GROWTH AND YIELD OF KOHLRABI AS INFLUENCED BY FERTILIZERS AND MULCHES

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CERTIFICATE

This is to certify that the thesis entitled ***"GROWTH AND YIELD OF KOHLRABI AS INFLUENCED BY FERTILIZERS AND MULCHES"*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***HORTICULTURE,*** *embodies the results of a piece of bona fide research work carried out by* ***NUSRAT JAMIL,*** *Registration. No.* ***11-04259*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated: June '17

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The Author

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ABSTRACT

The field experiment was conducted during the period of November 2016 to January 2017 at Horticulture farm of Sher-e-Bangla Agricultural University Dhaka-1207, Bangladesh. Four levels of organic and inorganic fertilizers viz., F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of poultry manure; and three levels of mulches i.e. M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch were used in the experiment. Result indicated that the vegetative growth of kohlrabi i.e. plants height (cm), number of leaves plant^{-1}, knob diameter (cm), knob weight with leaves (g), knob weight without leaves (g), root length (cm), and yield plot^{-1} (kg) and yield ha^{-1} (t ha^{-1}) were highest in case of F_4 treatment and M_2 treatment. The combined effect of F_4M_2 produced the superior result for all vegetative growth and yield of kohlrabi.

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AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
cv.	Cultivar
DAT	Days after transplanting
^{0}C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
kg	Kilogram
Min	= Minimum
MP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
Wt.	Weight

CHAPTER I

INTRODUCTION

Kohlrabi (*Brassica oleraceae* var. *gongylodes*) is a member of the botanical family Brassicaceae and considered as a Cole crop. Its edible portion is enlarged stem (knob). It is well known that, kohlrabi has enormous nutritional and medicinal values due to its high contents vitamins (A, B_1, B_2, B_5, B_6 and E), minerals (Ca, Mg, Zn and Fe) and antioxidant substances which prevent the formation of cancer causing agents (Beecher,1994). Kohlrabi is widely cultivated in European and American countries. In Bangladesh, still it is grown in a very limited scattered Areas and total cultivated area is not exactly known.

Production of Kohlrabi depends on many factors such as quality of seed, variety, plant spacing, fertilizer and proper management practices. The production of Kohlrabi has not been extended much beyond the agricultural farms in Bangladesh (BBS, 2014). Kohlrabi responds greatly to major essential nutrients, like N, P, K and organic fertilizer in respect of growth and yield. In 2012-2013, Bangladesh produces 35 thousand tons of Kohlrabi per year from 7.29 thousand hectares of land with an average yield of 4.80 t ha^{-1} which is very low against the potential yield (BBS, 2014).

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 formation of protoplasm and since protoplasm is highly hydrated, the plant becomes more succulent. Normal metabolic activities can continue only in the presence of optimum level of nitrogen. The addition of nitrogen enhances vegetative growth and its deficiency leads to stunted growth with small yellow leaves and low production. Phosphorus plays a vital role in several key physiological processes, viz. photosynthesis, respiration, energy storage and transfer, cell division and cell enlargement. It stimulates root growth, blooming and fruit setting. 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 and breathing regulator and retards diseases. But potassium is not fully effective without its co-efficients such as N and P (Chandra, 1989). Deficiency of potassium may hamper various physiological processes such as, respiration, photosynthesis, chlorophyll development, and may reduce water content of leaves which is directly related to plant growth and yield. The cost of inorganic fertilizers is very high and sometimes it is not available in the market. Consequently, the farmers fail to apply inorganic fertilizer to the crop field in the optimum dose. On the other hand, the organic fertilizer is easily available to the farmers, and its cost is relatively low than the inorganic fertilizers. The crop production cost is more or less similar to organic and inorganic fertilizer (Haque, 2000).

Kohlrabi is cultivated in Bangladesh during the winter season when rainfall is scanty. Mulching and irrigation can minimize the requirement of water (Amal *et al.* 1990). Mulches also reduce the water loss from the soil by evaporation (Prihar *et al.* 1996; Amal *et al.* 1990 and Vanderwerken *et al.* 1988), conserve soil moisture and also suppress the weed growth. Mulch reduces the loss of fertilizers by eliminating downward movement during heavy rain, it is possible to reduce near about 25% amount of fertilizer (Diane, 2000). Nutrients do not leach so readily under mulches because less rainwater penetrates. Vegetables remain cleaner in mulched gardens because they have less contact with the soil. Finally, mulches can keep soils cool. So, mulching may be exploited to successful kohlrabi production.

To attaining considerable production and quality yield for any crops it is necessary to proper management including ensuring the availability of essential nutrient components. In Bangladesh population is increasing day by day. On the other hand, area under crops production is decreasing, because of the limitation of land. By the proper management of fertilizer specially organic and inorganic fertilizer management, it will be easy to grow vegetable to meet up

the requirement of food of the nation. A combination of chemical fertilizer, organic fertilizer and mulch makes a good side dressing. The chemical fertilizers give the initial boost required by young plants; organic fertilizers provide nutrients uniformly throughout the season; and mulch keeps the soil more evenly moist and the nutrients more uniformly available (Sam and Frank, 2006).

The present investigation was therefore, carried out with a view to achieving the following objectives:

i. To find out the effect of organic and inorganic fertilizer on the yield contributing characters of Kohlrabi.
ii. To study the feasibility of producing knob of kohlrabi by using mulching as an alternative to irrigation.
iii. To find out the suitable combination of organic and inorganic fertilizer with mulch material for ensuring higher Kohlrabi production.

CHAPTER II

REVIEW OF LITERATURES

Vegetative growth and yield of kohlrabi have been studied in various parts of the world, but a little study has been done on this crop under the agro-ecological condition of Bangladesh. However, available information pertaining to this study has been reviewed and presented in this chapter under the following heads.

2.1 Effect of fertilizers

Biswas *et al*. (2016) reported that, the effect of different salinity levels on growth, yield, yield attributes, and different parameters of germination and seedling growth of kohlrabi, Brassica oleracea var. gongylodes, a vegetable of the family Brassicaceae. This study was carried out using completely randomized design in seven replications. Experimental treatment includes five levels of salinity (3, 6, 9, 12 and 15 dSm^{-1}) along with control. Highest germination energy (56.79%), shoot length (4.84 cm), root length (3.46 cm) and dry weight of seedling (75.88 mg) were observed in control which were statistically similar to 3 dSm-1 (50%, 4.81cm, 3.36 cm and 69.29 mg respectively). The highly decreased germination percentage (46.79%), root length (2.17 cm) and dry weight of seedling (52.57 mg) were observed in 15 dSm^{-1} salinity level compared to their control values which was statistically similar to 12 dSm^{-1} salinity level. In case of pot study, the highest leaf number $plant^{-1}$ (15) and leaf width (15.31 cm) were obtained from control condition. Moreover, highest diameter of knob (9.04 cm), dry weight of knob (46.86 g), fresh weight of shoot (128.3 mg) and dry weight of shoot (12.57 mg) were obtained from control condition which were statistically similar to 3 dSm^{-1} (8.19 cm, 36.01 g, 99.86 mg and 10.29 mg respectively), 6 dSm^{-1} (7.43 cm, 33.9 g, 104.6 mg and 10.71 mg respectively) and 9 dSm-1 (7.36 cm, 32.81 g, 124.7 mg and 11.14 mg respectively) salinity levels. Considering all the growth, yield and yield attributes observed in this study, kohlrabi was found

tolerant to salinity levels up to 9 dSm^{-1} while in respect of germination and seedling growth, it was found tolerant to salinity levels up to 3 dSm^{-1}.

Lošák *et al*. (2016) stated that, three treatments were used in a two-year (2014–2015) vegetation pot experiment with kohlrabi of the cv. Moravia: (1) untreated control; (2) digestate; (3) digestate + phosphorus (P). The nitrogen (N) rate was the same in treatments 2–3. There were significant differences between years in all parameters. The weight of single kohlrabi bulbs in the unfertilized control was significantly lower in both years (33.1–46.9%) than in the digestate treatment (100%). Digestate supplemented with P (treatment 3) increased the bulb yield significantly by 11.0–14.3% compared with pure digestate (treatment 2). In both years the content of bulb nitrates (mg $NO3^{-}$/kg FM (fresh matter)) was significantly the lowest in the unfertilized control (135 and 163, respectively). After digestate applications the nitrates content (mg $NO3^{-}$/kg FM) increased significantly in both years, i.e. to 315–327 (2014) and to 486–509 (2015) compared to unfertilized control. In two years the content of ascorbic acid (mg/kg FM) did not differ among the three treatments (274–288 in 2014 and 311–329 in 2015). Digestates can be recommended for kohlrabi fertilization prior to planting.

Osman and Salim (2016) reported that, under unfavorable growth conditions, the swollen tuber-like stem (marketable part) of kohlrabi plant become woody and tough which reflected on reducing its revenue. Studies on the effect of salinity on growth and quality of kohlrabi stems are extremely limited. Consequently, an outdoor pot experiment was conducted to evaluate the effect of different levels of NaCl salinity (0, 1000, 2000, 3000, 4000, 5000 and 6000 ppm) on the growth attributes of kohlrabi. Results of the preliminary experiment indicated that kohlrabi is a moderate salinity sensitive plant, where growth of the stem significantly reduced after exposing to NaCl at 3000 ppm, whereas the high reduction in growth of both leaves and stems recorded when the applied concentration of NaCl is equal or more than 4000 ppm. NaCl salt as a source of salinity stress was applied at 0 and 4000 ppm in the subsequent

main experiment to study the promotive effect of urea and seaweed extract on enhancing the growth and quality of kohlrabi plant under salinity conditions. The concentration of foliar application treatments were four levels for urea (0, 5, 10 and 15 g/l) and two levels of seaweed extract (0 and 0.5 g/l), in addition to their combinations. Application of NaCl at 4000 ppm reduced leaf f.w, leaf area, leaf area index, photosynthetic pigments and total soluble sugars (TSS), which in turn reflected on the reduction of stem f.w, as quantitative trait. In addition to that, salinity has a negative effect on the quality of kohlrabi stems, through increasing firmness value and fibre %. These negative effects of salinity on quantity and quality traits of kohlrabi plant disappeared when urea as individual applications or combined with seaweed extract were applied to the plant as foliar treatments. Moreover, most foliar treatments enhanced the stem f.w, whereas reduced firmness values and fibre %. Application of combined treatment of seaweed extract at 0.5 g/l + urea at 15 g/l maximized the quality and yield of kohlrabi swollen stems under stressed or non-stressed conditions.

Ekandjo and Ruppel (2015) stated that, Biological Nitrogen Fixation (BNF) is a process of great importance in crop production systems, as it provides additional natural sources of mineral nitrogen. BNF is catalyzed by diazotrophs that are identified by the nif operon presence comprising the nifH gene that encodes for enzyme nitrogenase synthesis. Thoroughly understanding of factors that influence diazotrophic abundance is crucial for their utilization to enhance sustainability and prevent land degradation in modern agriculture. In this study the impacts of nitrogen fertilization on diazotrophic abundance in Brassica oleracea roots and leaves was investigated in greenhouse experiments by real-time qPCR. One-way ANOVA was used to compare means and bivariate Pearson correlation tested for relationships between variables. Increased nitrogen fertilization significantly increased the nitrogen content in leaves but not in roots. No significant changes in nifH gene copy numbers nor in proportion of nifH gene copy numbers were detectable. This indicates no

effect of mineral N fertilization on the abundance of total native diazotrophic bacterial numbers in Brassica oleracea plants.

Pane *et al*. (2014) reported that, the use of compost tea (CT) is becoming interesting for applications in organic agriculture. CTs are oxygenated extracts of compost that give positive effects on the crops because contain bioactive molecules and microorganisms that improve plant growth and health. This study was carried out to evaluate the effects of CTs applied as foliar spray and drenching, respectively, on kohlrabi and lettuce cultivation. The CT tested here was originated by an aerated water-extraction of two artichoke and fennel composts. CT treatments considerably improved crop yields. CT, in fact, increased lettuce and kohlrabi commercial yields higher 24% and 32%, respectively. Due to CT, the physiological and nutritional status of the plants increased, as noticed by foliar chlorophyll content assessment measured during crop cycles. The results provided encouraging indications about the practical application of CT in horticultural organic farming system.

Antonova *et al*. (2014) stated that, a new Bulgarian kohlrabi variety Niki was studied in two systems of organic crop production: organic system without fertilizer and without pesticide treatment of the plants and organic system by use of biological fertilizer and plant protection with biological insecticides and biofungicides. The morphological characteristics: size of leaf rosette, number and weight of rosette leaves and weight, height and diameter of the kohlrabi (knob) were investigated. It was established that the new kohlrabi variety demonstrates relatively good biological potential for realization in organic crop production systems although the values recorded for almost all studied characters of the morphological characteristics were lower compared to those recorded in the conditions of conventional crop production. The phenotypical manifestations of the variety were better in organic system production with use of bioproducts for fertilization and plant protection where the values of the characters from the morphological characteristics were with 6 % to 23 % lower than those recorded in conventional production system. The values of the

studied characters of kohlrabi grown in organic production without application of products for fertilization and plant protection were with 15 % to 34 % lower compared to the recorded in the conventional production. The average weight of the kohlrabi (knob) was 1.110 kg in organic system production with use of bioproducts for fertilization and 0.897 кg by growing in organic production without application of products for fertilization and plant protection which were smaller compared to the registered knob weight in conventional production 1.256 kg.

EI-Bassiony *et al*. (2014) reported that, two cultivars of Kohlrabi plants Delikatess weisser and Burble Vina were grown in a sandy soil at the Experimental Station of the National Research Centre in El- Nubaria region, Behira Governorate on the two successive seasons of 2010/2011 and 2011/2012, to study the effect of two varieties and foliar spray of yeast, amino acid and chitosan on growth, yield and chemical content of Kohlrabi plants. Obtained results show that the highest plant height was found by cv. Delikatess weisser with foliar spray of chitosan. Meanwhile, the highest values of dry weight of leaves and tubers were found by Delikatess weisser with foliar spray of yeast. Furthermore, the highest values of leaves number, tuber height and diameter and fresh weight of tubers as well as total yield of tubers of Kohlrabi plants were recorded by cv. Burble Vina with foliar spray of chitosan. Furthermore, the highest amount of N, P and K% in leaves and N% in tubers of Kohlrabi were found by cv. Burble Vina with foliar spray of chitosan.

Saleh *et al*. (2013) stated that, two field experiments were carried out in newly reclaimed land at El-Nobaria, Northern Egypt during the two successive seasons of 2009/2010 and 2010/2011 to study the response of Kohlrabi plants (*Brassica oleracea var. Gongylodes* L.) to different fertilizer sources and application rates of Nitrogen (N). The experiments were carried out in a split plot design with three replicates. Three fertilizer sources, i.e., mineral-N fertilizer (control) as ammonium nitrate (33.5% N), organic-N as chicken manure (3.4% N) and combined application of 50% mineral-N (ammonium

nitrate) + 50% organic-N (chicken manure) were assigned to the main-plots, while three N rates, i.e., 50, 75 and 100 kg N/feddan (4200 m^2) were randomized and occupied the sub-plots. Plant growth characters (plant height, number of leaves per plant and plant fresh weight), chlorophyll content and tuber yield as well as chemical composition of edible part (tuber) were evaluated. The data showed that applying of mineral-N source ranked the first in increasing Kohlrabi yield followed by the combined application of 50% organic-N with 50% mineral-N and lastly coming organic-N source. Organically fertilized plants resulted in 83-87% yield containing less nitrate (75-68%) compared to the mineral-N source. The productivity of Kohlrabi plants fertilized by 50% mineral-N in combination with 50% organic-N was similar (approx 95-96%) to those fertilized by 100% mineral-N. Moreover, the edible part (tuber) had much vitamin C and TSS as well as less nitrate content. On the other hand, increasing the application rate of N within the range of 50 up to 100 kg N/fed. increased all studied plant growth characters, chlorophyll content and tuber yield, but the differences within application rate of 75 and 100 were not great enough to be significant. It could be concluded that, the economical and useful fertilizer source and application rate of N for the best growth, productivity and tuber quality of Kohlrabi plants is the combined source of 50% organic-N with 50% mineral-N at application rate of 75 kg N/feddan (4200 m^2).

Sultana *et al*. (2012) stated that, an experiment was carried out at the Horticulture Farm of the Bangladesh Agricultural University, Mymensingh during the period from November 2010 to January 2011 to study the effects of cowdung and potassium on growth and yield of Kohlrabi. The experiment consisted of three levels of cowdung (0, 20 and 40 t/ha) and four levels of potassium (0, 20, 50, 80 kg /ha). The experiment was laid out in randomized complete block design with three replications. All the parameters were significantly influenced by application of cowdung and potassium. The highest plant height (44.65 cm), number of leaves per plant (12.11), length of largest leaf (37.54 cm), and breadth of largest leaf (18.66 cm) were obtained from the

highest dose of cowdung and potassium applied (40 t cowdung + 80 kg K/ha) while the lowest plant height (33.64 cm), number of leaves (9.01), length of largest leaf (27.94 cm), and breadth of largest leaf (11.00 cm) were obtained from control treatment combination. The highest fresh weight of leaves (49.33 g), fresh weight of knob (328.66 g) and fresh weight of roots (66.55 g) per plant were also recorded under the treatment combination of 40 t cowdung + 80 kg K/ha, while the lowest fresh weight of leaves (22.11 g), fresh weight of knob (136.00 g) and fresh weight of roots (23.33 g) were obtained from control treatment combination. Similarly, the dry weight of leaves (19.34%), knob (15.19%) and roots (32.75%) were highest under the same treatment combination of 40 t cowdung + 80 kg K/ha and the lowest dry weight of leaves (11.71%), dry weight of knob (7.38%) and dry weight of roots (15.29%) were obtained from control treatment combination C0K0. The marketable yields of knob per plot (7.86 kg) and per hectare (39.58 tons) were also the highest under the treatment combination 40 t cowdung/ha and 80 kg potassium per hectare.

Shams (2012) reported that, field experiments were carried out on Kohlrabi (*Brassica oleracea var. gongylodes*) 'Purple Vienna cv.' at the Experimental Farm of the Faculty of Agriculture, Moshtohor, Benha University, Egypt, during the winter seasons of 2009 and 2010 under drip irrigation system. This study aimed to investigate the effect of organic manure and/or mineral N-fertilizer with or without biofertilizer inoculation on growth, yield and quality of kohlrabi knobs. Results show that using 50% mineral-N + 50% organic-N combined with biofertilizer, improved plant growth, yield and knob quality compared to other N-fertilizer systems. Inoculation of kohlrabi transplants with biofertilizer gave good results in this respect. Therefore, this treatment gave the best growth and increased total yield with the best knob quality as compared with uninoculated one. The highest content of nitrate in knobs (803.84 mg kg^{-1} DW) was recorded by using 100% mineral-N treatment (average in both seasons). Whereas, adding 100% organic-N recorded the lowest content of nitrate in knobs (387.75 mg kg^{-1} DW) average of both seasons. It is worthy to mention that nitrate concentration in tested kohlrabi knobs is still in the safe

border for human consumption. Finally, kohlrabi plant contains good amounts of antioxidants substances positioned to be at the forefront of salad plants.

Losak *et al*. (2011) stated that, in a one-year vegetation pot experiment we compared the effect of the digestate from a biogas station and mineral fertilizers on yield and quality characteristics of kohlrabi, variety Seguza. Four treatments were used as follows: 1) untreated control, 2) urea, 3) digestate, 4) urea, triple super phosphate, KCl, MgSO4. The rate of N was the same in treatments 2-4: 1.5 g N/pot. In treatment 4 the rate of P, K and Mg corresponded with the rate of these nutrients in the digestate treatment. The weight of single bulbs of the control unfertilized treatment were significantly the lowest (22.9%), as well as nitrate (6.0%) and ascorbic acid levels (66.2%) compared to the urea treatment (100%) and the other fertilized treatments. After the application of the digestate (treatment 3) and mineral fertilizers (treatment 4) the weight of single bulbs significantly increased by 27.9 and 29.2%, respectively, compared to the urea treatment. The concentration of ascorbic acid in the fertilized treatments did not differ (772-789 mg/kg) but it increased significantly compared to the unfertilized treatment (511 mg/kg). There were no significant differences between the two treatments fertilized with mineral fertilizers in the bulb nitrate conc. (678 and 641 mg $NO3^-$/kg fresh matter, respectively). After digestate application their levels decreased significantly to 228 mg $NO3^-$/kg fresh matter. Digestate treatment resulted in comparable or better yield and qualitative characteristics compared to treatment with mineral fertilizers.

Uddin *et al*. (2009) reported that, an experiment was conducted at Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October-December, 2007 to study the effect of different organic manures on growth and yield of kohlrabi plant. Three types of organic manures viz., were compared with control (no manure) in the experiment. The maximum plant height (36.50 cm), plant canopy (63.50 cm), leaf length (30.42 cm), leaf breadth (14.25 cm), fresh leaves weight per plant (131.10g), diameter of knob

(8.23cm), Knob weight (366.60 g), yield per hectare (22.90 t ha G) were found in poultry manure application. Only the maximum number of leaves (20.00) was 1 found in control treatment. On the other hand, the minimum plant height (32.25 cm), plant canopy (55.75 cm), leaf length (24.92 cm), leaf breadth (10.75 cm), fresh leaves weight per plant (86.97g), diameter of knob (7.95 cm), Knob weight (177.50 g), yield per hectare (15.40 t ha G) were found in control treatment. Minimum number of 1 leaves (14.33) was found with cowdung application.

Losák *et al*. (2008) stated that, in a greenhouse pot experiment with kohlrabi, variety Luna, we explored the joint effect of N (0.6 g N per pot = 6 kg of soil) and S in the soil (25–35–45 mg kg^{-1} of S) on yields, on N, S and $NO3^-$ content in tubers and leaves, and on alterations in the amino acids concentration in the tubers. S fertilization had no effect on tuber yields. The ranges of N content in tubers and leaves were narrow (between 1.42– 1.48 % N and 1.21–1.35 % N, respectively) and the effect of S fertilization was insignificant. S concentration in the tubers ranged between 0.59 and 0.64 % S. S fertilization had a more pronounced effect on the S concentration in leaf tissues where it increased from 0.50 to 0.58 or to 0.76 % S under the applied dose. The $NO3^-$ content was higher in tubers than in leaves. Increasing the S level in the soil significantly reduced $NO3^-$ concentrations in the tubers by 42.2–53.6 % and in the leaves by 8.8–21.7 %. Increasing the S content in the soil reduced the concentration of cysteine + methionine by 16–28 %. The values of valine, tyrosine, aspartic acid and serine were constant. In the S_0, S_1, and S_2 treatments the levels of threonine, isoleucine, leucine, arginine, the sum of essential amino acids and alanine decreased from 37 to 9 %. The histidine concentration increased with increasing S fertilization. S fertilization of kohlrabi can be recommended to stabilize the yield and reduce the undesirable $NO3^-$ contained in the parts used for consumption.

Gerendás *et al*. (2008) reported that, Glucosinolates (GSss) represent bioactive compounds of *Brassica* vegetables whose health-promoting effects merely

stem from their breakdown products, particularly the isothiocyanates (ITCs), released after hydrolysis of GSs by myrosinase. GSs are occasionally discussed as transient S reservoirs, but little is known concerning the interactive effect of S and N supply on ITC concentrations. Therefore, kohlrabi plants were grown in a pot experiment with varied S (0.00, 0.05, and 0.20 g pot^{-1}) and N (1, 2, and 4 g pot^{-1}) supplies. Plant growth exhibited a classical nutrient response curve with respect to both S and N. The ITC profile of kohlrabi tubers was dominated by methylthiobutyl ITC (11−1350 μmol (g $DM)^{-1}$), followed by sulforaphan (7−120 μmol (g $DM)^{-1}$), phenylethyl ITC (5−34 μmol (g $DM)^{-1}$), and allyl ITC (5−38 μmol (g $DM)^{-1}$), resulting from the hydrolysis of glucoerucin, glucoraphanin, gluconasturtiin, and sinigrin, respectively. The ITC profile was in agreement with reported data, and concentrations of all ITCs were substantially reduced in response to increasing N and decreasing S supply. A growth-induced dilution effect could be ruled out in most cases, and the results do not support the hypothesis that GS acts as transient reservoir with respect to S.

Biesiada *et al*. (2007) reported that, three field experiments were established in 1996-2003 in order to determine the effects of term of harvest and stage of maturity on biological value of leek, zucchini and kohlrabi. The results of experiments showed that delay the harvest date associated with considerable increment of crop yield caused the enhancement of dry matter, total and reducing sugars in leek and kohlrabi. In zucchini the fruits of smaller size contained higher amounts of dry matter and similar sugars like more developed. Advanced term of harvest appeared to be favorable for vitamin C, phosphorus and potassium content in vegetables. Changes in magnesium and calcium concentration under influence of the stage of maturity were highly dependent on plant species. Plants of kohlrabi and leeks harvested at later stage of maturity contained lower level of nitrates, but in zucchini there was observed the increment of this compound in fruits of a bigger size at harvest.

Ahmed *et al*. (2003) reported that, effect of seven different NPK levels on the growth and yield of Kohlrabi was investigated. 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^{-1}) was recorded in plots fertilized with 160-120-160 kg NPK ha^{-1}. It can be concluded that NPK @ 160-120-60 kg ha^{-1} was found to be the best fertilizer dose for the higher yield of Kohlrabi.

Fischer (1992) stated that, the aims of this study were to investigate the influence of fertiliser treatments on the chemical flavor composition of kohlrabi (*Brassica oleracea* var *gongylodes* L). Increasing nitrogen and potassium supply resulted in variable amounts of isothiocyanates, organic cyanides, sulphides and aldehydes measured by headspace analysis. Therefore, it could be suggested that the desirable flavor of kohlrabi is influenced by the level of fertilization. The effect of applied potassium on flavor quality is less clear cut. The observed inverse relationship between the amounts of flavor compounds and nitrogen supply might be utilized in production practices to obtain an optimal flavor quality.

Venter and Fritz (1979) reported that, the influence of different nitrogen doses given in different nitrogen forms on the nitrate contents of kohlrabi plants was examined in greenhouse-and field experiments. Increasing nitrogen amounts applied are followed by an increase in the nitrate contents of kohirabi. Nitrate fertilizers resulted in the highest and calcium cyanamide in the lowest nitrate contents. The nitrate contents of kohlrabi tubers sharply decreased along with prolonged period of time between the last nitrogen fertilization and harvesting. The nitrate increase was highest in the leaf stalks on the external and middle leaves but was only 20 to 25% of that level in the leaf blades and in tubers. At about the same level of nitrogen fertilization, nitrate contents of greenhouse kohlrabi cultivated at a time of year poor in light were considerably higher than those of field grown kohlrabi in summertime.

2.2 Effect of mulching

Benko *et al*. (2016) stated that, during the spring growing period of kohlrabi mulching increase soil temperature that promote the faster plant growth, early maturation and higher quality. The aim of this study was to determine the impact of cultivars and mulch on yield components of four kohlrabi cultivars. Plants were grown on the mulch of straw, black and white PE-film, and on the uncovered soil. Mass of cultivars thickened stems ranged from 172.98 to 333.34 g, while the marketable yield was in the range from 1.8 to 4.5 kg/m^2. The highest proportion of unmarketable plants was found with straw mulch (54.2%), and the lowest on the uncovered soil (13.2%). The cultivation of cultivars 'Timpano', 'Opus' and 'Opimes' on black PE-film, but also on the uncovered soil could be recommended.

Žutić *et al*. (2014) reported that, considering its short vegetation period, kohlrabi is a vegetable species suitable as an intercrop in crop rotation. Application of mulch in kohlrabi production can provide a favourable microenvironment for development of plants. Research with the aim to determine the effect of mulch, compared to the bare soil, on morphological and agronomic traits of newer kohlrabi cultivars was set up during spring growing period. Five kohlrabi cultivars ('Timpano', 'Olivia', 'Opimes', 'Opus', 'Octave') and three mulches (bare soil, black and white PE-film) were tested in two factorial experiment set up according to split-plot method. In the single harvest, cultivar 'Timpano' grown on black PE-film had the highest share of marketable plants (100%) while the share of unmarketable plants varied from 3% ('Olivia') to 39% ('Opimes'). The highest diameter of swollen stems had cultivar 'Timpano' both on white and black PE-film (80 and 82 mm). Mass of swollen stem varied from 321 ('Octave') to 379 g ('Timpano'). Marketable yield was determined in range from 2.68 (uncovered soil) to 3.84 kg m^{-2} (black PE-film). Depending on the combination of cultivar and mulch, cultivar 'Timpano' on black PE-film obtained the highest yield of swollen stem (4.85 kg m^{-2}) while the lowest yield was recorded at cultivar 'Opimes' grown on uncovered soil

(1.91 kg m^{-2}). Cultivars 'Timpano' and 'Olivia' grown on black PE-film could be recommended for kohlrabi production in spring growing period.

Özer *et al*. (2015) stated that, in this study, Samsun ecological conditions in unheated plastic greenhouse cultivation possibilities and appropriate in order to determine kohlrabi varieties, cultivation was conducted during the autumn between 2008 and 2007. in Research were tested four autumn (September 1, September 15, October 1 and October 15) by 15 day interval, two hybrid varieties (Kolibri F1 ve Korist F1) and two applications (mulch and uncovered). The highest yields 2958.90 kg/da was obtained from 1 October period Korist F1 varieties grown as mulching. Depending on year, planting time and application kohlrabi varieties of ranged from plant weight 311.17 to 838.33 g, tuber weight 175.33 to 580.28 g, leaf weight 89.50 to 317.22 g, vitamin C 25.89 to 66.55 mg/100 g and yield 969.12 to 2958.90 kg/da. Examined in terms of characteristics such as plant weight, tuber weight, tuber diameter, number of leaves, leaf weight, vitamin C and yield were determined that performs better the mulch application. As a result, kohlrabi Samsun ecological conditions were identified during autumn can be cultivated successfully in unheated plastic greenhouse.

Kosterna *et al*. (2011) reported that, a field experiment was carried out in 2006-2008. The study examined the effect of soil mulching with synthetic materials (black polyethylene film, black polypropylene nonwoven 50 g m^{-2}, and black polypropylene fabric 94 g m^{-2}) on the fruit yield and quality of two melon cultivars (‘Seledyn’ and ‘Yupi’) grown in the field under the climatic conditions of central-eastern Poland. Specimens grown without mulching served as the control. The climatic conditions during the study years had a significant influence on the level of total, marketable and early yield of melon. The highest melon yield was obtained in 2007, which was characterised by the most favourable weather conditions for melon cultivation. The comparison of the cultivars showed that ‘Seledyn’ was better adapted to the climatic conditions of Poland. From cultivation, this cultivar achieved significantly

higher early and total fruit yield compared with 'Yupi'. 'Seledyn' was also characterised by a higher share of early yield of the total yield, a higher number of fruit in the early yield and a higher mean fruit weight. In turn, 'Yupi' produced a significantly higher share of marketable yield of the total yield and a higher number of marketable fruit.

Moniruzzaman *et al*. (2007) reported that, a field experiment on cauliflower (var. Rupa) was conducted in two consecutive years from November 2000 to March 2002 in sandy clay loam soil at the Agricultural Research Station, Raikhali, Rangamati Hill District to observe the effect of irrigation and mulch materials on its yield, yield attributes and profitability. Twenty combinations of treatments consisting of four levels of irrigation (no irrigation = control, irrigation at 7, irrigation at 14 and irrigation at 21 days interval) and five levels of mulching (non mulch (control), black polythene mulch, rice straw mulch, sun grass mulch and mango leaves' mulch) were used for this trial. Irrigation at 7 days interval and mulching with black polythene independently as well as in combination produced maximum values for yield attributes and marketable yield of cauliflower. The highest curd yields of 30.38 and 29.40 t ha^{-1}were obtained from 7 days irrigation interval with black polythene mulch in 2000-01 and 2001-02, respectively. The lowest curd yields of 10.50 and 10.04 t ha^{-1} were obtained from without irrigation and mulching in 2000-01 and 2001-02, respectively. Seven days interval irrigation and mulching with forest leaves (mango leaves) in combination gave the highest benefit cost ratio (6.51) closely followed by 14 days interval irrigation with the same mulch (6.48). But maximum marginal rate of return (1156.89%) was recorded from the combination of 14 days interval irrigation and mulching by mango leaves followed by irrigation at 21 days interval with the same type of mulch (936.92%).

Streck *et al*. (1995) stated that, the effect of soil mulching with transparent, black, white, and co-extruded white-on-black polyethylene sheets on soil temperature and tomato yield was evaluated in the Subtropical Central Region

of the Rio Grande do Sul State, Brazil. The experiment was carried out from August 21, 1994 to December 2, 1994 in a 10mx 25m nonheated plastic greenhouse located at the county of Santa Maria. Highest soil temperatures were obtained under transparent mulch. Maximum amplitude of soil temperature waves was smaller under opaque mulches. Tomato yield was not significantly affected by mulch treatments; however, a tendency of greater yield was observed for opaque mulches as compared to transparent mulch. Among opaque mulches, the highest yield was obtained from white mulches.

Farias-Larios *et al*. (1994) reported that, research was conducted to evaluate the use of plastic mulches in the production of cucumber under micro-irrigation in tropical conditions. Clear (C) plastic mulch installed on beds increased the fruit number and the yield of cucumber (*Cucumis sativus* L. cv. Fanci Pack) in comparison to unmulched (U) soil, during 1992–1993. White (W) and black (B) plastic mulches showed a moderated effect. Marketable yields of 63.3,46.2,44.8 and 21.6 t/ha were achieved under C, W, B and U treatments respectively ($P<0.05$). The plastic mulches reduced the number of days to flowering and to first harvest and increased the fruit number. It is concluded that clear plastic mulch is more adequate for tropical conditions than black or white plastic mulches.

Pessala (1993) stated that, the methods of covering the plants with fibrecloth, and a fibrecloth- and plastic-tunnel were tested with six cultivars of kohlrabi. With fibrecloth cover the yields were a little better and the growing time some days shorter. However, in the timing of yield the choice of cultivar seemed to be as important as the covering with fibrecloth. The F_1-hybrid cultivars 'Bocal', 'Korist', 'Kolpak' and 'Kolibri' had shorter growing time than the older cultivars 'Lanro' and 'Purple Vienna'.

CHAPTER III

MATERIALS AND METHODS

This chapter describes the materials and methods which were used in the field to conduct the experiment entitled "growth and yield of kohlrabi as influenced by fertilizers and mulches" during the period from November 2016 to January 2017. It comprises a short description of experimental site, soil and climate, variety, growing of the crops, experimental design and treatments and collection of data presented under the following headings.

3.1 Experimental site

The study was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. Geographically the experimental area is located at $23^0$41' N latitude and $90^0$22' E longitudes at the elevation of 8.2 m above the sea level (FAO, 1988).

3.2 Characteristics of soil

Soil of the experimental field was silty loam in texture. The soil of the experimental area belongs to the Madhupur Tract under the AEZ No. 28. Soil sample of the experimental plot was collected from a depth of 0-30 cm before conducting the experiment and analyzed in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix I.

3.3 Climate and weather

The climate of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October. Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargaon, Dhaka and presented in Appendix II.

3.4 Plating material

The “Quick Star” cultivar of Kohlrabi was used in the experiment. The seeds of the cultivar were collected from Siddique Bazar, Dhaka.

3.5 Seedbed preparation

Seedbed was prepared on November 2016 for raising seedlings of kohlrabi and the size of the seedbed was 3m×1m. For making seedbed, the soil was well ploughed to loosen friable and dried masses to obtained good tilth. Weeds, stubbles and dead roots were removed from the seedbed. Cowdung was applied to prepared seedbed. The soil was treated by Sevin 50WP @ 5kg/ha to protect the young plants from the attack of mole crickets, ants and cutworm.

3.6 Seed treatment

Seeds were treated by Provax 200WP @ 3g/1kg seeds to protect some seed borne diseases.

3.7 Seed sowing

Seeds were sown on November 2016 in the seedbed. Sowing was done thinly in lines spaced at 5 cm distance. Seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light watering by water can. Thereafter the beds were covered with dry straw to maintain required temperature and moisture. The cover of dry straw was removed immediately after emergence of seed sprout. When the seeds were germinated, shade by white polythene was provided to protect the young seedlings from scorching sunshine and rain.

3.8 Raising of seedlings

Light watering and weeding were done several times. No chemical fertilizers were applied for raising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 25 days old seedlings were transplanted into the experimental field on December 2016.

3.9 Treatment of the experiment

The experiment consisted of two factors viz., fertilizer amendment and mulching.

Factor A: Four levels of fertilizer amendment, viz.

a) **F_1:** Control
b) **F_2**: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha)
c) **F_3**: Recommended dose of poultry manure (11 t/ha),
d) **F_4:** ½ recommended doses of NPK+ ½ recommended doses of Poultry manure.

Factor B: Different mulch materials such as,

a) **M_1**: Control
b) **M_2:** White polythene mulch
c) **M_3:** Black polythene mulch

There are 12 treatment combination such as F_1M_1, F_1M_2, F_1M_3, F_2M_1, F_2M_2, F_2M_3, F_3M_1, F_3M_2, F_3M_3, F_4M_1, F_4M_2 and F_4M_3.

3.10 Design and layout of the experiment

The two-factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were distributed randomly. There were 36-unit plots altogether in the experiment. The size of each plot was 1.05 m × 1.5 m. The distance maintained between two blocks and two plots were 1 m and 0.5 m, respectively. The plots were raised up to 10 cm. In the plot with maintaining distance between row to row and plant to plant were 35 cm and 30 cm, respectively.

3.11 Land preparation

The plot selected for conducting the experiment was opened in the 1st week of December 2016 with a power tiller and left exposed to the sun for a week. After

one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil was obtained for transplanting of seedling. In order to avoid water logging due to rainfall during the study period, drainage channels were made around the land. The soil was treated with Furadan 5G @ 15 kg ha^{-1} when the plot was finally ploughed to protect the young seedlings from the attack of cut worm.

3.11.1 Application of Fertilizer

Manure and fertilizer was applied as per the treatment. Organic manure and inorganic fertilizer was used as the source of nitrogen, phosphorus and potassium. Total amount of organic manure was applied during final land preparation as per treatment.

3.11.2 Application of mulching materials

Two types of mulch materials; viz., black polythene mulch and white polythene mulch were used. Polythene sheet with small opening which was made for maintaining proper plant to plant and row to row distance before placing over the plots. These polythene mulch materials were used as per the treatments.

3.11.3 Transplanting

The seedbed was watered before uprooting the seedlings to minimize the damage of roots. Twenty-five days old healthy seedlings were transplanted at the spacing of 35 cm × 30 cm in the experimental plots on December 2016. Planting was done in the afternoon. Light irrigation was given immediately after transplanting around each seedling for their better establishment. Watering was done up to five days until they became capable of establishing on their own root system.

3.12 Intercultural operations

3.12.1 Gap filling

Very few seedlings were damaged after transplanting and new seedlings from the same stock were replaced these.

3.12.2 Weeding

The plants were kept under careful observation. Weeding was done at two times. First weeding was done two weeks after transplanting. Another weeding was done after 30 days of first weeding.

3.12.3 Irrigation

Light irrigation was given immediately after transplanting around each seedling for their better establishment. Watering was done up to five days until they become capable of establishing on their own root system. Irrigation was given by observing the soil moisture condition. Four times irrigation were done during crop period.

3.12.4 Earthing up

Earthing up was done only on un-mulched plots by taking the soil from the space between the rows at 15 days after transplanting. Earthing up was not necessary in mulched plots.

3.12.5 Insects and diseases management

The crop was attacked by cutworms, mole cricket and field cricket during the early stage of growth of seedlings in the month of December. This insect was controlled by spraying Dursban 20 EC @ 0.1%.

3.12.6 General observation

The field was frequently observed to notice any changes in plants, pest and disease attack and necessary action was taken for normal plant growth.

3.12.7 Harvesting

Whole plants with knobs were harvested at proper matured time. Main knobs were harvested when the plants formed compact knobs. The final harvesting was done on January 2017.

3.13 Collection of data

The data pertaining to following characters were recorded from five plants randomly selected from each plot except yield of knobs which was recorded plot wise. The following parameters were studied for the present experiment.

1. Plant height (cm)
2. Number of leaves per plant
3. Diameter of knob (cm)
4. Knob weight with leaves (g)
5. Knob weight without leaves (g)
6. Root length (cm)
7. Yield per plot (kg)
8. Yield per ha (t/ha)
9. Dry weight

3.14 Data collection procedure

3.14.1 Plant height

Plant height was measured from base to the tip of the longest leaf at 30, 45 days after transplanting (DAT) and harvest time. A meter scale was used to measure plant height of the plant and expressed in centimeter (cm).

3.14.2 Number of leaves per plant

Total number of leaves produced by each plant was counted at 30, 45 DAT and harvest time. The time of main knob harvesting excluding the small leaves.

3.14.3 Diameter of knob

Knob diameter was taken by using a meter scale at the final harvest. Diameter of the knob was measured at different directions and finally the average of all directions was recorded and expressed in centimeter (cm).

3.14.4 Knob weight with and without leaves

Weight of the knob was recorded including leaves and excluding leaves and expressed in gram (g).

3.14.5 Root length

Root of Kohlrabi was measured using the measuring tape and express as centimeter (cm).

3.14.6 Yield per plot

The yield per unit plot was calculated by adding the yields of all plants of each unit plot and expressed in kilogram (kg).

3.14.7 Yield per hectare

The yield of knob per hectare was calculated by conversion of the knob weight per plot and recorded in ton.

3.14.8 Dry weight

The 100 g fresh of stem, roots and leaves was taken and kept in oven. Then the dry weight of 100 g of stem, roots and leaves was calculated and expressed in gram (g).

3.15 Statistical analysis

The data collected on various parameters were statistically analyzed using SPSS (Version 20.00) to find out the statistical significance of the treatment effect. The mean values of all the treatments were calculated and analyses of variance for all the characters were performed by the p-test. The significance of the difference among the treatments and combinations of means was estimated by DMRT (Duncan's Multiple Range Test) at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter represents the results and discussions for the growth and yield of Kohlrabi as influenced by fertilizers and mulches. Data on different growth, yield contributing characters and yield of Kohlrabi were recorded. The results have been presented and discussed with the help of graphs, tables and possible interpretations given under the following headings

4.1 Plant height

With the application of fertilizers, plant height of kohlrabi showed increasing trend up to the harvest. Data showed that positively significant plant height of kohlrabi was found (Figure 1 and Appendix III, IV, V). The tallest plant of kohlrabi was recorded in the F_4 (34.27, 41.51 and 43.45 cm at 30 DAT, 45 DAT and harvesting time, respectively) treatment and the shortest plant was found in the F_1 (24.20, 30.37 and 30.97 cm at 30 DAT, 45 DAT and harvesting time, respectively) treatment. At 30 DAT F_1 and F_2 treatments were identically similar. The result might be due to the fact that fertilizer enhances the vegetative growth of kohlrabi. The present finding is agreed with the findings of Saleh *et al*. (2013). They found that plant height was significantly increased by the combined application of 50% organic-N with 50% mineral-N.

Effect of mulch materials on kohlrabi showed significant difference for the plant height (Figure 2 and Appendix III, IV, V). Plant height of kohlrabi rapidly increased from 30 DAT to 45 DAT but it increased slowly from 45 DAT to harvest. The tallest plant was recorded 30.51, 37.19 and 38.59 cm at 30 DAT, 45 DAT and harvesting time, respectively in M_2 (white mulched polythene) treatment. In case of 45 DAT M_2 treatment is closely followed by M_3 treatment. The shortest plant was found 27.12, 32.89 and 35.39 cm at 30 DAT, 45 DAT and harvesting time, respectively in M_1 treatment. In case of 30 DAT M_2 and M_3 treatments were identically similar. This might be due to that, mulch materials

helped to increase fertilizer activity which ultimately increase the vegetative growth of kohlrabi. Benko *et al.* (2016) also reported the similar finding.

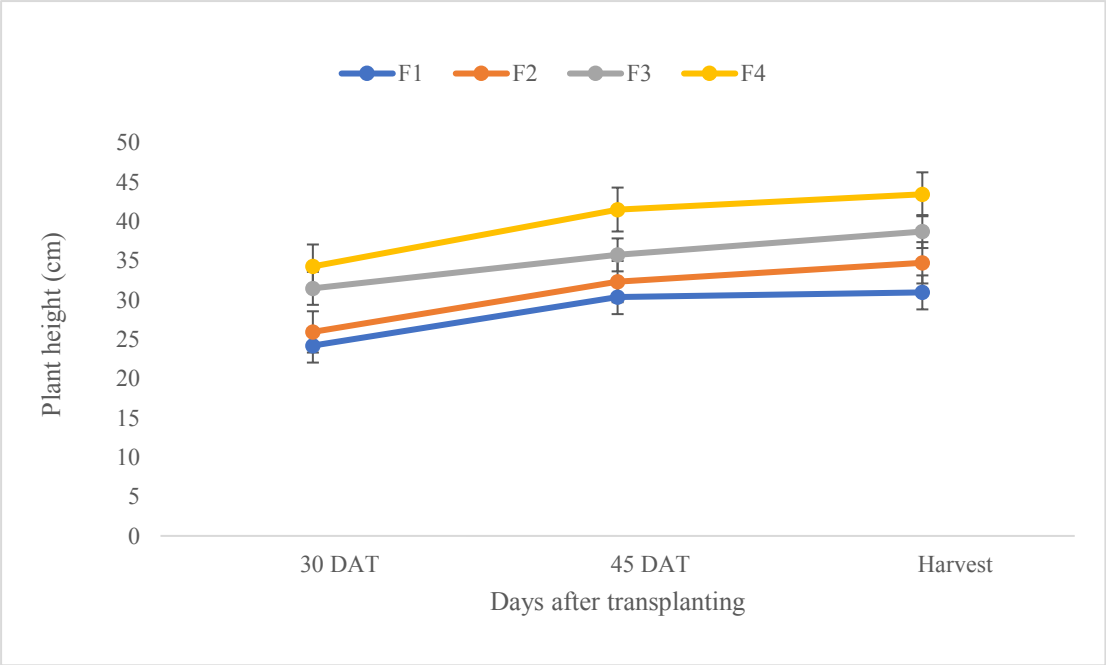

Fig. 1: Effect of fertilizers on plant height (cm) of Kohlrabi

DAT= Days after transplanting, F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of Poultry manure.

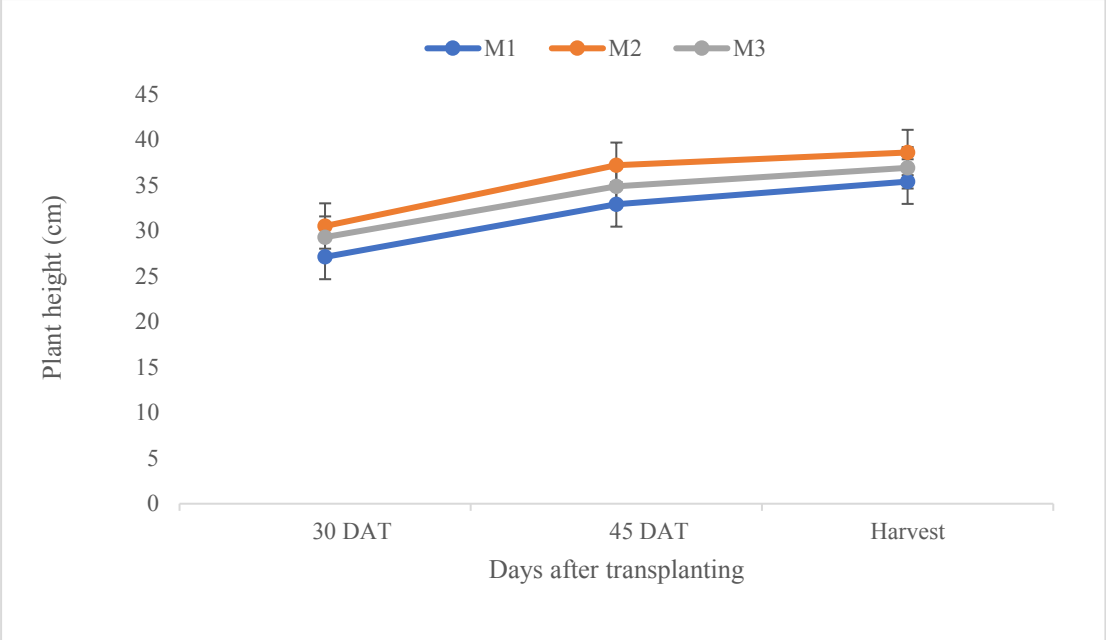

Fig. 2: Effect of mulches on plant height (cm) of Kohlrabi

DAT= Days after transplanting, M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch

The combined effect of fertilizers and mulches showed positively significant variation at all sampling dates except at 30 DAT (Table 1 and Appendix III, IV, V). The tallest plant was found 36.34, 43.60 and 45.38 cm at 30 DAT, 45 DAT and harvesting time, respectively in F_4M_2 treatment combination and the shortest plant was recorded 21.38, 28.41 and 29.31 cm at 30 DAT, 45 DAT and harvesting time, respectively in F_1M_1 treatment combination compared to other treatment combinations.

Table 1. Combined effect of fertilizers and mulches on plant height of Kohlrabi

Treatments	Plant height (cm) at		
	30 DAT	45 DAT	Harvest
F_1M_1	21.38 f	28.41 j	29.31 l
F_1M_2	24.45 ef	32.24 h	32.25 j
F_1M_3	26.78 de	30.45 i	31.35 k
F_2M_1	25.52 ef	30.30 i	33.37 i
F_2M_2	27.61 c-e	34.33 f	36.46 g
F_2M_3	24.70 ef	32.40 h	34.38 h
F_3M_1	29.27 b-e	33.40 g	37.44 f
F_3M_2	33.66 ab	38.60 d	40.29 d
F_3M_3	31.51 a-d	35.23 e	38.40 e
F_4M_1	32.30 a-c	39.46 c	41.46 c
F_4M_2	36.34 a	43.60 a	45.38 a
F_4M_3	34.18 ab	41.46 b	43.51 b
Standard Error	1.840	0.19	0.14

DAT: Days after transplanting; F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of Poultry manure; M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch

4.2 Number of leaves per plant

With the application of fertilizers, number of leaves per plant showed increasing trend up to the harvest. Data showed that, positively significant number of leaves per plant of kohlrabi was obtained (Figure 3 and Appendix VI, VII, VIII). The maximum number of leaves per plant of kohlrabi was recorded in the F_4 (12.05, 16.21 and 18.25 at 30 DAT, 45 DAT and harvest time, respectively) treatment. In case of 30 DAT F_3 and F_4 treatments were identically similar and at 45 DAT F_2 and F_3 treatments were identically similar. The minimum number of leaves per plant was found in the F_1 (9.30, 11.79 and 12.63 at 30 DAT, 45 DAT and harvest time, respectively) treatment. Similar result was obtained by Sultana *et al*. (2012) and they observed that the number of leaves were increased by application of both organic and inorganic fertilizers. This findings was also supported by Ekandjo and Ruppel (2015) and Ahmed *et al.* (2003).

Effect of mulch materials on kohlrabi showed positively significant difference for the number of leaves per plant (Figure 4 and Appendix VI, VII, VIII). The number of leaves per plant of kohlrabi rapidly increased from 30 DAT to 45

DAT. But it increased slowly from 45 DAT to harvesting time. The maximum number of leaves per plant was recorded (11.86, 15.20 and 16.80 at 30 DAT, 45 DAT and harvesting time respectively) in M_2 (white mulched polythene) treatment. M_2 treatment was closely followed by M_3 treatment. The minimum number of leaves per plant was found (9.67, 12.46, 14.20 at 30 DAT, 45 DAT and harvesting time respectively) in M_1 (control) treatment. White polythene mulch increases the growth and development of Kohlrabi. Thus the maximum number of leaves per plant was found in white mulched polythene than no mulch condition. Ozer *et al.* (2015) also reported the similar finding.

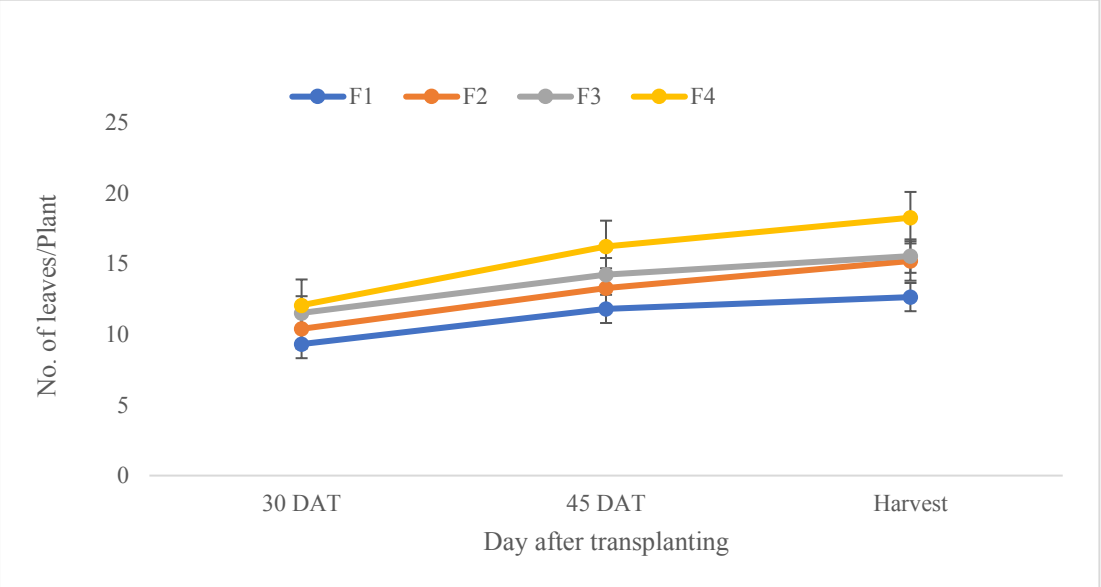

Fig. 3: Effect of fertilizers on number of leaves per plant of Kohlrabi

DAT= Days after transplanting, F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of Poultry manure.

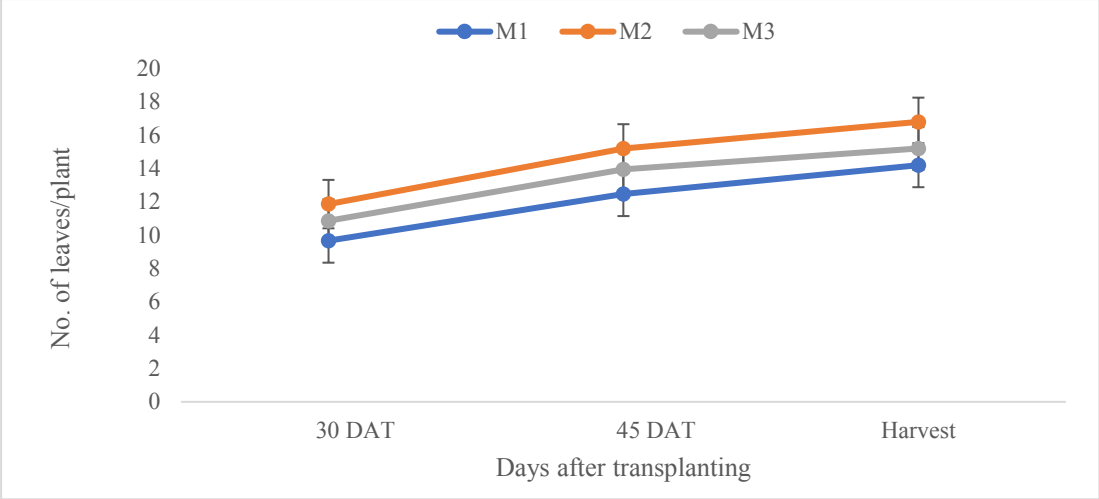

Fig. 4: Effect of mulches on number of leaves per plant of Kohlrabi

DAT: Days after transplanting; M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch

The combined effect of fertilizers and mulches showed positively significant variation at all sampling dates (Table 2 and Appendix VI, VII, VIII). At 30 DAT the maximum number of leaves per plant was found (13.40) in F_4M_2 treatment combination which was closely followed by F_3M_2 and F_4M_3 treatment combinations. At 45 DAT the maximum number of leaves per plant was found (18.18) in F_4M_2 treatment combination. At harvesting time the highest number of leaves was found (19.43) in F_4M_2 treatment combination which was closely followed by F_4M_3, F_4M_1 and F_3M_2 combinations. The minimum number of leaves per plant was recorded (8.11, 10.12 and 11.16 at 30 DAT, 45 DAT and harvesting time respectively) in F_1M_1 combination compared to other treatment combinations.

Table 2. Combined effect of fertilizers and mulches on number of leaves of Kohlrabi

Treatments	Number of leaves at		
	30 DAT	45 DAT	Harvest
F_1M_1	8.11 h	10.12 g	11.16 h
F_1M_2	10.27 ef	13.12 e	14.37 f
F_1M_3	9.53 g	12.14 f	12.36 g
F_2M_1	9.66 fg	12.35 f	14.21 f
F_2M_2	11.33 d	14.27 d	16.20 d
F_2M_3	10.15 efg	13.18 e	15.15 e
F_3M_1	10.30 ef	13.17 e	14.25 f
F_3M_2	12.63 b	15.24 c	17.19 c
F_3M_3	11.60 cd	14.22 d	15.15 e
F_4M_1	10.60 e	14.22 d	17.17 c
F_4M_2	13.40 a	18.18 a	19.43 a
F_4M_3	12.17 bc	16.24 b	18.14 b
Standard Error	0.18	0.06	0.11

DAT: Days after transplanting; F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of Poultry manure; M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch

4.3 Root length

With the application of fertilizers, root length showed positively significant variation (Table 3 and Appendix IX). The highest root length of kohlrabi (14.49 cm) was recorded in the F_4 treatment which was closely followed by F_3 treatment. The lowest root length (10.54 cm) was found in the F_1 treatment. The result might be due to the fact that N and P fertilizer enhances the length of root on Kohlrabi. Poultry manure also contains N and P which induces the root length. The present finding is agreed with the findings of Sultana *et al*. (2012)

Effect of mulch materials on kohlrabi showed positively significant difference for the root length (Table 4 and Appendix IX). The maximum root length was recorded (13.79 cm) in M_2 treatment which was closely followed by M_3 treatment. The minimum root length was found (11.66 cm) in M_1 treatment. Mulch materials ensure the optimum soil moisture for proper root development, and these conditions enhance root development as well as increase root length.

The combined effect of fertilizers and mulches showed non-significant for root length of kohlrabi (Table 5 and Appendix IX). Although having non-significant effect the highest root length was found (15.43 cm) in F_4M_2 combination. In the treatment combinations F_2M_2, F_3M_3 and F_4M_1 were identically similar. F_1M_2 and F_3M_1 combinations were also identically similar. The lowest root length was found (9.42 cm) in F_1M_1 treatment combination.

4.4 Individual knob weight with leaves

Fertilizers had a significant effect on individual knob weight with leaves of kohlrabi (Table 3 and Appendix X). The maximum value of individual knob weight with leaves (391.44 g) was recorded in F_4 treatment. The minimum value of individual knob weight with leaves (250.29 g) was found in F_1 treatment which was closely followed by F_2 treatment. This might be due to fertilizer helped to facilitate the reproductive development of kohlrabi. The findings was also supported by Losak *et al*. (2011) and Losak *et al.* (2008).

The individual knob weight with leaves varied significantly for the mulch materials (Table 4 and Appendix X). The white polythene mulch (M_2) produced statistically highest individual knob weight with leaves (347.85 g). The control treatment produced the lowest individual knob weight with leaves (304.00 g). It was closely followed by M_3 treatment. This might be due to mulch material helped to conserve soil water and increased the fertilizer activity that ultimately increased the reproductive development of kohlrabi. Kosterna *et al.* (2011) also reported the similar finding.

The combined effect of fertilizers and mulches had significant effect on individual knob weight with leaves of kohlrabi (Table 5 and Appendix X). The highest individual knob weight with leaves (442.61 g) was recorded in F_4M_2 which was identically similar with F_4M_1 treatment. In F_3M_3 combination individual knob weight with leaves (341.27 g) was recorded which was identically similar with F_4M_3 treatment. F_2M_2 and F_2M_3 treatment combinations

were also identically similar. The lowest value of individual knob weight with leaves (215.43 g) was recorded in F_1M_1 treatment combination.

4.5 Individual knob weight without leaves

With the application of fertilizers, individual knob weight without leaves showed positively significant variation (Table 3 and Appendix XI). The highest individual knob weight without leaves of kohlrabi was recorded in the F_4 (326.12 g) treatment. F_3 treatment were closely followed by F_2 treatment. The lowest individual knob weight without leaves was found in the F_1 (174.31 g) treatment. The present finding is agreed with the findings of Losak *et al.* (2011) and they stated that application of mineral fertilizers increased the weight of single knobs. Uddin *et al.* (2009) also stated that the highest knob weight were found due to the application of poultry manure. .

Effect of mulch materials on kohlrabi showed positively significant difference for the individual knob weight without leaves (Table 4 and Appendix XI). The highest individual knob weight without leaves was recorded (254.23 g) in M_2 treatment while the lowest individual knob weight without leaves was found (215.90 g) in M_1 treatment. Moniruzzaman *et al.* (2007) and Farias-Larios *et al.* (1994) also reported the similar findings.

The combined effect of fertilizers and mulches showed significant effect for individual knob weight without leaves of kohlrabi (Table 5 and Appendix XI). The highest individual knob weight without leaves was found (345.40 g) in F_4M_2 combination. F_1M_2 and F_2M_1 treatment combinations were identically similar. The lowest individual knob weight without leaves was found (147.88 g) in F_1M_1 combination which was closely followed by F_1M_3 combination.

Table 3. Effect of fertilizers on root length, individual knob weight with leaves and individual knob weight without leaves of Kohlrabi

Treatments	Root length (cm)	Individual knob weight with leaves (g)	Individual knob weight without leaves (g)
F_1	10.54 d	250.29 d	174.31 d
F_2	12.41 c	308.79 c	211.97 c
F_3	13.42 b	330.53 b	235.44 b
F_4	14.49 a	391.44 a	326.12 a
Standard Error	0.12	7.84	0.89

F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of Poultry manure.

Table 4. Effect of mulch materials on root length, individual knob weight with leaves and individual knob weight without leaves of Kohlrabi

Treatments	Root length (cm)	Individual knob weight with leaves (g)	Individual knob weight without leaves (g)
M_1	11.66 c	304.00 c	215.90 c
M_2	13.79 a	347.85 a	254.23 a
M_3	12.69 b	308.94 b	240.75 b
Standard Error	0.10	6.79	0.7748

M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch

Table 5. Combined effect of fertilizers and mulches on root length, individual knob weight with leaves and individual knob weight without leaves of Kohlrabi

Treatments	Root length (cm)	Individual knob weight with leaves (g)	Individual knob weight without leaves (g)
F_1M_1	9.42 g	215.43 f	147.88 k
F_1M_2	11.66 de	274.73 de	196.52 i
F_1M_3	10.53 f	260.70 ef	178.53 j
F_2M_1	11.46 e	295.17 cde	192.97 i
F_2M_2	13.50 c	321.77 bcd	228.33 f
F_2M_3	12.26 d	309.43 bcd	214.60 h
F_3M_1	12.20 de	298.07 cde	221.40 g
F_3M_2	14.56 b	352.27 b	246.67 d
F_3M_3	13.51 c	341.27 bc	238.27 e
F_4M_1	13.58 c	407.33 a	301.35 c
F_4M_2	15.43 a	442.61 a	345.40 a
F_4M_3	14.46 b	324.37 bc	331.60 b
Standard Error	0.21	13.49	1.57

F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of Poultry manure; M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch

4.6 Knob diameter

Fertilizers had a significant effect on Knob diameter of kohlrabi (Table 6 and Appendix XII). The highest value of knob diameter (8.37 cm) was recorded in F_4 (½ recommended doses of NPK+ ½ recommended doses of poultry manure) treatment while the lowest knob diameter (5.44 cm) was found in F_1 treatment. Poultry manure enhances its role in photosynthesis, energy storage, cell division and cell enlargement. And it also rich in N and nutrient content. As a result inorganic fertilizers and organic fertilizer (poultry manure) combinedly increases the diameter of kohlrabi. The present finding is agreed with the findings of EI-Bassiony *et al*. (2014) and Biesiada *et al*. (2007).

The knob diameter varied significantly for the mulch materials (Table 7 and Appendix XII). The white polythene mulch (M_2) produced statistically highest knob diameter (8.20 cm) while the control treatment (M_1) produced the lowest

knob diameter (5.91 cm). Zutic *et al.* (2014) and Ozer *et al.* (2015) also reported the similar finding.

The combined effect of fertilizers and mulches had non-significant effect on knob diameter of kohlrabi (Table 8 and Appendix XII). In spite of having non-significant effect the highest knob diameter (9.65 cm) was recorded in F_4M_2 combination and the lowest value of knob diameter (4.32 cm) was recorded in F_1M_1 treatment combination. Treatment F_3M_3 and F_2M_2 were identically similar. F_1M_2 and F_2M_3 also showed identically similar results.

4.7 Dry weight

Significant effect of fertilizers were observed on dry weight of 100 g of stem, roots and leaves of kohlrabi (Table 6 and Appendix XIII). The highest value of dry weight of 100 g of stem, roots and leaves (33.24 g) was recorded in F_4 (½ recommended doses of NPK+ ½ recommended doses of poultry manure) treatment while the lowest dry weight of 100 g of stem, roots and leaves (23.78 g) was found in F_1 treatment. This might be due to fertilizer helped to facilitated the dry matter production of kohlrabi. The present finding is agreed with the findings of Sultana *et al.* (2012) and Venter and Fritz (1979).

The dry weight varied significantly for the mulch materials (Table 7 and Appendix XIII). The white polythene mulch (M_2) produced statistically highest dry weight (29.60 g) while the control treatment (M_1) produced the lowest dry weight (26.62 g). Benko *et al.* (2016) also reported the similar finding.

The combined effect of fertilizers and mulches had significant effect on dry weight of kohlrabi (Table 8 and Appendix XIII). The highest dry weight of (35.23 g) was recorded in F_4M_2 treatment combination and the lowest value of dry weight (22.46 g) was recorded in F_1M_1 treatment combination.

4.8 Yield per plot

Fertilizers had a significant effect on yield per plot of kohlrabi (Table 6 and Appendix XIV). The highest value of yield per plot (5.51 kg) was recorded in F_4 (½ recommended doses of NPK+ ½ recommended doses of poultry manure) treatment while the lowest yield per plot (2.61 kg) was found in F_1 treatment. This might be due to fertilizers helped in energy storage and transfer, cell division, cell enlargement, nitrogen metabolism, enzyme activation and growth of meristematic tissue. Poultry manure also helps to provide necessary amount of N. As a result yield per plot of kohlrabi were increased. The present finding is agreed with the findings of Pane *et al.* (2014).

The yield per plot varied significantly for the different mulch materials (Table 7 and Appendix XIV). The white polythene mulch (M_2) produced statistically highest yield per plot (5.00 kg) while the control treatment (M_1) produced the lowest yield per plot (2.85 kg). This might be due to white mulches reduce the amount of water lost from the soil due to evaporation. It also aid in evenly distributing moisture to the soil which reduce plant stress. As a result yield of kohlrabi increased. Pessala (1993) also reported the similar finding.

The combined effect of fertilizers and mulches had significant effect on the yield per plot of kohlrabi (Table 8 and Appendix XIV). The highest yield per plot (6.57 kg) was recorded in F_4M_2 treatment combination which was closely followed by F_4M_3 and F_3M_2 treatment combinations. F_4M_3 and F_3M_2 treatment combinations were identically similar. The lowest value of yield per plot (1.23 kg) was recorded in F_1M_1 treatment combinations.

Table 6. Effect of fertilizers on knob diameter, dry weight and yield per plot of Kohlrabi

Treatments	knob diameter (cm)	Dry weight (g)	Yield plot^{-1} (kg)
F_1	5.44 d	23.78 d	2.61 d
F_2	6.58 c	25.98 c	3.20 c
F_3	7.83 b	29.44 b	4.48 b
F_4	8.37 a	33.24 a	5.51 a
Standard Error	0.09	0.12	0.04

F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of Poultry manure.

Table 7. Effect of mulch materials on knob diameter, dry weight and yield per plot of Kohlrabi

Treatments	Knob diameter (cm)	Dry weight (g)	Yield plot^{-1} (kg)
M_1	5.91 c	26.62 c	2.85 c
M_2	8.20 a	29.60 a	5.00 a
M_3	7.05 b	28.11 b	4.01 b
Standard Error	0.07	0.34	0.04

M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch

Table 8. Combined effect of fertilizers and mulches on knob diameter, dry weight and yield per plot of Kohlrabi

Treatments	Knob diameter (cm)	Dry weight (g)	Yield per plot (kg)
F_1M_1	4.32 g	22.46 i	1.23 i
F_1M_2	6.56 e	25.44 f	3.70 e
F_1M_3	5.42 f	23.45 h	2.89 g
F_2M_1	5.33 f	24.24 g	2.13 h
F_2M_2	7.85 c	27.17 e	4.22 d
F_2M_3	6.56 e	26.53 e	3.26 f
F_3M_1	6.85 de	28.51 d	3.37 f
F_3M_2	8.72 b	30.56 c	5.50 b
F_3M_3	7.92 c	29.24 d	4.59 c
F_4M_1	7.14 d	31.27 c	4.69 c
F_4M_2	9.65 a	35.23 a	6.57 a
F_4M_3	8.31 bc	33.23 b	5.28 b
Standard Error	0.15	0.20	0.08

F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of Poultry manure; M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch

4.9 Yield per hectare

With the application of both organic and inorganic fertilizers, yield per hectare showed positively significant variation (Figure 5 and Appendix XV). The highest knob yield per hectare of kohlrabi was recorded in the F_4 (34.17 t/ha) treatment and the lowest yield per hectare was found in the F_1 (16.58 t/ha) treatment. F_1 treatment was identically similar with F_2 treatment. The present finding is agreed with the findings of Uddin *et al*. (2009).

Effect of mulch material on kohlrabi showed positively significant difference for the yield per hectare (Figure 6 and Appendix XV). The highest yield per hectare was recorded (31.75 t/ha) in M_2 treatment while the lowest yield per hectare was found (17.50 t/ha) in M_1 treatment. Farias-Larios *et al.* (1994) also reported the similar finding.

The combined effect of fertilizer and mulching showed non-significant for yield per hectare of kohlrabi (Table 9 and Appendix XV). Although having non-significant effect the highest yield per hectare was found (41.73 t/ha) in F_4M_2

combination while the lowest yield per hectare was found (7.83 t/ha) in F_1M_1 treatment combination. Among the treatment combinations F_2M_2 and F_3M_3 showed the identically similar results. F_2M_3 and F_3M_1 treatment combinations were also identically similar.

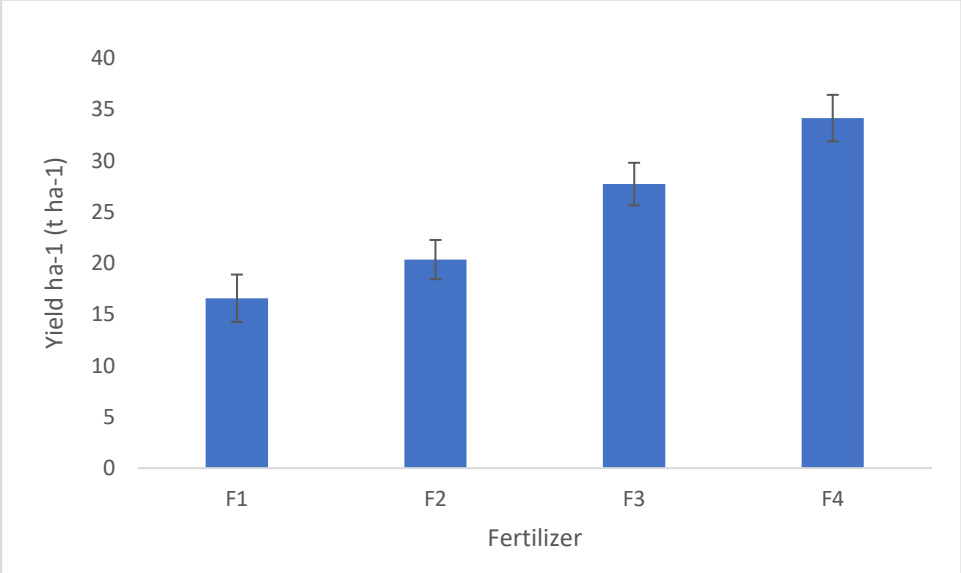

Fig. 5: Effect of fertilizers on yield per hectare (t/ha) of Kohlrabi

F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of Poultry manure.

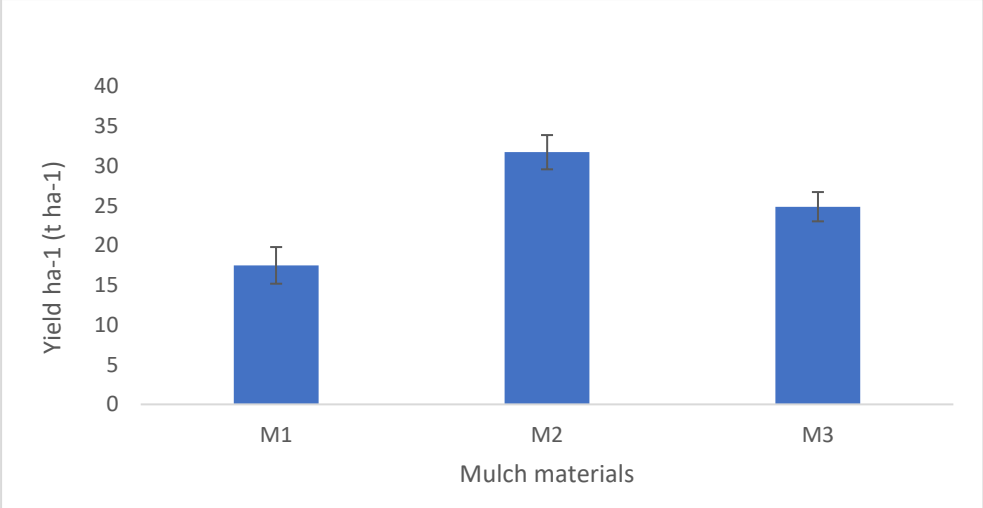

Fig. 6: Effect of mulches on yield per hectare (t/ha) of Kohlrabi

M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch

Table 9. Combined effect of fertilizers and mulches on yield per hectare of Kohlrabi

Treatments	Yield per hectare (t/ha)
F_1M_1	7.83 h
F_1M_2	23.53 de
F_1M_3	18.39 f
F_2M_1	13.56 g
F_2M_2	26.79 cd
F_2M_3	20.74 ef
F_3M_1	21.39 ef
F_3M_2	34.94 b
F_3M_3	26.86 cd
F_4M_1	27.22 c
F_4M_2	41.73 a
F_4M_3	33.56 b
Standard Error (±)	1.50

F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of Poultry manure; M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch

CHAPTER V

SUMMARY AND CONCLUSION

The investigation was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University to study the growth and yield of kohlrabi as influenced by fertilizers and mulches during the period of November 2016 to January 2017. The experiment consisted of four levels of organic and inorganic fertilizers viz., F_1: Control, F_2: Recommended doses of NPK (N=125kg/ha, P=60kg/ha, K=110kg/ha), F_3: Recommended dose of poultry manure (11 t/ha), F_4: ½ recommended doses of NPK+ ½ recommended doses of poultry manure; and three levels of mulches i.e. M_1: Control, M_2: White polythene mulch, M_3: Black polythene mulch. The experiment was laid in Randomized Complete Block Design (RCBD) with three replications. There were all together twelve treatment combinations in this experiment. After transplanting of seedlings, various intercultural operations were accomplished for better growth and development of the plant. Data of growth and yield parameters were collected and analyzed statistically.

The tallest plant of kohlrabi was recorded in the treatment F_4 (34.27, 41.51 and 43.45 cm at 30 DAT, 45 DAT and harvesting time, respectively) and the shortest plant was found in the treatment F_1 (24.20 cm, 30.37 cm and 30.97 cm at 30 DAT, 45 DAT and harvest time, respectively). In case of mulches highest plant height was recorded (30.51, 37.19 and 38.59 cm at 30 DAT, 45 DAT and harvesting time, respectively) in M_2 treatment and the shortest plant was found (27.12, 32.89 and 35.39 cm at 30 DAT, 45 DAT and harvesting time, respectively) in M_1 treatment. The tallest plant was found (36.34, 43.60 and 45.38 cm at 30 DAT, 45 DAT and harvesting time, respectively) in F_4M_2 combination and the shortest plant was recorded (21.38, 28.41 and 29.31 cm at 30 DAT, 45 DAT and harvesting time, respectively) in F_1M_1 combination.

The maximum number of leaves per plant of kohlrabi in case of fertilizers were recorded in the treatment F_4 (12.05, 16.21 and 18.25 at 30 DAT, 45 DAT and harvesting time, respectively) and the minimum number of leaves per plant was

found in the treatment F_1 (9.30, 11.79 and 12.63 at 30 DAT, 45 DAT and harvesting time, respectively). In case of mulches the maximum number of leaves per plant was recorded (11.86, 15.20 and 16.80 at 30 DAT, 45 DAT and harvesting time, respectively) in M_2 treatment while the minimum number of leaves per plant was found (9.67, 12.46, 14.20 at 30 DAT, 45 DAT and harvesting time, respectively) in M_1 treatment. The maximum number of leaves per plant was found (13.40, 18.18 and 19.43 at 30 DAT, 45 DAT and harvesting time, respectively) in F_4M_2 combination and the minimum number of leaves per plant was recorded (8.11, 10.12 and 11.16 at 30 DAT, 45 DAT and harvesting time, respectively) in F_1M_1 combination compared to other combinations.

The highest value of knob diameter (8.37 cm) was recorded in F_4 treatment (½ recommended doses of NPK+ ½ recommended doses of poultry manure) while the lowest knob diameter (5.44 cm) was found in F_1 treatment. The white polythene mulch produced statistically highest knob diameter (8.20 cm) while the control treatment produced the lowest knob diameter (5.91 cm). In spite of having non-significant effect the highest knob diameter (9.65 cm) was recorded in F_4M_2 combination and the lowest value of knob diameter (4.32 cm) was recorded in F_1M_1 treatment combination.

The highest root length of kohlrabi was recorded in the treatment F_4 (14.49 cm) and the lowest root length was found in the treatment F_1 (10.54 cm). The highest root length was recorded (13.79 cm) in M_2 treatment while the lowest root length was found (11.66 cm) in M_1 treatment. Although having non-significant effect the highest root length was found (15.43 cm) in F_4M_2 combination while the lowest root length was found (9.42 cm) in F_1M_1.

The highest value of individual knob weight with leaves (391.44 g) was recorded in F_4 (½ recommended doses of NPK+ ½ recommended doses of poultry manure) treatment while the lowest individual knob weight with leaves (250.29 g) was found in F_1 treatment. The white polythene mulch produced statistically highest individual knob weight with leaves (347.85 g) while the

control treatment produced the lowest individual knob weight with leaves (304.00 g). The highest individual knob weight with leaves (442.61 g) was recorded in F_4M_2 combination and the lowest value of knob diameter (215.43 g) was recorded in F_1M_1 treatment combination.

In case of individual knob weight without leaves the highest weight was recorded in the F_4 (326.12 g) treatment and the lowest individual knob weight without leaves was found in the F_1 (174.31 g) treatment. The highest individual knob weight without leaves was recorded 254.23 g in M_2 treatment while the lowest individual knob weight without leaves was found (215.90 g) in M_1 treatment. The highest individual knob weight without leaves was found (345.40 g) in F_4M_2 combination while the lowest individual knob weight without leaves was found (147.88 g) in F_1M_1 combination.

The highest value of yield per plot (5.51 kg) was recorded in F_4 treatment (½ recommended doses of NPK+ ½ recommended doses of poultry manure) while the lowest yield per plot (2.61 kg) was found in F_1 treatment. The white polythene mulch produced statistically highest yield per plot (5.00 kg) while the control treatment produced the lowest yield per plot (2.85 kg). The highest yield per plot (6.57 kg) was recorded in F_4M_2 combinationand the lowest value of yield per plot (1.23 kg) was recorded in F_1M_1 treatment combination.

The highest fruits yield per hectare of kohlrabi was recorded in the F_4 (34.17 t/ha) treatment and the lowest yield per hectare was found in the F_1 (16.58 t/ha) treatment. The highest yield per hectare was recorded (31.75 t/ha) in M_2 treatment while the lowest yield per hectare was found (17.50 t/ha) in M_1 treatment. Although having non-significant effect the highest yield per hectare was found (41.73 t/ha) in F_4M_2 combination while the lowest yield per hectare was found (7.83 t/ha) in F_1M_1 treatment combination.

The highest value of dry weight of 100 g of stem, roots and leaves (33.24 g) was recorded in F_4 (½ recommended doses of NPK+ ½ recommended doses of poultry manure) treatment while the lowest dry weight of 100 g of stem, roots and leaves (23.78 g) was found in F_1 treatment. The white polythene mulch

(M_2) produced statistically highest dry weight of 100 g of stem, roots and leaves (29.60 g) while the control treatment (M_1) produced the lowest dry weight of 100 g of stem, roots and leaves (26.62 g). The highest dry weight of 100 g of stem, roots and leaves (35.23 g) was recorded in F_4M_2 combination and the lowest value of dry weight of 100 g of stem, roots and leaves (22.46 g) was recorded in F_1M_1 treatment combination.

The present experiment was conducted only one season even in a single location. So, it is difficult to recommend this finding without further study. By considering the results of the present experiment, further studies in the following areas are suggested below

I. Studies of similar nature could be carried out in different agro-ecological zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability.
II. In this study, few levels of fertilizer and mulching was used, it is recommended to increase the fertilizer levels and mulching to get accurate result.

Therefore, it can be concluded that, ½ recommended doses of NPK+ ½ recommended doses of poultry manure and white polythene mulch materials can be used to get higher vegetative growth and yield of kohlrabi.

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APPENDIX

Appendix I. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
pH	6.00-6.63
Organic mater	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41meq / 100 g soil

Source: Soil resource and development institute (SRDI), Dhaka

Appendix II. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from November 2016 to January 2017.

Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
November, 2016	29.6	19.2	77	34.4	5.7
December, 2016	26.4	14.1	69	12.8	5.5
January, 2017	25.4	12.7	68	7.7	5.6

Source: Sher-e-Bangla Agricultural University Weather Station

Appendix III. Anova table for plant height at 30 DAT

Source	DF	SS	MS	F value	P value
Fertilizer	3	596.618	198.873	61.47	0.0000
Mulching	2	71.005	35.502	10.97	0.0004
Fertilizer ×Mulching	11	39.984	6.664	2.06	0.0964

Appendix IV. Anova Table for plant height at 45 DAT

Source	DF	SS	MS	F value	P value
Fertilizer	3	642.700	214.233	3706.28	0.0000
Mulching	2	110.971	55.485	959.91	0.0000
Fertilizer ×Mulching	11	2.729	0.455	7.87	0.0001

Appendix V. Anova Table for plant height at harvest

Source	DF	SS	MS	F value	P value
Fertilizer	3	774.061	258.020	8547.65	0.0000
Mulching	2	61.434	30.717	1017.58	0.0000
Fertilizer ×Mulching	11	2.698	0.450	14.90	0.0000

Appendix VI. Anova table for number of leaves at 30 DAT

Source	DF	SS	MS	F value	P value
Fertilizer	3	40.3861	13.4620	264.55	0.0000
Mulching	2	30.1725	15.0863	296.47	0.0000
Fertilizer ×Mulching	11	1.4986	0.2498	4.91	0.0021

Appendix VII. Anova table for number of leaves at 45 DAT

Source	DF	SS	MS	F value	P value
Fertilizer	3	92.538	30.8461	5541.21	0.0000
Mulching	2	45.120	22.5601	4052.71	0.0000
Fertilizer ×Mulching	11	4.483	0.7472	134.22	0.0000

Appendix VIII. Anova table for number of leaves at harvest

Source	DF	SS	MS	F value	P value
Fertilizer	3	142.721	47.5738	2287.51	0.0000
Mulching	2	41.264	20.6320	992.06	0.0000
Fertilizer ×Mulching	11	1.786	0.2977	14.31	0.0000

Appendix IX. Anova table for root length

Source	DF	SS	MS	F value	P value
Fertilizer	3	76.420	25.4733	383.25	0.0000
Mulching	2	27.062	13.5308	203.57	0.0000
Fertilizer ×Mulching	11	0.357	0.0594	0.89	0.5149

Appendix X. Anova table for knob weight with leaves

Source	DF	SS	MS	F value	P value
Fertilizer	3	91794	30597.9	112.04	0.0000
Mulching	2	13840	6920.2	25.34	0.0000
Fertilizer ×Mulching	11	20020	3336.7	12.22	0.0000

Appendix XI. Anova table for knob weight without leaves

Source	DF	SS	MS	F value	P value
Fertilizer	3	112505	37501.7	10073.91	0.0000
Mulching	2	9074	4536.9	1218.72	0.0000
Fertilizer ×Mulching	11	502	83.6	22.45	0.0000

Appendix XII. Anova table for knob diameter

Source	DF	SS	MS	F value	P value
Fertilizer	3	46.5763	15.5254	331.84	0.0000
Mulching	2	31.3731	15.6866	335.28	0.0000
Fertilizer ×Mulching	11	0.4748	0.0791	1.69	0.1664

Appendix XIII. Anova table for dry weight

Source	DF	SS	MS	F value	P value
Fertilizer	3	462.065	154.022	2399.51	0.0000
Mulching	2	53.223	26.611	414.58	0.0000
Fertilizer ×Mulching	11	4.745	0.791	12.32	0.0000

Appendix XIV. Anova table for yield plot^{-1}

Source	DF	SS	MS	F value	P value
Fertilizer	3	45.7876	15.2625	1407.77	0.0000
Mulching	2	27.5936	13.7968	1272.57	0.0000
Fertilizer ×Mulching	11	0.8882	0.1480	13.65	0.0000

Appendix XV. Anova table for yield ha^{-1}

Source	DF	SS	MS	F value	P value
Fertilizer	3	1652.72	550.908	151.52	0.0000
Mulching	2	1218.37	609.183	167.55	0.0000
Fertilizer ×Mulching	11	25.43	4.238	1.17	0.3570