth of knol-khol and poor quality yield (Alt and Rimmek, 1996) found the application of organic fertilizer at a rate of 15 or 60 t ha⁻¹ year⁻¹ to be insufficient to supply enough humus for holding nutrients for knol-khol growth (Abedin *et al.*, 1994)

Gutezeit (2001) reported that in high rainfall areas, where soils are acidified and highly leached, deficiencies of boron and zinc can be corrected by applying high levels of chicken manure. Another problem is that organic fertilizers have a relatively low nutrient content, thus large quantities of organic fertilizers are required to supply enough nutrients for optimum growth of a crop. For vegetables such as knol-khol (heavy feeder), organic fertilizers with a low nutrient content reduce growth as well as the crop yield (Lampkin, 2009).

Kedino and Shankar (2009) conducted a field experiment during the year 2006-07 in Nagaland, India to study the effect of organic manures and biofertilizers on growth, yield and quality of knol-khol. Nine treatments were included in the experiment. They reported that application of FYM @ 60 t/ha produces the highest plant height, knob diameter, thickness and gave the highest net return.

Kabir (2002) carried out an experiment in Bangladesh Agricultural University to find out the effects of nutrient application on knol-khol cv. early white. The treatments included in organic manures according to the yield goal (high yield goal, medium yield goal and low

yield goal) and organic manure (cowdung, poultry manure and compost). Individual treatment at full recommended rate, and treatment combinations of inorganic and organic sources (each applied at half of the recommended rates) were used. The most economic knob was obtained with MYG (Moderate yield goals) + cowdung. Protein content was the highest at HYG (High yield goals) + poultry manure, and ascorbic acid content was the highest with HYG + cowdung. Application of HYG + poultry manure was the most profitable with a benefit- cost ratio of 2.21 (Choi *et al.*, 2004)

A field experiment was conducted from June 2011 to March 2012 in Ethiopia during October 2011 to March 2012 on influence of vermicompost on kohlrabi growth. There were five treatments i.e. Vermicompost @ 25 g plant⁻¹, Vermicompost @ 50g plant⁻¹, Vermicompost @ 100 g plant⁻¹, Vermicompost @ 200 g plant⁻¹ and control (no vermicompost). Vermicompost was applied at rate of 25, 50, 100 and 200 g plant⁻¹ individually. Totally 40 plants were used for control group in which 10 plants were selected randomly. The highest leaf length (21.9 cm), leaf width (18.1 cm) , plant height (34.9 cm) and maximum number of leafs per plant (35.6) and plant root (17.39cm) was recorded at 200g of vermicompost plant⁻¹ compare to control (Getnet, 1970).

Bahadur (2004) carried out an experiment during 2001-2002 and 2002-2003 at Varanasi, Uttar Pradesh, India to evaluate the effect of organic and biofertilizers on the growth and yield of kholrabi. There were 13 treatments consisting 4 organic manures (farmyard manure, pressmud, digested sludge and vermicompost) in combination with 3 biofertilizer (Azospirillum, Vesicular arbuscular mycorrhiza (VAM) and phosphate sulubilizing microorganisms (PSM) plus the control (Recommended NPK only). All treatment received

the recommended dose of NPK (120, 60, 80 kg ha⁻¹). Pressmud + VAM recorded the highest values for all the parameters studied.

Ghuje (2007) conducted a field experiment during 2002-03 in Parbhani, Maharashtra, India to assess the effect of combined use of organic and inorganic nutrients sources on the growth and yield of knol-khol. The experiment was consisted of 10 treatments. Among the treatments 50 % PM + 50 % Vermicompost i.e. treatment T₂ gave the maximum plant height (47.56 cm), knogb circumference (10.42 cm) and knob weight (325.60 gm).

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.

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 knob yield (25850 kg/ha) was recorded in plots fertilized 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 *Brassica oleracea* var. *caulorapa* [*Brassica 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 cm²), 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 (1 925.06 cm²) and knob yield (212.21 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 Pradesh, 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 20 cm 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) studied 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 knol-khol (*Brassica oleracea* var. *gongylodes*) cv. White Vienna 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 experiment during the rabi seasons of 1995-98, in Assam, India, to study the effect of potash on growth, yield and quality of knol-khol (*Brassica caulorapa* [*Brassica oleracea* 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 uniform 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, weight 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 38.89 ton/ha associated with the highest knob weight of

380.20 g. Potash application also reduced the intensity of cracking and the minimum 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 knol-khol.

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.

Elkhom (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.

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) whereby 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.

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 form did not affect photosynthesis or stomatal transpiration.

Fink (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 by N-expert resulted in significant yield losses.

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 isothiocyanates, 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 alkyl isothiocyanates with their low threshold values and specific odour qualities.

Will and Hahndel (1989) carried out a field experiment in Germany where kohlrabi grown under polythene sheeting alone and given 0-300 kg N/ha. The added N was in a slow release form 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.* (2007) reported that N applied @ (0-160 kg/ha), P_2O_5 @ (0 or 50 kg/ha) and $ZnSO_4$ @ (0-30 kg/ha) produced maximum knol-khol i.e (238 q/ha).

During 1983-86 a field experiment was conducted by Lawande *et al.* (2008) to study the effect of N, P and K fertilizers demonstrated that yield and average stem tuber weight of 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 NH_4NO_3 + urea of equivalent N rates and were significantly higher than in unfertilized controls. Late application of fertilizer produced slightly higher yields and markedly higher crop NO_3 contents than early-season application. Applying the fertilizer in >3 split doses produced no further increases in yield but tended to increase crop NO_3 contents.

It is revealed from above review of literature that the work on the effect of different combination of organic and inorganic fertilizers on the growth and yield of knol-khol is meager in respect of Bangladesh. So, the present study was undertaken.

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

The field experiment was conducted at Dr. Purnendu Gain Field Laboratory, Khulna University, Khulna during the period from November 2014 to February 2015 to study the effect of organic and inorganic fertilizer on the growth and yield of knol-khol. Experimental field was located at 89°33' E Longitudes and 22°50' N Latitude at an altitude of 8 meters above the sea level (UNDP, 1988). Soil was sandy loam in texture having a pH of 5.56. Physical and chemical characteristics of the soil have been presented in Appendix VI.

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 scanty of rainfall during 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 (November 2014 to February 2015) have been shown in appendix (VII).

3.3 Materials used for the experiment

The variety of knol-khol selected for the experiment was Early White (DEB 170). This a hybrid variety. Seeds of the variety were collected from Siddique Bazar, Dhaka.

Characterstics of Early White variety

This is an early variety with globular, light green, smooth, tender, medium-sized knobs having creamy-white tender flesh with delicate flavour. Its plants are dwarf, leaves and stems are medium green. It has a yield potential of 150–200 q/ha. It matures 55–65 days after transplanting. Early White has dwarf plants, short tops and globular round knobs. It takes 50–60 days for knob formation (Haq, 2006).

3.4 Raising of Seedlings

Seedlings of knol-khol was raised at the Germplasm Center of Agrotechnology Discipline, Khulna University, Khulna, under special care in five seed beds each measuring 3 m x 1 m. Soil of the seed bed was ploughed and make the soil loose and friable. To inhibit the infestation of damping off disease, the seed beds were dried in the sun. Cow dung was applied to the prepared seed beds @ 5 t/ha. Ten grams of seeds of was sown in each seed bed on 25 November, 2014. The seeds were covered with fine light soil after sowing 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 favorable environmental condition for raising healthy seedlings.

3.5 Treatments of the experiment

A variety and nine different types of treatments were used in this experiment.

T₀: Control (No fertilizer)

T₁: Recommended dose of NPK (Urea, TSP, MP) (100%)

T₂: Cow dung (CD) (100%)

T₃: Vermicompost (VC) (100%)

T₄: Poultry manure (PM) (100%)

T₅: 50% NPK + 50% CD

T₆: 50% CD+ 50% VC

T₇: 50% VC + 50% PM

T₈: 25% NPK +25% CD + 25% VC + 25% PM



3.6 Layout and design of the experiment

The experiment was laid out in the Randomized Complete Block Design (RCBD) with Four replications. Whole experimental area (25.50 m x 8.55 m) was first divided into four blocks each block was divided into 9 unit plots and a total of 36 (4 x 9) unit plots were included in the experiment. The size of a unit plot was 2.25 m x 1.2 m. The distance between two plots was 50 cm and between two blocks was 75 cm. Total area used for the experiment was 218.03 square meter.

3.7 Land preparation

Land was first opened on 10 November, 2014 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 removed as from the field and big clods were broken through laddering into tiny pieces. Diazinon 57 EC 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 cow dung @ 20 t/ha for treatment T₂, @10 t/ha for treatment T₅ and T₆ & @ 5 t/ha for treatment T₈ was applied at the time of initial land preparation. According to the treatment and layout whole amount of TSP and MoP 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.

Table 1. The doses of manures and fertilizers applied in the experiment

Treatments	Dose (per hectare)	Dose (Per plot)
T ₀	Control (No fertilizer)	0 kg Cow dung+ 0 kg Urea+0 kg TSP+ 0 kg MoP
T ₁	300 kg Urea + 300 kg TSP +250 kg MoP	81 g Urea+81 g TSP+ 67.5 g MoP
T ₂	20 ton Cow dung	5.4 kg
T ₃	20 ton Vermicompost	5.4 kg
T ₄	12 ton Poultry Manure	3.24 kg
T ₅	(150+150+125) kg NPK+ 10 ton Cow dung	41 g Urea+41 g TSP+ 34 g MoP+2.7 kg Cow dung
T ₆	10 ton cow dung+ 10 ton Vermicompost	2.7 kg Cow dung + 2.7 kg Vermicompost
T ₇	10 ton Vermicompost+ 6 ton Poultry manure	2.7 kg Vermicompost + 1.62 kg Poultry manure
T ₈	(75+75+62.5)kg NPK+5 ton CD+5ton VC+ 3ton PM	21 g Urea+21 g TSP +17 g MoP+1.35 kg CD+1.35 kg VC +0.82 kg PM

3.9 Transplanting of seedlings

Seedlings were transplanted in the experimental plots on December 25, 2014. Healthy and uniformed 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 45 cm x 30 cm accommodating 20 plants in each unit plot. After transplanting, the seedlings were watered immediately. Banana leaf sheath pieces were used to protect the seedlings from scorching sun. 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. Some seedlings were damaged and those were replaced. Replacement was done with healthy seedlings grown on border of plot. Gap filling was done as and when 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 days after transplanting. It was practiced by watering can until full saturation of the soil.

3.10.4 Pest management

At the time of establishment of seedling in the field the attack of soil insects was a serious problem. Dursban 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 February 19, 2015 when the edible part of the plants formed well-sized. Sharp knife was used for harvesting of the crop.

3.12. Data collection

Data was recorded from 06 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 scale. Height was measured from ground level to the tip of the largest leaf of an individual plant. Thus mean value of the six 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 6 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 the largest leaf per plant

Breadth of the 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 the largest leaf of the plant

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

3.12.6 Fresh weight of leaves per plant

Fresh weight of leaves from six plants was taken at harvest. Then the average weight of leaves per plant was recorded in gram with a beam balance.

3.12.7 Knob yield per plant

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

3.12.8 Knob yield per plot

Fresh weight of the edible part of the plot was recorded and expressed in kilograms..

3.12.9 Fresh weight of roots per plant

Fresh weight of root was measured at harvest in gram.

3.12.10 Diameter of knob per plant

Selected six knobs were sectioned vertically in the middle position with a sharp knife. The diameter of the knob was measured in centimeter with a scale as the horizontal distance from one side to another side of the sectioned knob.

3.12.11 Thickness of knob per plant

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

3.12.12 Number of lateral roots per plant

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

3.12.13 Average length of root per plant

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

3.12.14 Dry weight of leaves per plant

At first the fresh weight of leaves per plant was recorded then one hundred gram of representing fresh leaves was sun dried for three days. Then the leaves were dried in an oven at 70°C for 72 hours. Then dry weight was taken and expressed in percentage.

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 then dried in an oven at 70°C for 72 hours. Then weight the dried root and expressed in percentage.

3.12.16 Biological yield

Biological yield of a knol-khol was measured as the whole plant weight including the leaves of all the plant of a plot and biological 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 Economic yield

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

3.12.18 Harvest Index

Harvest index is the proportion of economic yield divided by biological yield. It was expressed in percentage.

3.12.19 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:

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

3.12.20 Statistical analysis

Calculated data on various parameters under study were statistically analyzed using MSTAT-C statistical 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 New Duncan's Multiple Range Test (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to investigate the effects of different organic manures and fertilizer management practices on the growth and yield of knol-khol. Results on main and combined effect of different organic manures and fertilizer management practices and their interactions have been presented and discussed in this chapter.

4.1 Plant height

The variation in plant height due to different manures and fertilizers was statistically significant in Knol-khol at 25, 35 and 45 days after transplanting (Appendix I). At 25 DAT maximum plant height was 31.50 cm found in the treatment T_1 (Recommended doses of NPK) and minimum plant height was found in the treatment T_0 (Control). In case of 35 DAT the maximum and minimum plant height was 41.49 cm and 26.95 cm for the treatments T_1 (Recommended doses of NPK) and T_0 (Control), respectively. The minimum plant height was statistically similar with the treatments T_6 (50 % Vermicompost + 50 % Cow dung), T_3 (Vermicompost), T_2 (Cow dung) and T_8 (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% Recommended doses of NPK) that is 32.20 cm, 31.50 cm, 30.55 cm and 27.13, cm respectively. The highest and lowest plant height was 45.90 cm for the treatment T_5 i.e., (50 % Cow dung + 50 % Recommended doses of NPK) and the lowest 32.65 cm was found in the treatment T_0 (Control) at 45 DAT. The variation in plant height of Knol-khol at different days after transplanting (DAT) has been represented in Appendix. I and fig 1.

Plant height is one of the important growth contributing characters for knol-khol plant. It depends on several factors like genetic makeup, nutrient availability, climate, soil, etc.

Among those, nutrient availability is one of the important factors for desirable plant height. From the result of present study it can be said that and inorganic fertilizers combinedly supplied adequate available plant nutrients for proper vegetative growth of knol-khol plants, which ultimately influenced the plant height.

Reddy and Padmaja (2005) found that combination of organic manures and inorganic fertilizers gave the highest plant height.

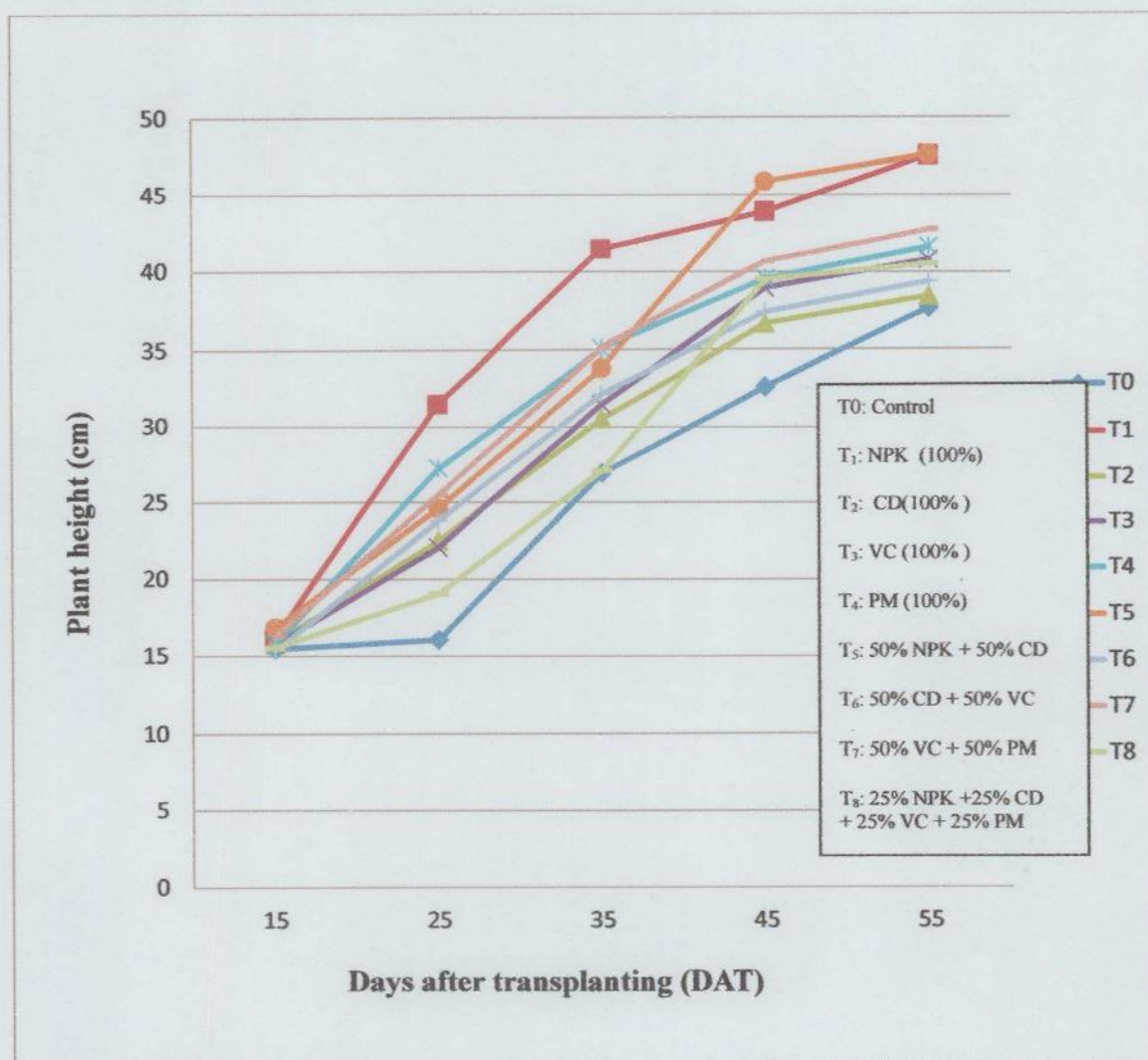


Fig. 1. Plant height of knol-khol at different days after transplanting (DAT) as influenced by manures and fertilizer.

4.2 Number of leaves per plant

The number of leaves produced per plant under different manure and fertilizers was statistically significant at 15, 25 and 55 DAT (Appendix. II) and fig. 2. The maximum number of leaves per plant (9.0) was from the treatment T₈ (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% Recommended doses of NPK) at 15 DAT and the minimum was found from the T₀ (Control) treatment at the same DAT. In 25 DAT, the treatment T₃ (Vermicompost) also produced maximum number of leaves (13.60) and minimum was found from the Control treatment i.e., (6.925) leaves. In 35 DAT, the maximum number of leaves per plant (18.25) was from the treatment T₁ (Recommended doses of NPK) and the minimum (12.45) was found from the T₀ (Control) treatment. Plants growing with vermicompost, poultry manures had maximum number of leaves (24.00) that might have enhanced the photosynthetic activities and prepared sufficient food for the growth and tuber enlargement.

Increased number of leaves per plant may be due to balanced fertilization of the crop. Eimhoit *et. al.*, (2005) found that combination of vermicompost and poultry manures gave the highest number of leaves.



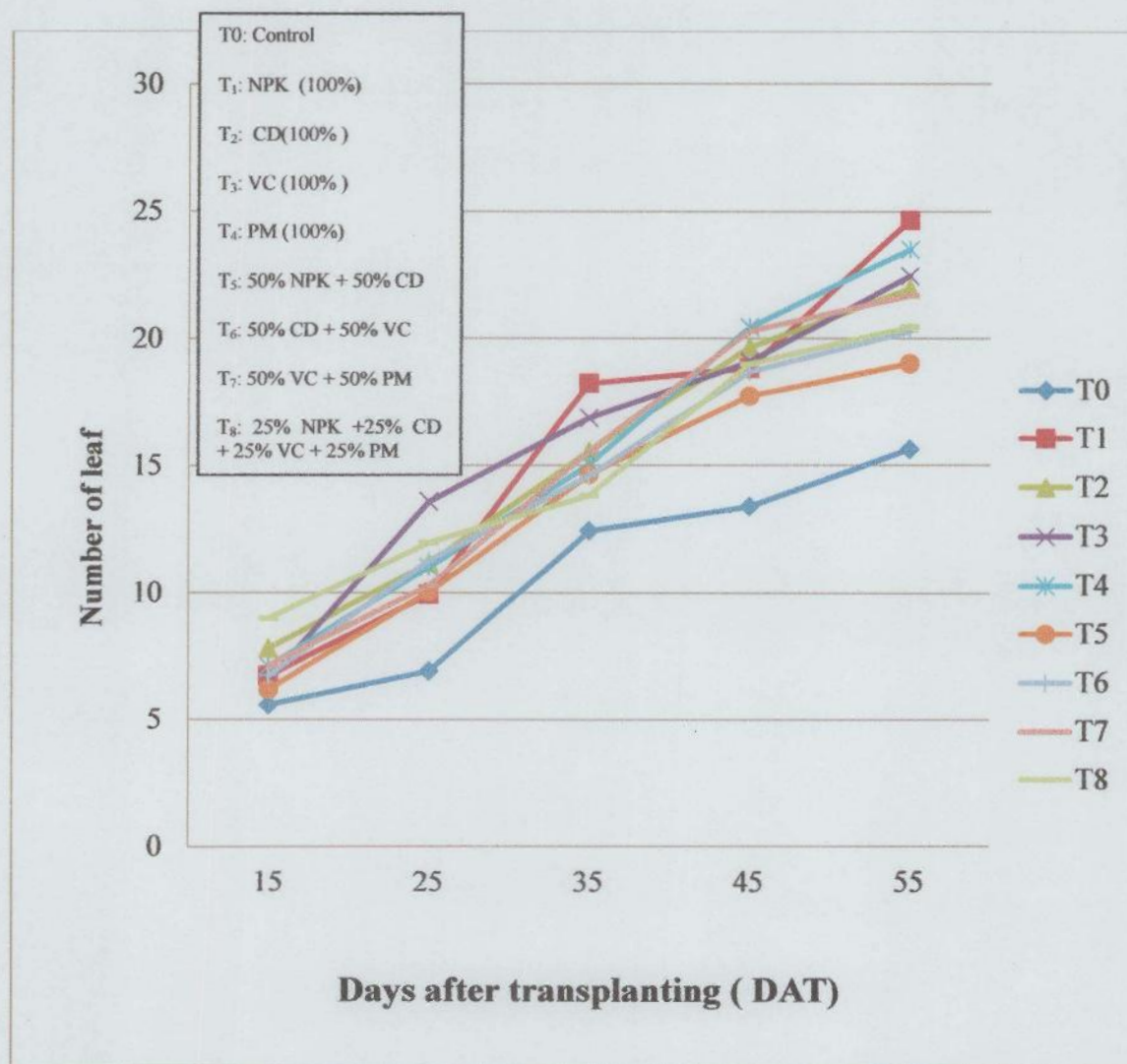


Fig. 2. Number of leaves of knol-khol at different days after transplanting as influenced by manures and fertilizers.

4.3 Length of the largest leaf

The variation in length of the largest leaf was significant in knol-khol at 25, 35 and 45 days after transplanting (DAT). At 25 DAT, the highest leaf length (30.0 cm) was found in the treatment T₃ (Vermicompost) and the lowest (18.20 cm) was found in the treatment T₀

(Control) which is statistically similar for the treatments T₆ (50 % Vermicompost + 50 % Cow dung), T₂ (Cow dung) and for the treatment T₈ (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% Recommended doses of NPK) which was 22.70 cm, 21.50 cm and 20.15 cm respectively. Then at 45 DAT, maximum leaf length was found (47.75 cm) and minimum length was (29.85 cm) from the treatment T₆ (50 % Vermicompost + 50 % Cow dung) and T₀ (Control) respectively.

The variation in length of largest leaves of Knol-khol at different days after transplanting (DAT) has been represented in Appendix III and fig. 3.

Ahmed *et al.* (2003) found that combination of poultry manures with NPK gave the largest leaf of plant in most cases.

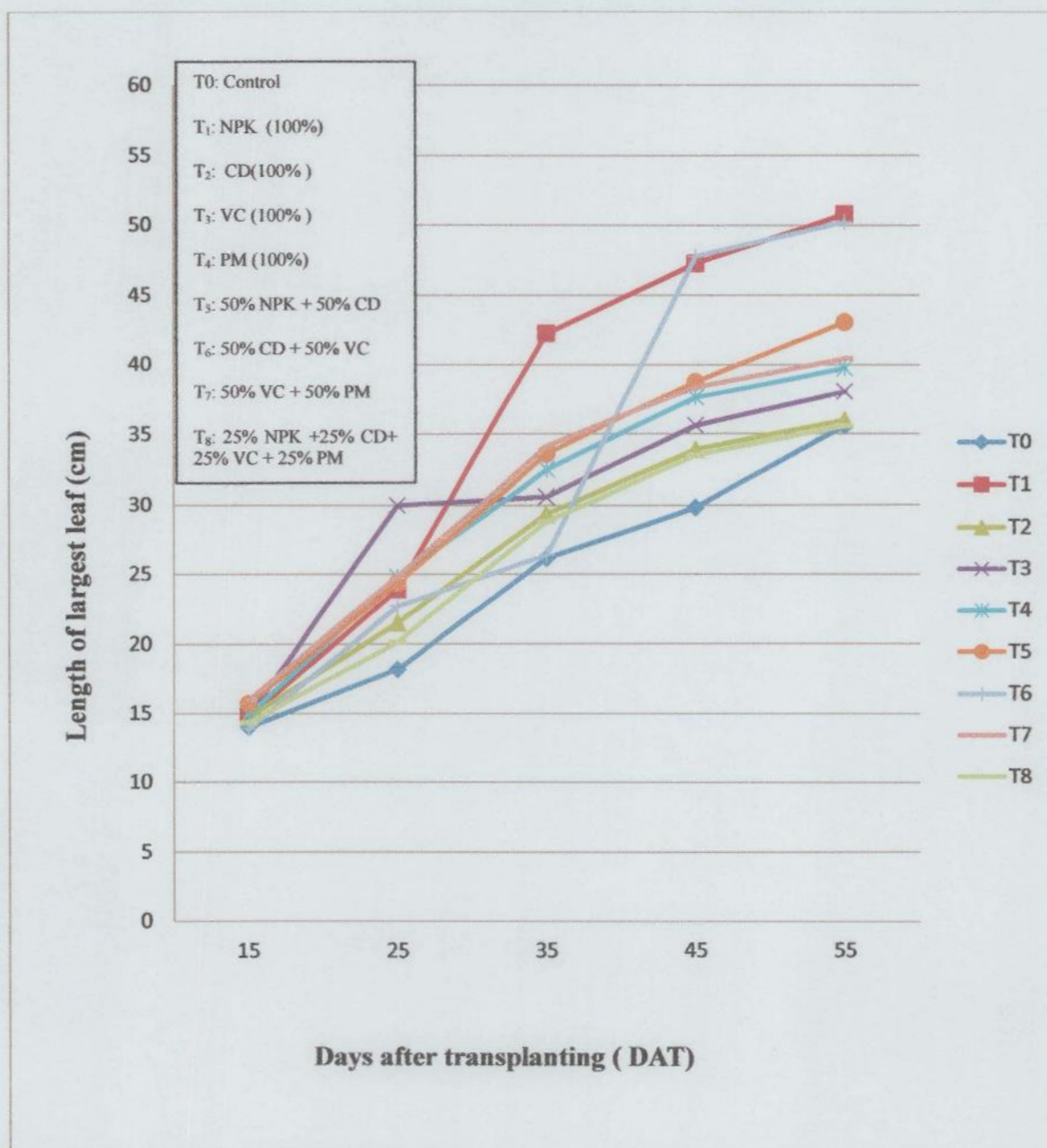


Fig. 3. Length of the largest leaf of knol-khol at different days after transplanting as influenced by manures and fertilizers.

4.4 Breadth of largest leaf per plant

Breadth of the largest leaf was found to be significant due to the application of different manures and fertilizers (Appendix. IV). Maximum breadth of the largest leaf (11.90 cm) which was statistically similar (11.85 cm) for the treatments T₁ (Recommended doses of NPK) and T₄ (Poultry manure) respectively at 25 DAT. In 45 days after transplanting (DAT) maximum breadth of largest leaf was (19.75 cm) and the minimum breadth was (12.05 cm) from the treatment T₈ (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% Recommended doses of NPK) respectively. The minimum breadth of largest leaf at 45 DAT was statistically similar for the treatments T₃ (Vermicompost), T₄ (Poultry manure), T₅ (50 % Cow dung + 50 % Recommended doses NPK) and T₇ (50 % Vermicompost + 50 % Poultry manure) and that was 14.15 cm, 14.03 cm, 12.95 cm and 12.95 cm respectively.

It increased with the passing of time and reached to the highest at 55 days after transplanting (Fig. 4). Simon (2006) found that different organic manures increases breadth of leaf of knol-khol, thus ensure photosynthesis and food production for healthy tuber production.

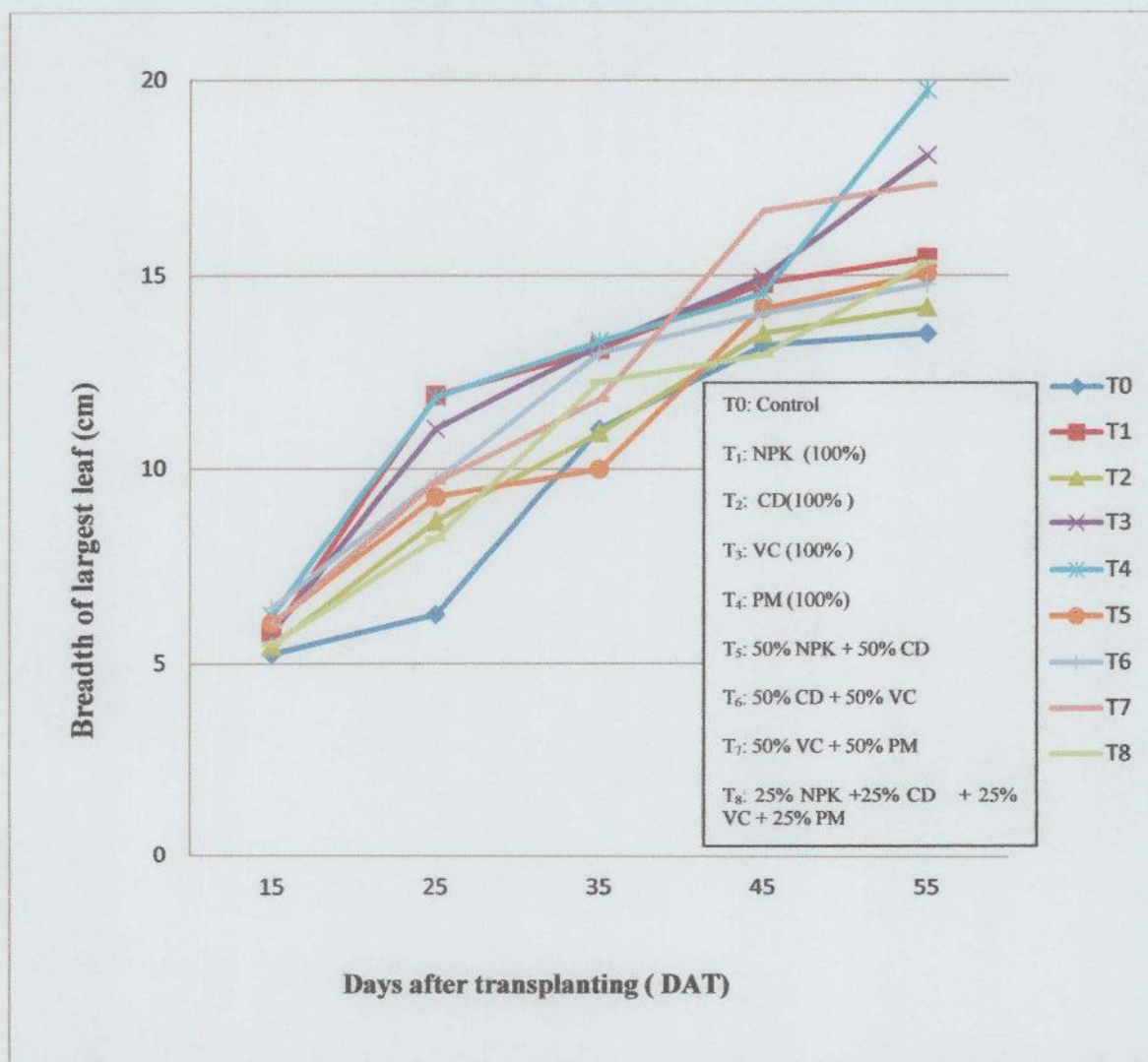


Fig. 4. Breadth of the largest leaf of knol-khol at different days after transplanting as influenced by manures and fertilizers.

4.5 Spread of plant plant canopy

Spread of plant canopy was found to be significant due to the application of different manures and fertilizers (Appendix V). It revealed that the spread of plant canopy was increased gradually with the advances of time (Fig. 5). At 25 DAT, maximum spread of plant (36.75 cm) was found from the treatment T₃ (Vermicompost) and the minimum (20.50 cm)

was found from the (Control) treatment. In case of 35 DAT, maximum spread of plant canopy was (52.50 cm) and minimum was (41.30 cm) from the treatment T₇ (T₇: 50% VC + 50% PM) and T₀ (Control), respectively. At, 45 DAT, maximum spread of plant canopy was 66.05 cm and minimum was 46.10 cm from the treatments T₂ (Cow dung) and T₀ (Control) respectively.

It was observed that the interaction effects of different organic manure and different fertilizers were significant on spread of plant canopy (Appendix V). 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.

Krupkin *et al.* (1994) and Steffen *et al.* (1994) found that combination of poultry manures with cow dung or vermicompost gave the maximum spread of plant canopy when it is grown in early rabi season.

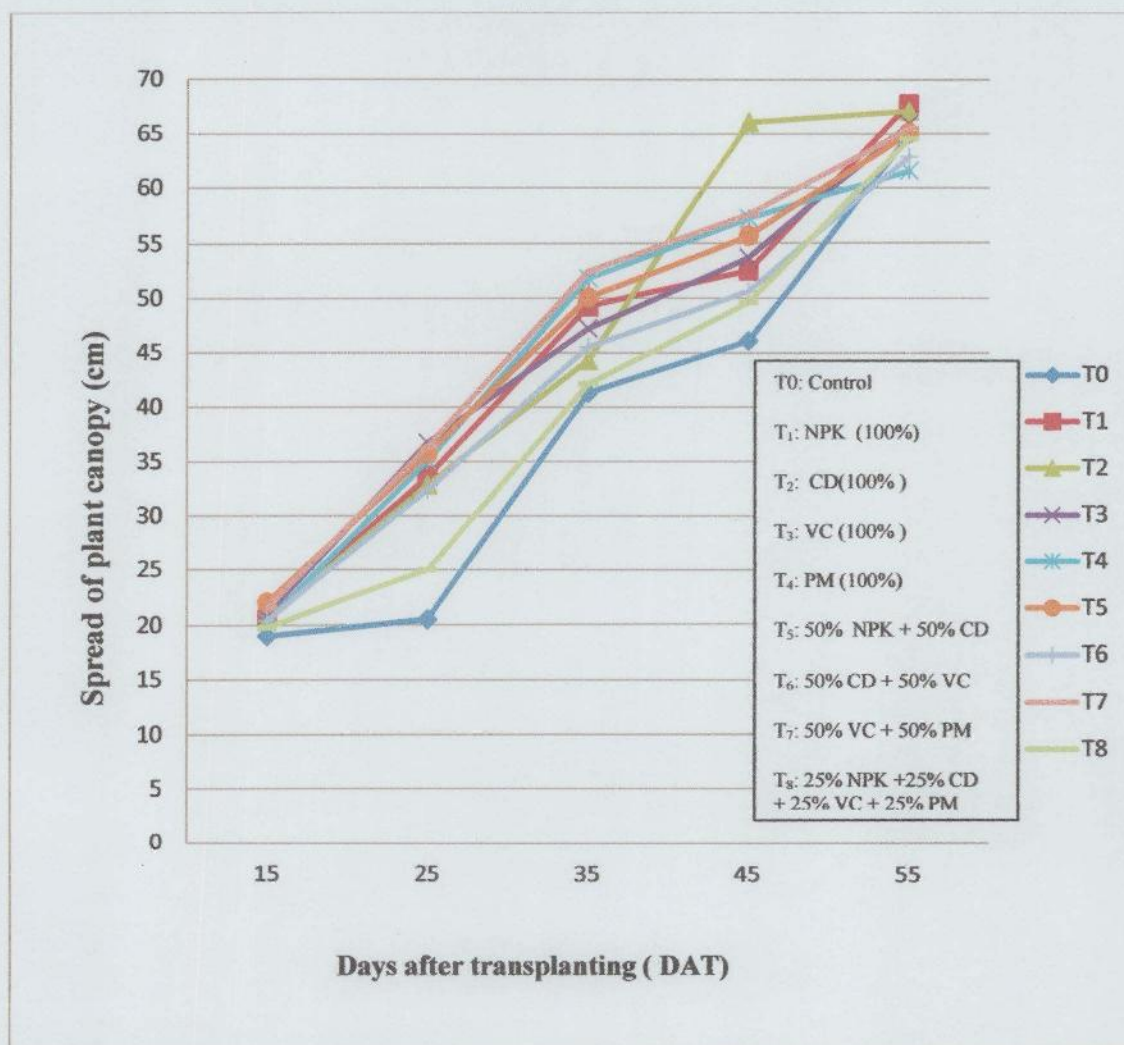


Fig. 5. Spread of plant canopy of knol-khol at different days after transplanting as influenced by manures and fertilizers.

4.6 Fresh weight of leaves per plant

Fresh weight of leaves varied significantly by the application of different manures and fertilizers. Maximum fresh weight of leaves (235 g) was recorded when the treatment T₂ i.e., (Cow dung) was applied and the minimum fresh weight (104.5 g) was found from the (Control) treatment (Table 2).

4.7 Dry weight of leaves

Effects of different manures and fertilizers were found significant in respect of dry weight of leaves per plant. Highest dry weight (23.95%) in respect of fresh weight was recorded with the treatment T₈ (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% Recommended doses of NPK) and minimum weight (19.44 %) was found in the treatment T₀ (Control) (Table 7).

4.8 Diameter of knob

Effect of different manures and fertilizers had significant influence on the diameter of knob (Table 2). The maximum diameter of knob (10.52 cm) was found with the treatment T₆ (50 % Vermicompost + 50 % Cow dung) and the minimum diameter of knob (5.25 cm) was obtained from (Control) treatment.

4.9 Thickness of knob.

Different fertilizers had significant effect on the thickness of knob (Table 2). Maximum thickness (7.5 cm) was obtained when plants produced with the treatment T₂ (Cow dung). Minimum thickness (4.25 cm) was found in the treatment T₀ (Control). As knol-khol is a short duration crops and highly feeding crops it requires readily available nutrients.

4.10 Knob yield per plant

Different organic manures and fertilizer had significant effect on fresh weight of knob per plant (Table 2). Maximum fresh weight of knob plant (328.75 g) was obtained from the treatment T₁ (Recommended doses of NPK) and the minimum fresh weight of knob (187.5 g) was found from the T₀ (Control) treatment. The maximum weight of single tuber might be

due to balanced fertilization 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 organic manure and fertilizers treatment were significant on fresh weight of knob. Fink (1998) found that inorganic fertilizers gave the highest fresh weight of knob.

4.11 Knob yield per plot

Different fertilizers had significant effect on fresh weight of knob per plant (Table 2). Maximum fresh weight of knob plant (6.575 kg) was obtained from the treatment T₁ (Recommended doses of NPK). Treatment T₄ (Poultry manure) produces second highest yield of knob per plot. The lowest weight (3.75 kg) was found from Control.

The maximum weight of knob per plot might be due to balanced fertilization 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 organic manure and fertilizers treatment were significant on fresh weight of knob per plot.

4.12 Number of lateral roots

Effect of different manures and fertilizers had non significant influence on the production of lateral roots of knol-khol. Maximum number of lateral roots (32.25) was obtained when the treatment T₈ i.e., (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% NPK) was applied and minimum (28.2) was recorded from the treatment T₀ (Control) (Table. 2)

Number of lateral roots increased gradually with balanced nutrient supply. From the above results, it was noted that different manures and synthetic fertilizers when combinedly used than it provides proper aeration, increase microbial activities as a result plant nutrients became available for better growth and development of roots which ultimately increased the number of lateral roots.

4.13 Length of roots

Effect of fertilizers revealed that there was a non significant difference among the organic manures and fertilizers in respect of average length of root (Table 2). Maximum length of root (16.85 cm) was recorded from the treatment T_1 (Recommended doses of NPK). Minimum length (14.66 cm) was found in the treatment T_0 (Control).

4.14 Fresh weight of root

Different organic manures and fertilizer had significant effect on fresh weight of roots per plant (Table 2).

Highest fresh weight of roots (16.25 g) was recorded from the treatment T_1 (Recommended doses of NPK) and the lowest (14.63 g) was found from the treatment T_0 (Control) treatment. This was due to the balanced application of fertilizers, which significantly influenced the root growth of knol-khol. Interaction effects of different organic manure and fertilizers treatment were significant in this regard.

4.15 Dry weight of roots

Variation due to the effect of application of different fertilizers in relation to percent dry weight of roots was found significant (Table 2). Maximum per cent dry weight (40.85 %) of

roots was recorded in the treatment T₇ (50 % Vermicompost + 50 % Poultry manure) and minimum per cent dry weight (21.52 %) of roots was recorded in the treatment T₀ (Control) (Table. 2).

4.16 Economic yield

Effects of different manures and fertilizers on economic 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 (21.92 t/ha) was found from treatment T₁ (T₀ Recommended doses of NPK) and minimum marketable yield (12.5 t/ha) was found from the treatment (Control) (Table 7).

It was observed that the interaction effect of different organic manures and fertilizers treatment on economic yield per hectare was statistically significant

4.17 Biological yield

Biological yield per hectare was significantly influenced by the application of different fertilizers. Maximum biological yield per hectare (36.62 ton) was produced by the plants grown under the treatment T₁ (Recommended doses of NPK). Then the second highest biological yield are 34.83 ton and 34.33 ton for the treatments of T₂ (Cow dung) and T₄ (poultry manure) which are statistically similar. While the lowest yield per hectare (21.51 ton) was found from (Control) (Table 7).

It was observed that the inorganic fertilizers gave the better result than the organic manures treatment. Study of Zhang *et al.* (2004) supports this result.

Interaction effects of different organic manure and fertilizers treatment were found to be significant for biological yield of knol-khol per hectare.

4.18 Harvest Index

Interaction effects of different organic manures and fertilizers treatment were found to be non significant in case of harvest index. Numerically the maximum harvest index was (58.80 %) and minimum was (52.06 %) for the treatment T₁ (Recommended dose of NPK) and T₈ (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% Recommended doses of NPK), respectively.

Table 2. Effect of different manures and fertilizers on growth and yield contributing characteristics of knol-khol

Treatments	Fresh weight of leaves/plant (gm)	Dry weight of leaves (gm)	Diameter of knob (cm)	Thickness of knob (cm)	Knob yield/plant (g)	Knob yield/plant (Kg)	Number of lateral roots	Length of roots (cm)	Fresh weight of root (gm)	Dry weight of roots (gm)	Economic yield (t/ha)	Biological Yield (t/ha)	Harvest Index (%)
T ₀	130.50 b	30.75 c	5.25 c	4.25 b	187.50 d	3.75 d	28.20	14.66	8.75 c	4.29	12.50 d	21.52 c	57.81
T ₁	201.30 a	37.85 b	9.43 ab	7.25 a	328.75 a	6.58 a	32.15	16.85	13.38 ab	4.33	21.92 a	40.08 a	59.80
T ₂	235.00 a	46.94 ab	7.80 b	7.50 a	287.50 abc	5.75 abc	29.60	16.15	13.75 ab	4.63	19.17 abc	34.83 ab	54.91
T ₃	206.30 a	37.03 b	7.85 b	6.80 a	237.50 bcd	4.75 bcd	31.90	15.80	13.13 ab	4.65	15.84 bcd	28.17 abc	56.18
T ₄	215.00 a	43.95 b	7.70 b	6.45 a	300.00 ab	6.00 ab	31.75	17.40	16.25 a	5.57	20.00 ab	34.33 ab	58.38
T ₅	218.80 a	48.25 ab	8.10 b	6.60 a	250.00 a-d	5.00 a-d	30.80	15.80	14.63 ab	5.28	16.67 abc	31.25 abc	53.64
T ₆	211.30 a	44.53 ab	10.52 a	6.15 a	262.00 a-d	5.20 a-d	31.50	15.90	13.63 ab	5.01	17.41 abc	31.59 abc	55.21
T ₇	213.80 a	40.68 b	7.95 b	6.90 a	275.00 abc	5.50 abc	32.13	15.90	13.38 ab	5.12	18.33 abc	36.62 ab	54.63
T ₈	185.10 a	50.33 a	7.55 b	6.05 a	212.50 cd	4.25 cd	32.25	15.22	13.68 bc	5.09	14.17 cd	25.84 bc	52.06
Level of significance	*	*	**	**	**	**	NS	NS	*	NS	**	*	NS
CV (%)	24.75	8.32	13.92	13.61	14.86	14.86	13.24	12.35	24.49	23.39	14.86	23.39	9.17

4.19 Economic analysis

Details of economic analyses have been shown in (Table 3). The input and overhead costs were recorded for all the treatment and calculated on per hectare basis. The total cost of production under different treatments ranged between Tk. 79809.00 to Tk. 181824.38 per hectare (Table 3). Among the treatment combinations, the variation was due to the cost of different organic manure and application of different fertilizers (organic, inorganic and organic-inorganic combination). Highest cost of production (Tk. 181824.38/ha) was involved in the treatment T₃ i.e., (Vermicompost) and the lowest Tk. 79809.00/ha was produced from treatment T₀ (Control). Because the price of vermicompost was very high and also not available. Biological return from different combinations ranged between Tk. 225000.00 to Tk. 394524.00 per hectare. Biological return was the total income through the sale of knob @ Tk. 18000 per ton at harvest. The highest biological return (Tk. 394524.00/ha) was obtained from the treatment T₁ (Recommended doses of NPK). The lowest biological return Tk. 225000.00/ha was obtained from (Control) treatment. Maximum net return was Tk. 297625/ha having a benefit cost ratio of 3.07 in the treatment combination of treatment T₁ (Recommended doses of NPK). On the other hand the lowest net return (Tk. 103205.62 .00/ha) and benefit cost ratio (0.57) were obtained from the treatment T₃ i.e., (Vermicompost).

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

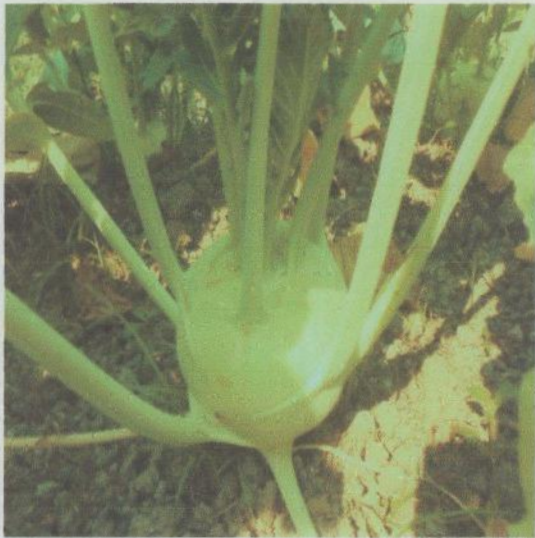
There was a wide gap between the lowest and the highest benefit cost ratio (BCR). However, the cost and return analysis was based on the crop yield as well as factor such as cost of

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.

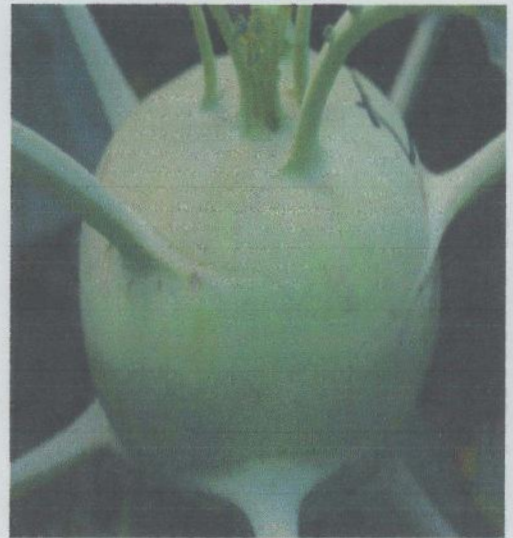
Table 3. Cost and return analysis in knol-khol production as influenced by different manures and fertilizers

Treatment	Economic yield (t/ha)	Income ('000 tk/ha)	Total cost of production ('000 tk/ha)	Net return ('000 tk/ha)	Benefit cost ratio (BCR)
T ₀	12.50 d	225.00 c	79.81	145.20 cd	1.82 b
T ₁	21.92 a	394.52 a	96.90	297.60 a	3.07 a
T ₂	19.17abc	344.97 ab	92.60	252.40 ab	2.73 a
T ₃	15.84 bcd	285.03 bc	181.82	103.20 d	0.57 c
T ₄	20.00 ab	360.00 ab	92.50	267.50 ab	2.89 a
T ₅	16.67 a-d	299.97 abc	94.39	205.60 abc	2.18 ab
T ₆	17.41 a-d	314.95 abc	138.30	176.70 bcd	1.28 bc
T ₇	18.33 abc	329.98 ab	135.51	194.50 bcd	1.44 bc
T ₈	14.17 cd	255.02 bc	112.54	147.00 cd	1.35 bc
Level of Significance	**	**		**	**
CV (%)	14.86	15.19		23.88	23.12

** Significant at 1 % level of probability



R₁T₃



R₂T₂



R₄T₁

Plate 1. Photograph of knob with different treatment combinations.

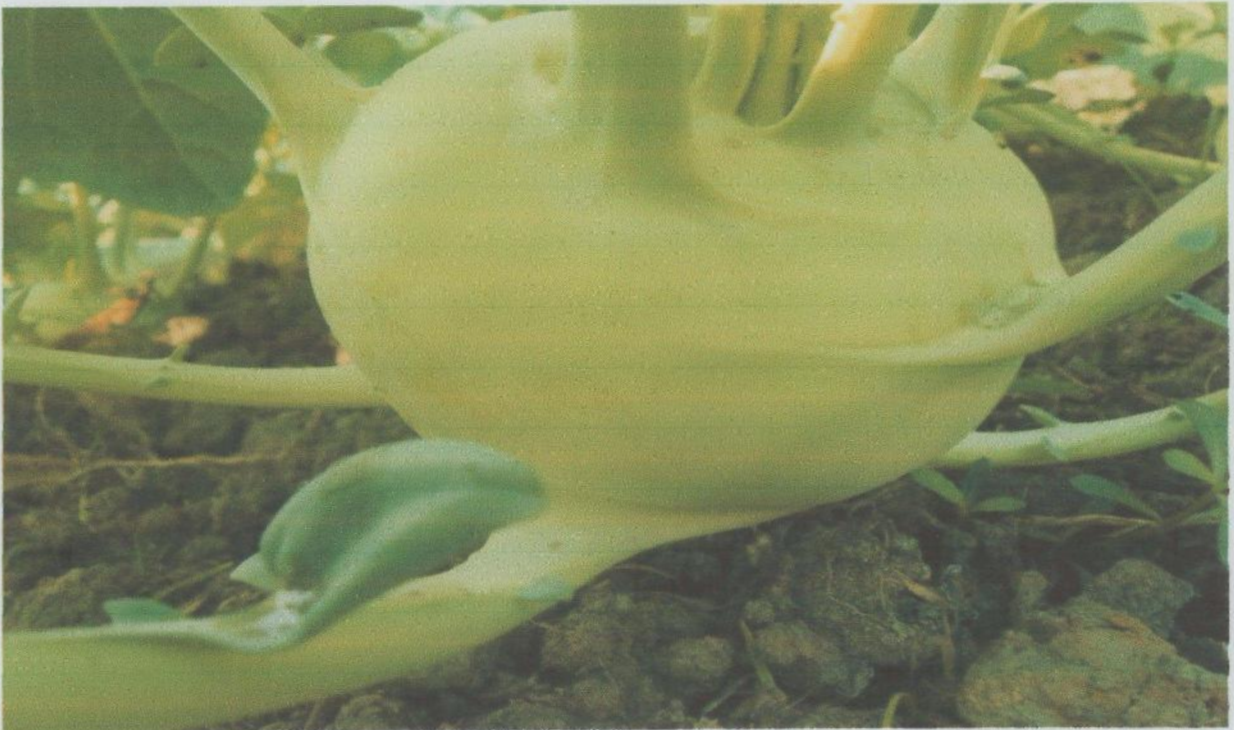




R_3T_0



R_2T_2



R_3T_4

Plate 2. Photograph of knob with different treatment combinations.



Plate 3. An overall view of experimental area.



Plate 4. A view of typical plant with knob.

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted to find out the performance of different manures and fertilizers on growth and yield of knol-khol cv. early white. The experiment was carried out at Dr. Purnendu Gain Field Laboratory, Agrotechnology Discipline, Khulna University, Khulna during the period from November 2014 to February 2015. The single factor experiment comprised of different types of fertilizers and manures viz., T₀ (Control), T₁ (Recommended doses of NPK), T₂ (Cow dung), T₃ (Vermicompost), T₄ (Poultry manure compost), T₅ (50 % Cow dung + 50 % Recommended doses of fertilizer), T₆ (50% Vermicompost + 50% Cow dung), T₇ (50% Vermicompost + 50 % Poultry manure), T₈ (25% Cow dung + 25% Vermicompost+ 25% Poultry manure + 25% Recommended doses NPK). Size of each unit plot was 2.25 m x 1.2 m i.e., 2.70 m². Thirty days old seedlings were transplanted on 25 December, 2014 and 20 plants were accommodated in each plot following a spacing of 45 cm x 30 cm and the crops were harvested on 19 February, 2015. From each plot, 6 plants were randomly selected and tagged with stick for collection of data. 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, biological yield per hectare, economic yields 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 New Duncan's Multiple Range Test (DMRT).

Different treatments influenced the growth and yield characters of knol-khol significantly. Maximum plant height (31.50 cm) was recorded for the treatment T₁ (Recommended doses of NPK) at 25 Days after Transplanting (DAT). In the same way minimum plant height (16.08 cm) was recorded for the treatment Control. In 35 DAT, maximum plant height (41.49 cm) was recorded for the treatment T₁ i.e., (Recommended doses of fertilizer NPK) and in the same way minimum plant height (26.95 cm) was recorded for the Control. In 45 DAT, maximum plant height (41.90 cm) was recorded for the treatment T₅ (50 % CD + 50 % NPK) and in the same way minimum plant height (32.65 cm) was recorded for the Control.

Maximum numbers of leaves per plant was recorded (9.0) for the treatment T₈ (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% Recommended doses of NPK) at 15 DAT. Whereas the minimum number of leaves (4.60) was obtained from the treatment T₀ (Control). At the 25 DAT, maximum numbers of leaves per plant was recorded (13.60) for the treatment T₃ (Vermicompost) whereas the minimum number of leaves (6.93) was obtained from the Control treatment. For 35 DAT, maximum numbers of leaves per plant was recorded (18.25) for the treatment T₁ (Recommended doses of NPK) whereas the minimum number of leaves (12.45) was obtained from the Control.

Result showed that effect of different manures and fertilizers on spread of plant were also remarkable and statistically significant at 25, 35 and 45 DAT. The highest spread of plant canopy (36.40 cm) was observed from the treatment combination of T₇ (50 % Vermicompost + 50 % Poultry manure) and minimum spread (20.50 cm) was found in the treatment T₀

(Control) at the 25 DAT. In 35 DAT highest spread of plant (52.50 cm) was observed from the treatment combination of T₇ i.e., (50 % Vermicompost +50 % Poultry manure) and minimum spread (41.30 cm) was found in the treatment combination of T₀ (Control).

Maximum length and breadth of the largest leaf per plant were significantly influenced by manures and fertilizers. At 25 DAT maximum length was 30.0 cm and minimum length was 18.20 cm at the treatment T₃ (Vermicompost) and control respectively. At, 35 DAT, maximum length was 42.25 cm and minimum was 26.15 cm for the treatment T₁ (Recommended doses of NPK) and T₀ (Control) respectively. Again, at 45 DAT, maximum length was 47.75 cm and minimum was 29.85 cm for the treatment T₆ (50 % Vermicompost + 50 % Cow dung) and control respectively. Breadth of the largest leaf at 25 DAT, maximum was 11.90 cm and minimum 6.28 cm for the treatment T₁ (Recommended doses of NPK) and control T₀ respectively. At 45 DAT, maximum was 19.75 cm and minimum 12.05 cm for the treatment T₈ (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% Recommended doses of NPK) and control treatment respectively.

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 single effect as well as combined effect of the treatment. Maximum dry weight of leaves 23.93% by the treatment T₈ (25% Cow dung+ 25% Vermicompost+ 25% Poultry manure + 25% Recommended doses of NPK) and roots 40.08% in the treatment T₇ (50 % Vermicompost + 50 % Poultry manure). Whereas the minimum dry weight of leaves and roots was 19.44 % and 21.42 % for the treatment T₀ (Control).

Maximum diameter of knob per plant (10.52 cm) and maximum thickness of knob per plant (7.50 cm) were observed from the treatment T₆ (50 % Vermicompost + 50 % Cow dung) and T₂ (Cow dung). Whereas, the minimum diameter of knob per plant (5.25 cm) and minimum thickness of knob per plant (4.25 cm) were recorded with the treatment T₀ i.e., (Control).

Highest average length of root per plant (16.85 cm) and the highest number of roots per plant (32.25) was found from the treatment T₁ (Recommended doses of NPK) and T₈ i.e., (25% CD+ 25% VC+ 25% Poultry manure + 25% NPK) and the lowest average length of root per plant (14.43 cm) and the lowest number of roots per plant (28.20) was observed from the control treatment.

Maximum fresh weight of leaves per plant (235.00 gm), maximum weight of knob per plant (328.75g) and maximum fresh weight of root per plant (16.25 g) were observed in the treatment T₂ i.e., (Cow dung) and T₁ i.e., (NPK) and treatment T₄ i.e., (Poultry manure) respectively. Whereas minimum fresh weight of leaves 130.50 g, minimum fresh weight of knob (187.50 g) were recorded from the treatment (control), and minimum fresh weight of roots per plant was (7.75 gm) also from the control.

Biological yield and economic yield were significantly influenced by manures and fertilizer management practices. The highest biological yield per (40.08 t/ha), economic yield (21.92 t/ha) were obtained from the treatment T₁ (Recommended doses of NPK). Minimum biological yields per hectare (21.51 t) and economic yield per hectare (12.50 t) were measured from the control treatment.

The treatment T₁ (Recommended doses of NPK) i.e., yielded significantly highest benefit cost ratio (3.07) which was statistically similar with the treatment T₄ (Poultry manure) and T₂

(Cow dung). The minimum benefit cost ratio (0.57) was obtained from the treatment T₃ (Vermicompost) which indicates that high cost of vermicompost affect net return severely. Although recommended doses of NPK produced maximum Benefit cost ratio, the treatment T₄ (Poultry manure) and T₂ (Cow dung) are very close to T₁ (Recommended doses of NPK) and statistically similar. So, we can consider the treatment T₄ (Poultry manure) and T₂ (Cow dung) for our soil health, environmental and ecological aspects.

From the present study the following conclusion could be made :

- ❑ From the point of economic yield, it is observed that higher yield could be obtained by cultivating the knol-khol variety Early White using inorganic fertilizers under Khulna region of Bangladesh.
- ❑ Although recommended doses of NPK produced maximum benefit cost ratio, the treatment T₄ (Poultry manure) and T₂ (Cow dung) are very close to T₁ (Recommended doses of NPK) and also statistically similar.
- ❑ So, we can consider the treatment T₄ (Poultry manure) and T₂ (Cow dung) for our soil health, environmental benefits and ecological safety.
- ❑ Further investigation may be carried out in different agro ecological zones of Bangladesh before giving final recommendation.

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Appendix I. Effect of different combinations of manures and fertilizers on plant height of knol-khol at different days after transplanting (DAT)

Treatments	Plant Height (cm)				
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT
T ₀	14.45	16.08 d	26.95 b	32.65 c	37.65
T ₁	16.20	31.50 a	41.49 a	43.95 ab	47.60
T ₂	15.90	22.50 bc	30.55 b	36.65 bc	38.42
T ₃	15.75	22.08 bcd	31.50 b	38.95 bc	40.83
T ₄	15.80	27.25 ab	35.08 ab	39.55 bc	41.68
T ₅	16.85	24.60 bc	33.85 ab	45.90 a	47.65
T ₆	15.35	23.80 bc	32.20 b	37.40 bc	39.38
T ₇	16.30	25.55 ab	35.15 ab	40.70 abc	42.78
T ₈	15.55	19.05 cd	27.13 b	39.50 bc	40.55
Level of Significance	NS	**	**	**	NS
CV (%)	11.48	13.95	9.17	11.25	11.73

** Significant at 1 % level of probability

NS – Non Significant

T ₀ : Control	
T ₁ : NPK (100%)	T ₅ : 50% NPK + 50% CD
T ₂ : CD(100%)	T ₆ : 50% CD + 50% VC
T ₃ : VC (100%)	T ₇ : 50% VC + 50% PM
T ₄ : PM (100%)	T ₈ : 25% NPK +25% CD + 25% VC + 25% PM

Appendix II. Effect of different combinations of manures and fertilizers on number of leaves of knol-khol at different days after transplanting

Treatments	Number of leaves per plant				
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT
T ₀	5.60 d	6.93 c	12.45 d	13.40	15.63
T ₁	6.75 bc	9.95 b	18.25 a	18.85	24.68
T ₂	7.82 b	11.20 ab	15.55 abc	19.65	21.95
T ₃	6.55 c	13.60 a	16.85 ab	19.10	22.45
T ₄	7.10 bc	11.05 ab	15.05 bcd	20.45	23.50
T ₅	6.20 c	10.05 b	14.65 bcd	17.75	19.03
T ₆	6.75 bc	11.30 ab	14.60 bcd	18.70	20.28
T ₇	7.15 bc	10.30 b	15.55 bcd	20.30	21.03
T ₈	9.00 a	12.00 ab	13.83 cd	19.00	20.48
Level of Significance	**	**	**	NS	NS
CV (%)	8.38	11.37	9.17	16.53	15.29

** Significant at 1 % level of probability

NS – Non significant

T ₀ : Control	
T ₁ : NPK (100%)	T ₅ : 50% NPK + 50% CD
T ₂ : CD(100%)	T ₆ : 50% CD + 50% VC
T ₃ : VC (100%)	T ₇ : 50% VC + 50% PM
T ₄ : PM (100%)	T ₈ : 25% NPK +25% CD + 25% VC + 25% PM

Appendix III. Effect of different combinations of manures and fertilizers on length of largest leaf of knol-khol at different days after transplanting

Treatments	Length of largest leaf (cm) per plant				
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT
T ₀	14.00	18.20 b	26.15 c	29.85 c	35.58
T ₁	14.78	23.90 ab	42.25 a	47.25 b	50.80
T ₂	14.75	21.50 b	29.40 bc	33.90 bc	35.98
T ₃	14.80	30.00 a	30.60 bc	35.60 bc	38.10
T ₄	14.90	24.80 ab	32.50 bc	37.65 b	39.78
T ₅	15.70	24.35 ab	33.60 b	38.80 b	43.08
T ₆	13.90	22.70 b	26.40 c	47.75 a	50.25
T ₇	15.95	24.85 ab	34.15 b	38.40 b	40.45
T ₈	14.35	20.15 b	28.83 bc	35.50 bc	36.02
Level of Significance	NS	**	**	**	NS
CV (%)	10.78	13.33	10.20	9.02	11.44

** Significant at 1 % level of probability

NS – Non Significant

T ₀ : Control	
T ₁ : NPK (100%)	T ₅ : 50% NPK + 50% CD
T ₂ : CD(100%)	T ₆ : 50% CD + 50% VC
T ₃ : VC (100%)	T ₇ : 50% VC + 50% PM
T ₄ : PM (100%)	T ₈ : 25% NPK +25% CD + 25% VC + 25% PM

Appendix IV. Effect of different combinations of manures and fertilizers on breadth of largest leaf of knol-khol at different days after transplanting

Treatments	Breadth of largest leaf (cm) per plant				
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT
T ₀	5.25	6.28 c	11.04	13.20	13.50 d
T ₁	5.75	11.90 a	13.10	14.80	15.45 bcd
T ₂	5.45	8.65 ab	10.95	13.50	14.18 cd
T ₃	5.80	11.05 ab	13.20	14.95	18.05 ab
T ₄	6.25	11.85 a	13.30	14.55	19.75 a
T ₅	6.05	9.25 ab	10.00	14.15	15.05 bcd
T ₆	6.45	9.70 ab	13.00	14.03	14.78 bcd
T ₇	6.00	9.65 ab	11.80	16.65	17.30 abc
T ₈	5.50	8.20 bc	12.25	12.95	15.32 bcd
Level of Significance	NS	**	NS	NS	**
CV (%)	13.9	17.13	11.23	12.68	10.25

** Significant at 1 % level of probability
NS – Non Significant

T ₀ : Control	
T ₁ : NPK (100%)	T ₅ : 50% NPK + 50% CD
T ₂ : CD(100%)	T ₆ : 50% CD + 50% VC
T ₃ : VC (100%)	T ₇ : 50% VC + 50% PM
T ₄ : PM (100%)	T ₈ : 25% NPK +25% CD + 25% VC + 25% PM

Appendix V. Effect of different combinations of manures and fertilizers on spread of canopy of knol-khol at different days after transplanting

Treatments	Spread of plant canopy (cm)				
	15 DAT	25 DAT	35 DAT	45 DAT	55 DAT
T ₀	19.05	20.50 c	41.30 d	46.10 c	64.98
T ₁	20.50	33.65 ab	49.28 abc	52.55 bc	67.75
T ₂	20.45	32.90 ab	44.30 bcd	66.05 a	67.08
T ₃	20.95	36.75 a	47.25 abc	53.70 bc	65.90
T ₄	20.35	35.10 a	51.85 ab	57.20 ab	61.60
T ₅	22.00	35.75 a	50.10 ab	55.65 bc	65.10
T ₆	20.40	32.45 ab	45.55 abcd	50.65 bc	62.93
T ₇	21.55	36.40 a	52.50 a	57.55 ab	65.50
T ₈	19.80	25.00 bc	42.11 cd	49.63 bc	64.55
Level of Significance	NS	**	*	*	NS
CV (%)	15.23	11.37	10.06	11.86	12.05

** Significant at 1 % level of probability

* Significant at 5 % level of probability

NS – non significant

T ₀ : Control	
T ₁ : NPK (100%)	T ₃ : 50% NPK + 50% CD
T ₂ : CD(100%)	T ₆ : 50% CD + 50% VC
T ₃ : VC (100%)	T ₇ : 50% VC + 50% PM
T ₄ : PM (100%)	T ₈ : 25% NPK +25% CD + 25% VC + 25% PM

Appendix VI : Chemical analysis of soil from experimental field

Parameters	Soil pH		EC (dS/m)		Organic matter (%)		Potassium (mg/ 100 g soil)		Total Nitrogen (%)		Phosphorus (μ g/ g soil)		Zinc (μ g/ g soil)		Boron (μ g/ g soil)	
	After applicati on	After harvest	After applicat ion	After harvest	After applicat ion	After harvest	After applicat ion	After harve st	After applicat ion	After harve st	After applicat ion	After harve st	After applicat ion	After harvest	After applicat ion	After harve st
T ₀	7.6	7.3	4.18	4.56	4.73	5.01	0.36	0.34	0.176	0.177	19.56	15.03	1.47	1.19	1.77	1.83
T ₁	7.4	7.2	5.32	5.07	3.69	4.70	0.46	0.48	0.178	0.178	100.90	59.13	1.69	1.27	1.78	1.73
T ₂	7.3	7.2	5.20	4.82	6.44	5.84	0.60	0.41	0.178	0.178	40.10	27.08	2.38	2.03	1.78	1.95
T ₃	7.3	7.0	5.32	5.20	6.29	5.41	0.49	0.48	0.178	0.179	48.41	37.65	2.73	1.73	2.14	1.74
T ₄	7.2	7.2	5.58	4.94	5.13	5.48	0.65	0.55	0.179	0.177	75.02	68.33	2.62	2.21	2.45	2.54
T ₅	7.5	7.3	3.80	3.93	5.44	5.43	0.39	0.34	0.172	0.174	34.00	37.54	1.55	1.33	1.61	1.95
T ₆	7.3	7.2	3.82	4.44	5.74	6.40	0.42	0.46	0.176	0.176	31.23	51.40	2.21	2.40	2.06	2.93
T ₇	7.1	7.1	6.08	2.11	5.58	5.99	0.60	0.48	0.180	0.169	78.37	60.82	2.49	2.45	2.36	2.43
T ₈	7.2	7.1	4.44	5.58	5.43	6.41	0.47	0.46	0.177	0.179	36.22	37.52	1.82	1.98	1.85	2.06
Range (Min. to Max.)	7.1-7.6	7-7.3	3.80- 6.08	2.11- 5.58	3.69- 6.44	4.70- 6.41	0.36- 0.60	0.34- 0.55	0.172- 0.180	0.169 - 0.179	19.56- 100.90	15.03 - 59.13	1.47- 2.73	1.19- 2.45	1.61- 2.45	1.73- 2.93
Average	7.32	7.18	4.97	4.52	5.39	5.63	0.49	0.39	1.59	0.176	51.34	43.83	2.11	1.84	1.98	2.13

Appendex VII. Mean monthly maximum and minimum temperature, relative humidity, sunshine and total rainfall in the study area during November 2014 to February 2015

Year	Months	Air temperature (°C)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hrs)
		Monthly average Maximum	Monthly average Minimum			
2014	November	30.4	18.2	76	00	8.25
	December	27.0	15.0	79	00	5.98
2015	January	24.0	12.6	82	00	5.23
	February	27.7	15.2	75	24	7.35

Source : Bangladesh Metrological Department, Gollamari, Khulna, Bangladesh .