GROWTH AND YIELD OF CABBAGE CULTIVARS AS INFLUENCED BY FERTILIZERS

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CERTIFICATE

This is to certify that the thesis entitled, **"Growth and Yield of Cabbage Cultivars as Influenced by Fertilizers"** Submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of bonafide research work carried out by **Mohammad Rezaul Hasan,** being Registration No**. 04-01228** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 30.6.2010
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Dedicated to
My
Beloved Parents

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The Author

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ABSTRACT

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the growth and yield of cabbage as influenced by fertilizers. The experiment comprised of two different factors such as, Factor-A; three cultivars viz. V_1 (Atlas 70), V_2 (Keifu 65) and V_3 (Autumn 60) and Factor-B; Four different fertilizers viz. F_0 (Control), F_1 (Cowdung), F_2 (Poultry manure), and F_3 (Inorganic fertilizer).The experiment was set up in Randomized Complete Block Design with three replications. In case of cultivars, V_1 gave the height (45.29t/ha) yield and lowest (35.95 t/ha) from V_3. For fertilizers, F_2 gave the height (47.92t/ha) yield and lowest (23.90 t/ha) from F_0. For combined effect, V_1F_2 gave the height (61.52t/ha) yield and lowest (22.13 t/ha) from V_3F_0. So, Atlas-70 with poultry manure gave the best performance.

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BARI	=	Bangladesh Agricultural Research Institute
CBR	=	Cost Benefit Ratio
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAT	=	Days after transplant
et al.	=	and others *(at elli)*
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
mg	=	miligram (s)
LER	=	Land Equivalent Ratio
FAO	=	Food and Agriculture Organization
MP	=	Muriate of Potash
m	=	Meter
SAU	=	Sher-e-Bangla Agricultural University
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Percent

CHAPTER 1

Introduction

Cabbage (*Brassica oleracea* L.) is an important cole crops, member of the family Cruciferae. Cole crops, including cabbage is important fresh and processing vegetable crop in most of the countries of the world. Cole crops are biennials, but are generally grown as annuals. They are suited to the climate of many regions.

Cabbage is a vegetable crop and generally grown in Rabi season in Bangladesh. Growth and yield of this vegetable crops remarkably influenced by organic and inorganic nutrients management. It is an established fact that use of inorganic fertilizer for the crops is not so good for health because of residual effect but in the case of organic fertilizer such problem does not arise and on the other hand it increase the productivity of soil as well as crop quality and yield (Tindall, (2000).

Cabbage is believed to have originated in Western Europe and it was the first cole crop to be cultivated. Prior to cultivation and use as food, cabbage was mainly used for medicinal purposes **(**Silva, 1986**)**. In addition to the fresh market, cabbage is now processed into Kraut, egg rolls and cole slaws and there is the potential for other specialty markets for the various types including red, savoy and mini cabbage. Cabbage is an excellent source of Vitamin C. In addition to containing some B vitamins, cabbage supplies some potassium and calcium to the diet.

Cabbage is an important and nutritious winter leafy vegetable in our country. It contains a range of essential vitamins and minerals as well as small amount of protein and good caloric value. In recent years vegetable consumption has increased. However, the productivity of cabbage per unit area is quite low as compared to the developed countries of the world (Anon., 2006). Among the

various factors involved nutrient supply is an important inputs for realizing higher cabbage yield and its nutrient content.

Experimental evidence showed that the response of cabbage is high to nitrogen application and moderate to phosphorus application. Several authors reported the importance of organic and inorganic fertilizer on the productivity and nutritional quality of cabbage. The information regarding organic and inorganic fertilizer on cabbage yield and its nutritional quality is meagre in our local climatic condition.

Soil management practices have recently changed dramatically including an increased use in synthetic fertilizers and pesticides to help crop yields. However, some studies have suggested that the excessive use of these agrochemicals may actually increase pest problems in the long run (Altieri and Nicholls 2003). Overall, these results propose a hypothesis that higher synthetic fertilizer inputs may lead to higher levels of herbivore damage to crops (Letourneau, 1996).

Variety is an important factor for successful crop yield. An improved variety represents higher yield than wild one. Generally nutrient requirement is determined by the variety of crops. High yielding variety requires more nutrients than the local or wild variety. Generally it depends on its vegetative and reproductive characters. And it was also mentioned that vegetable variety and history of fertilizer use are important factors to be considered in the development of a soil nutrient management program (Huang, 2006).

The cultivation of cabbage is required proper supply of plant nutrients. The requirement of these plants nutrients can be provided by applying inorganic fertilizer or organic manure or both. However, farmers are now showing interest in organic farming because of, they are more aware about the residual effect of chemical substances used in the crops field and environmental degradation. Besides, the execess application of inorganic fertilizer causes hazard to public health and to the environment.

But the application of both organic and inorganic fertilizer combinedly, can increase the yield as well as keep the environment sound (Hsieh *et al.*, 1996). Considering the above factors, the present experiment was undertaken with the following objectives.

- To identify the suitable variety that could be suggestive for growth and yield of cabbage for the farmers of Bangladesh.
- To determine the optimum Organic fertilizer option for better growth and yield of cabbage.
- To determine the combinaton of variety and fertilizer management of growth and yield of cabbage.

CHAPTER 2

REVIEW OF LITERATURE

Cabbage is one of the most important leafy vegetables in Bangladesh, as well as in the world. Researches on various aspects of its production technology have been carried out worldwide. Among these researches a limited number of works have been done on variety and different sources of nutrients. Most of them included crops like tomato, potato, cucumber, carrot, cauliflower etc. Very few numbers of works were reported where the effect of as well as cowdung and poultry manure and/or in combination with inorganic fertilizers on cabbage was studied. However, some of the researches and their findings related to the present study carried out at home and abroad are reviewed in this chapter under the following headings.

2.1 Effect of variety

There is very few information about performance of cabbage with different variety or cultivars available at present in Bangladesh**.** However, some information is available on the effect of variety and management on the performance of cabbage and their cultivars. So there is a brief review of the available literature has been furnished in this section.

Haque (2005) carried out a comprehensive study on the performance of cultivar (K.K. cross, K.Y. cross, N.S. cross and Drum) and time of planting (25 October, 5 November, 15 November and 25 November) in relation to growth, yield and nutrient content of cabbage. The maximum plant height, shoot and stem length, head diameter, head thickness, total weight per plant and yield was obtained in cabbage planted on 25 October and K.K. cross. Cabbage planted on 25 November exhibited the highest contents of total solids, ascorbic acid and total soluble solids.

Cabbage planted on 15 November gave the highest contents of ash and reducing sugar, while the highest contents of phosphorus, calcium, sodium and potassium and titratable acidity were observed for cabbage planted on 25 October. K.K. cross gave the highest contents of protein, phosphorus, calcium, sodium, potassium and titratable acidity. K.Y. cross gave the highest total solid, ascorbic acid, total soluble solid and reducing sugars content. Comparative data on planting time x variety interaction effect on total solid, ascorbic acid, ash, pH, total soluble solid, protein, reducing sugar, iron, phosphorus, calcium, sodium, potassium and titratable acidity of cabbage are tabulated.

Waltert and Theiler (2003) an experiment was conducted on the effects of growth of different cultivars of Cauliflower and Broccoli were analyzed by the diameter of curd, stem and weight of curd and showed that there was a strong correlation between the diameter of stem and plant biomass and diameter of stem and curd. Growth of stem and curd diameter is dependent on days after transplantation in the field, but dependence is even stronger if related to the sum of maximum daily temperature. Growth of curd showed higher cultivar variation and was more sensitive to environmental factors than growth of stem. In consequence there is a higher variation between curds of one crop, which differs between cultivars. Depending on the correlations and the variation of harvesting period for cultivars can be predicted.

2.2 Effect of inorganic fertilizers on the growth and yield of cabbage

Fertilizers are indispensable for the production system of modem 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, inorganic fertilizers are used largely by the plants. Physico-morphological and biological development of plants depends on the judicious

application and supply of inorganic fertilizers. An excess or deficiency of inorganic fertilizers causes remarkable effect on growth and development of plant. Some available information about the effects of inorganic fertilizers on growth and yield of cabbage are reviewed here.

Haque (2006) conduct an experiment in field condition to study the effect of nitrogen-phosphorus fertilization on growth, yield and nutrient content of cabbage. The experiment was laid out in randomize block design with three replications. The yield and yield components were maximized by N_3P_2 fertilizer treatment. Nutrient content of cabbage varied with fertilizer treatment. The maximum amount of reducing sugar, ascorbic acid, phosphorus were found at the highest rate of N - P fertilization whereas accumulation of titrable acidity, iron, calcium were maximum at the rate of N_2P_2 treatment. However pH, ash content was more or less same throughout the experiment.

The recent introduction of nutrient management legislation in Ontario may force vegetable growers to reduce nitrogen (N) application. Experiments were conducted on mineral soil in Simcoe, Ontario in 2000 and 2001 to re-evaluate the N needs of cabbage. Nitrogen application rates of 0, 85, 170, 255, and 340 kg ha^{-1} were applied 75% pre plant and 25% side dress to Atlantis, a mid-season cultivar. Total yield, marketable yield, weight per head, head density, and head size were assessed at harvest. In 2001, total yield showed a peak at 265 kg N ha^{-1} while in 2001 no significant effect was recorded. Head size and weight per head increased with increasing N rate only in 2000, reflecting differences in yield. Cabbage density was generally unaffected by N rate. Days to maturity decreased with increasing N rate reaching a minimum at 245 and 226 kg ha^{-1} in 2000 and 2001, respectively. Nitrogen rates above current recommended levels are beneficial in maximizing cabbage yields in wet years and minimizing days to maturity (Westerveld *et al*. 2005).

Burghardt (2001) observed that under sub-optimal total nutrients supply, a foliar fertilizer (12 N: 4 P: 6 K) at concentrations up to 15% was tolerated, without leaf damage by dwarf beans, carrots, beetroots, endives, Broccoli, leeks and white cabbages. These concentrations were equivalent to >100 kg N/ha. Plant development and leaf color improved and yields increased by 12 to 74%. Crop quality was unchanged in most crops by foliar spraying, but it improved in beetroots and leeks. Leaf nitrate content was little affected by foliar spraying.

Current fertilizer recommendations for ornamental cabbage (*Brassica oleracea* var. *acephala* [*B. oleracea* var. *viridis*]) suggest applying 150-300 mg N/litre until the initiation of colour development, after which fertilization should be reduced or discontinued. Because these plants are actively growing during cool weather when coloration is initiated, nutrient deficiencies may reduce overall plant quality. The objectives of this study were to investigate N to K ratios for plant growth of ornamental cabbage and the effects of continual and discontinued fertilization during the period of coloration. The application of 150-200 mg N and 150-200 mg K/litre produced high-quality plants and provided sufficient tissue concentrations of N and K. Center-head coloration was not inhibited by N concentrations as high as 250 mg/litre. Ceasing fertilization prior to center-head coloration resulted in the rapid depletion of N, P, and K concentrations in the lower foliage, leading to the appearance of deficiency symptoms and lower leaf loss. The plants were still actively growing as measured by increased shoot mass during the early stages of coloration; therefore, growers should continue to provide a complete fertilizer analysis at N concentrations of >=150 mg/litre until market date (Gibson and Whipker, 2003).

Westerveld (2003) conducted an experiments on mineral soil in Simcoe, Ontario, Canada in 2000 and 2001 to re-evaluate the N requirements of cabbage. Nitrogen at 0, 85, 170, 255, and 340 kg ha^{-1} were applied as a pre-plant treatment (75%) and as side dressing (25%) to the mid-season cultivar Atlantis. Total yield, marketable

yield, weight per head, head density, and head size were evaluated at harvest. In 2000, the highest total yield was obtained with 265 kg N ha-1 while in 2001, no significant effect was recorded. Head size and weight per head increased with increasing N rate only in 2000, reflecting differences in yield. Cabbage density was generally unaffected by the N rate. The number of days to maturity decreased with increasing N rate, reaching the lowest value at 245 and 226 kg ha^{-1} in 2000 and 2001, respectively. Nitrogen rates higher than the current recommended levels are beneficial in the enhancement of cabbage yields in wet years and in reducing the number of days to maturity.

Potato was intercropped with radish or cabbage and treated with 5 different doses of NPK in a field experiment conducted in a field experiment conducted in Himachal Pradesh, India during the summer (March-July) and autumn (August-December) of 1999-2000. Potato-radish sequence recorded higher yield in terms of equivalent yield and net returns compared to the potato-cabbage sequence. Highest net return for potato-cabbage (Rs. 23.892) and potato-radish sequence were obtained by application of the recommended full dose of fertilizer. In both sequences, a slight build-up of N, P and K were observed when higher doses of NPK were applied while application of 75% of the recommended dose improved the N, P and K in soil (Singh and Lal, 2001).

Muhammad and Javed (2001) conducted an experiment in Pakistan during 1998 on Chinese cabbage cultivars; Tropicana and Michihili treated with different levels of N fertilizer (0, 110, 130, 150, 170, 190, 210 and 230 kg N/ha). Tropicana gave maximum head weight (1.201 kg), head diameter (13.45 cm), number of leaves/plant (18.83), leaf area/plant (351.3 cm), and head yield (96.05 t/ha) at 190 kg N/ha compared to Michihili.

Shchelkunova (1974) reported that raising the N rate to 280 kg/ha increased the yield of cabbage to 51 t/ha. But this slightly raised the production cost. He also found that half of this rate of N, i.e. 140 kg/ha produced 48.6 t/ha cabbage at the lowest production cost.

Saxena *et al*. (1975) carried out an experiment to investigate the effects of inorganic fertilizers (N, P and K) on cabbage and tomato and described that increments in the rate of N caused linear yield increase. The cabbage cv. O-S-Cross increased yield from 13.1 to 26.8 t/ha when N was increased from 56 to 228 kg/ha. While K-K-Cross yielded from 21.9 to 32.0 t1ha. Increasing rate of nitrogen also increased head size of both the cabbage cultivars.

Dragland (1976) reported that yield of cabbage increased with increasing levels of nitrogen up to 390 kg/ha. He applied 150kg N/ha before planting. Similar results were also reported by Hellwing *et al*. (1976) and Ghanti *et al*. (1982). Hellwing *et al*. (1976) observed that increasing rate of nitrogen (150-250 kg/ha) with basal P and K application increased yield of cabbage, but marketable yield was influenced to a lesser extent. Ghanti *et al*. (1982) conducted a two-year experiment with the cabbage cv. Pusa Drum Head used N at 100 kg/ha or 200 kg/ha and recorded that the higher rate significantly increased the cabbage yield.

Mallik and Bhattacharya (1996) pointed out that cabbage yield was increased with increasing rate of N application (57.76 and 331.46 q/ha with 0 and 120 kg respectively). Maximum net profit and cost benefit ratio were obtained at 120 kg N/ha.

Halim *et al*. (1994) carried out an experiment on the effect of different doses of NPK on the growth and yield of cabbage in 1990-91 at Jamalpur. Nitrogen was applied at 0, 100, 150 or 200 kg/ha, P at 0, 50, 100 or 150 kg P_2O_5/ha and K at 0, 75, 150 or 225 kg K_2O/ha in 12 combinations to cabbage cv. K-K Cross.

Gross yield and marketable head weight per plant were maximum with 150 kg N_2 + 100 kg P_20_5 + 150 kg K_2O or 200 kg N_2 + 100 kg P_20_5 + 150 kg K_2O combination.

An experiment was designed by Hill (1990) with 6 levels of nitrogen viz. 0, 50, 100, 200, 300 and 400 kg N/ha. He found 200-300 kg/ha to be the best for getting highest yield (126.6 t/ha) of cabbage. He also reported that the highest N-rate caused soft rot disease, which contributed to the reduced yield.

Khadir *et al*. (1989) studied the effect of nitrogen (0, 138 and 276 kg/ha) on the growth and yield of cabbage. They reported that the mean head weight, diameter and yield were higher at the maximum rate of nitrogen. They also found that the increased leaf number per plant, vegetative growth and maximum yield were the effect of 376 kg N/ha.

Pravakar and Srinivas (1987) conducted an experiment in Bangalore, India with 25 day-old cabbage seedling and reported that yield increased with the increasing rate of N application up to 150 kg N/ha. Jaiswal *et al*. (1992) found in an experiment at Madhya Pradesh, India that plant growth and productivity were increased with increasing levels of nitrogen application and was the highest (770.77 q/ha) with 375 kg N/ha applied.

White and Forbes (1977) worked with cabbage in Florida, USA to find out the positive and negative effect of nitrogen on the growth and yield of cabbage. They concluded that cabbage responded positive to N application up to the level of 308 kg/11a. More than this dose resulted reduced head weights proportionately. Similar results were also observed by Vleck and Polach (1977). They pointed out that application of 140 kg N/ha were effective for higher cabbage yields. They also noticed that application of 280 kg N/ha reduced the marketable yield of cabbage by producing more loose leaves instead of compact head. Batsei *et al*. (1979) observed that 240 kg N/ha and 120 kg P/ha produced the highest yield of white cabbage.

While experimenting in the Steppe region of Crinea, Russia, Botnar (1988) stated that 100-400 kg/ha of nitrogen was required for higher cabbage yield.

The effect of 3 spacings, N at 60-120kg/ha and P_2O_5 at 30-90 kg/ha on the yield and its attributes of cabbage cv. Pride of India studied by Singh and Naik (1988). They reported that the closest spacing (45cm × 30 cm) gave higher numbers of marketable heads which resulted in the highest yield. The head weight was maximum at 60 cm × 45 cm spacing. Nitrogen at 180 kg/ha significantly increased yield and number of marketable heads. Application of P at 60 kg/ha gave the highest yield, average head weight and number of heads/ha.

Yetistiren and Vural (1991) conducted an experiment with the application of Nat 10 or 20kg /ha, K at 15 or 30 kg K20/ha and P at 10 kg/ha on cabbage (cv. Yalova-1) and highest yield was obtained with 20kg N + 30 kg K20/ha combination.

Samant *et al*. (1993) carried out an experiment to investigate die balanced fertilizer use for cabbage with the cultivar Pride of India, application of 75 kg/ha, 80 kg P_2O_5/ha and 150 kg K_2O/ha gave the highest yields (17.42 t/ha in the first year and 12.03 t/ha in the second year) and was the most economic dose.

According to Lopandic *et al*. (1997) 10 fertilizer combinations were used to investigate the actual effect of nitrogen fertilizer on the yield of cabbage. The treatment combination of 240 kg N/ha + 140 kg P/ha +210 kg K/ha + 45% foliar sprayed urea showed the best result (average 42.14 t/ha over the 3 years).

A two year trial was conducted by Ciszinszky and Schester (1985) in Florida, USA to investigate the effect of nitrogen on yield and found that the high nitrogen rate of 227 kg/ha increased head size in both spring and autumn-winter, but the result significantly showed that marketable yield increased only in the spring season.

Lawande *et al*. (1986) found that 240 kg N/ha was proved to be effective for cabbage yield. Farooque and Mondal (1987) carried out an experiment under Bangladesh Agricultural University Farm conditions and obtained the maximum marketable yield of cabbage with the application of 336-kg N/ha. They also observed that plant height, number of loose leaves and head size were higher with the application of increased nitrogen dose and the gross and marketable yield of cabbage were increased by 2.5-3 times than the control.

An experiment was conduced by Pant *et al*. (1996) during 19911 at Kunaon hills, India to evaluate the influence of N (40, 60, 80, 120, 140, 160, 180 or 200 kg/ha) on the marketable head yield of cabbage. Yield increased to 49.83 t/ha with increasing rates on N up to 180 kg/ha. Yield decreased with the further increase in N rates.

2.3 Effect of organic manures on the growth and yield of cabbage

The organic matter is called the life of the soil. Fertility of a particular soil is determined by the presence of organic matter. The organic matter content of soil varies from 0-5% and it depends on several factors like origin of soil, climatic conditions, vegetation, microbial activities etc. The physical, chemical and biological properties of soil are greatly influenced by organic matter. Although, organic matter content all the essential plant nutrients, but after application of organic manures required time to convert its available form to the plant. That is why the response of crops to organic manures is low. But due to the residual and beneficial effects on soil properties, application of organic manures are encouraged. Some available information about the effects of organic manures on growth and yield of cabbage are reviewed here.

Hsieh (2004) conducted an experiment on conventional farming and partial organic farming and showed that growth and yield of cabbage and cauliflower in the organic treatments were greater than in the control. Poultry manure compost treatment gave the highest weight/plant, head diameter and yield, which was

26.28% higher than that of the control, followed by pig manure compost treatment, which was 18.38% higher.

Little research has been carried out on the agronomic value of compost produced from garden organics for vegetable production. A field experiment was established in Camden, near Sydney, Australia, to (i) evaluate the effect of the compost on vegetable production and soil quality relative to conventional practice, (ii) compare vegetable production under high and low soil P status, and (iii) monitor the changes in soil P concentration under two compost treatments relative to conventional farmers' practice. After three successive crops (broccoli, eggplant and cabbage), results indicate that compost (120 dry t/ha) and half-compost (60 dry t/ha supplemented by inorganic fertilisers) treatments can produce similar yield to the conventional practice of using a mixture of poultry manure and inorganic fertilizer. Furthermore, similar yields were achieved for three different crops grown under high and low P soil conditions, clearly demonstrating that the high extractable soil P concentrations currently found in the vegetable farms of Sydney are not necessary for maintaining productivity. The compost treatments also significantly increased soil organic carbon and soil quality including soil structural stability, exchangeable cations, and soil biological properties. Importantly, the compost treatment was effective in reducing the rate of accumulation of extractable soil P compared with the conventional vegetable farming practice. Our results highlight the potential for using compost produced from source separated garden organics in reversing the trend of soil degradation observed under current vegetable production, without sacrificing yield (Chan *et al*. 2008).

Commercial brands of alternative, organic fertilizers were compared in Lednice (Czech Republic) in 2004 and 2005 with conventional, mineral fertilizers using head cabbage. There were six different treatments: conventional farmyard manure, Agro (made from poultry bedding and molasses), Dvorecky agroferm (granulated, made from dried, aerobically-fermented farmyard manure), Agormin (an organo-mineral fertilizer), compost manufactured from plant waste material, mineral

fertilizer, and an unfertilized control. All the treatments were applied at rates providing approximately the same level of nutrients. After harvest, the levels of the minerals (K, Na, Ca, and Mg), ascorbic acid, nitrates and yield were measured. There were no significant differences between the treatments in levels of K, Na and Ca in the case of organic fertilizers (farmyard manure, Agro, Agormin and compost). The unfertilized control had the highest levels of ascorbic acid; it was significantly higher than in the case of farmyard manure which, in turn, had significantly higher values than compost. Significant differences between the treatments were found in the levels of nitrates; the lowest in the case of Dvorecky agroferm and in the control. The highest marketable yields were recorded with farmyard manure and Dvorecky agroferm, the latter being significantly higher than the control. This study shows that alternative, organic fertilizers (except for compost) have similar qualities as farmyard manure (Zahradnik and Petrikova 2007).

Vimala (2006) conduct and experiment to determined the effects of organic fertilizer (processed poultry manure) on the growth, yield and nutrient content of cabbage in tunnel-shaped structures with plastic roof and netted sides in Serdang, Malaysia. Treatments consisted of varying rates (0, 15, 30, 45 and 60 t/ha) of processed poultry manure. The control treatment was an inorganic fertilizer applied at 2 t/ha. A quadratic yield response to organic fertilizer rates, represented by the equation Y=9.832+0.636x-0.008x2, where Y=yield in t/ha and x=organic fertilizer in t/ha, was recorded. The optimum rate of fertilizer was 39.75 t/ha. Yields obtained at this rate was 22.47 t/ha. A quadratic response to fertilizer rates was also obtained for canopy width. A linear response was obtained for head diameter. Organic fertilizer rates had significant effects on the P and K contents of the crop. The N content increased with increasing rates of organic fertilizer, although the increase was significant only for the outer leaves. Organic fertilizer rates did not significantly affect Mg content. Nitrate contents did not differ significantly but were highest in the outer leaves with the application of inorganic

fertilizer. All rates of organic fertilizer improved the soil chemical properties compared to inorganic fertilizer. It is concluded that about 40 t/ha of processed poultry manure as the sole source of nutrients can be used for organic cultivation of lowland cabbage grown on clay soils under shelter.

Lathiff and Maraikar (2003) conducted an experiments commencing in the season of 1999/2000, on a reddish brown latosolic soil, at Gannoruwa in the midcountry wet zone of Sri Lanka, to study the performance of different vegetable crops when grown as a monocrop and as mixed crops under an organic farming system. Cattle (CM) and poultry (PM) manure, applied at rates of 20, 30, 40 and 10, 20, 30 t/ha, were the only source of nutrients for the crops. For comparison, a chemical fertilizer treatment, using recommended quantities of NPK, was included in all experiments conducted. In the monocrop experiments, aubergine, cabbage and tomato gave comparable or sometimes higher yields when treated with manure than with NPK. The performance of bush bean [Phaseolus vulgaris], on the other hand, was poor when treated with manure than with NPK. In the mixed crop experiments, where the performance of different combinations of bush bean, cabbage, capsicum, carrot and knol khol [Brassica oleracea var. gongylodes], were tested, there was no significant yield increase with increasing rates of CM, but there was a significant difference between yields obtained with PM at 10 and 30 t/ha. Changes in soil quality, particularly pH and Olsen P content, were evident after 6 seasons of continuous manure application. The medium rate of manure used in this study seems sufficient to produce satisfactory organic vegetable yields.

The chemical composition of the juice obtained from three cabbage cultivars, i.e. Kamienna Gowa, Decema and Amager, was investigated. Ten enzymatic preparations were used to obtain the juices from these cultivars. In both the fresh material and the obtained juices, the contents of dry substance, total extract, total sugars, total acids, vitamin C [ascorbic acid], macro- and micro elements, proteins, raw fibre and total ash were determined. The results revealed that chemical

composition and juice yield were influenced by the cultivar. The best cultivar was Decema, which was characterized by high dry substance (8.55%), total extract (7.33%), proteins (1.40%), total sugars (3.61%), total ash (0.84%) and vitamin C (36.40 mg) in the raw material. In terms of industrial use, however, Kamienna Gowa was the best cultivar, as it gave significantly higher juice yield (74.1%) and more profitable contents of total extract (6.04%), total acids (0.29 g/100 g), vitamin C (20.53 mg), potassium (1674.46 mg/kg), magnesium (104.44 mg/kg) and calcium (340.69 mg/kg). The addition of enzymatic preparations allowed to obtain juices with increased dietary value (Zalewska and Kalbarczyk 2001).

Chemical and physical analysis, 27-d plant growth assays with carrot (Daucus carota) and Chinese cabbage (Brassica campestris var. chinensis), and 5-d phytotoxicity assays with Chinese cabbage and perennial ryegrass (Lolium perenne) were used to investigate the suitability of anaerobically digested poultry slaughterhouse waste for fertiliser in agriculture and the effect of aerobic post-treatment on the properties of the digested material. The digested material appeared to be rich in nitrogen. In 27-d assays with digested material as nitrogen source, carrots grew almost as well as those fertilised with a commercial mineral fertiliser used as reference, whereas, the growth of Chinese cabbage was inhibited. In further 5-d phytotoxicity assays, the digested material inhibited the germination and root growth of ryegrass and Chinese cabbage, apparently because of organic acids present in it. Aerobic post-treatment of the material reduced its phytotoxicity but, probably due to the volatilisation of ammonia, resulted in loss of nitrogen (Salminen 2001).

Jiang and Fu Jian (2005) conducted a field experiment and showed that the yield was increased by 23.67% (1234.5 kg/667 m^2), quality was improved and NO_3^- content of autumn cabbage was decreased by using organic compound fertilizer. The N, P_2O_5 and K_2O removal rates for 1000-kg cabbage was 3.7, 1.07 and 6.0 kg, respectively. The N:P_2O_5:K_2O ratio was 1:0.29:1.60. The maximum nutrient absorption rate was recorded at 60-80 days after sowing.

Lu, N. and Edwards, J.H. (1994) conducted a greenhouse pot study with a Wynnville sandy loam surface soil to determine the influence of application rates of poultry litter (PL) on growth and nutrient uptake of collard [kale] cv. Champion, and the residual effects of PL on growth and nutrient uptake of cabbage cv. Rio Verde. PL at 0, 13, 26, 53 and 106 g/kg was incorporated into limed (pH 6.5) and non-limed (pH 5.2) soil. Collard plants were grown for 52 days. The residual effects of PL were evaluated by growing 3 successive crops of cabbage without further application of PL (total 218 days). Collard plants were severely damaged or killed within 7 days after transplanting when the application rate of PL exceeded 26 g/kg soil. The rate of PL application that resulted in maximum cabbage DM yield increased from 26 to 106 g PL/kg soil during 3 successive crops. After 4 successive growth periods, 6-37% of N, 3-62% of Ca, 20-120% of K, 5-60% of Mg and 3-25% of P added through PL was removed by plants. The decrease in water-extractable K accounted for the decrease in soil salinity. The results suggest that application rates of PL of <more or =>53 g/kg soil can result in elevated levels of salts and NH3 in soil, which can produce severe salt stress and seedling injury.

Subhan (1988) carried out an experiment on cabbage cv. Gloria Osena and applied 15, 20, 25 or 30 t/ha of cattle manure, composted maize straw or composted rice straw. He observed that application of organic manure increased head diameter at 60 days after planting and the average number of leaves/plant and reduced the number of days to crop maturity. Application of 25 or 30 t cattle manure/ha gave the largest cabbage and the highest yield/plot.

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

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

Beresniewiez and Nowosielski (1985) found that organic fertilization and liming increased total and marketable yield of cabbage at the optimum level of mineral fertilization.

The growth of cabbage in loamy soils was severely inhibited and the yield of marketable head was reduced, as reported by Nishimune *et al*. (1994). They also found that repeated applications of compost alleviated the problem but yields were not higher compared to newly cropped or rotated fields.

Omori *et al*. (1972) reported that application of 10 t/acre of fresh cattle manure increased the yield of pimento, eggplant and Chinese cabbage but reduced the yield of cucumber and tomato compared with normal (rate unspecified) application. Fresh chicken manure at the rate of 5-10 t/acre could be used for pimento, eggplant and Chinese cabbage without deleterious effect.

Maslo and Gamayunov (1989) conducted an experiment on four-course rotations (Cucumber, tomato, cabbage and potato). They added 65 t/ha cattle manure per rotation, including 40 t/ha for cucumber and 25 t/ha for cabbage. Lime was applied once per rotation, mineral fertilizers were applied at N-308, P-150 and K-390, equivalent to and combined with 65 t/ha FYM or alone at N-330, P-390, K390. The most positive effect on soil fertility was observed following combined mineral and organic fertilizer application. Yield was increased by 57-136% and productivity by 11-33% more than manuring alone.

Cheung and Wong (1983) carried out an experiment on animal manures and sewage sludges for growing vegetables and stated that chicken manure and pig manure resulted in better growth than sewage sludges.

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

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

Lu and Edwards (1994) suggested that application of 26 to 106 g Pm/kg soil resulted the maximum DM yield in cabbage grown in a green house pot study in USA.

Roe (1998) carried out an experiment by using compost, obtained from dairy manure and municipal solid waste to find out the beneficial effects on broccoli. He found beneficial effects on growth, yields and nutrient contents with compost application in the broccoli production.

Vidigal *et al*. (1997) performed an experiment in Brazil with lettuce using various organic compounds viz. crushed sugarcane, napier grass and coffee straw mixed with pig slurry in various combinations with or without gypsum or triple superphosphate.

They found that napier grass + coffee straw + pig slurry was the best mixture, increasing yields by 10.8% and 17.6% than those produced by NPK in first and second crops, respectively.

An experiment was carried out by Zarate *et al*. (1997) in Brazil to evaluate the rates and methods of application of poultry manures on lettuce. The soil was supplied with 0, 7 or 14 t semi-rotted poultry manure incorporated into the soil and 0, 7 or 14 t semi-rotted poultry manure applied to the soil surface. They found in the absence on incorporated manure, surface application of 14 t manure/ha gave significantly higher yield (17.8 t fresh matter/ha) than other nutrients. When 7 t/ha was incorporated, the rate of surface application had no significant effect on yields (13.3 - 17 t/ha), where as when 14 t/ha was incorporated, surface application of 7 t/ha manure gave the significantly highest yields (20 t/ha Fresh matter).

Devliegher and Rooster (1997a) conducted an experiment on lettuce and Chinese cabbage by using pre-plant compost, obtained from different sources. The composts were comprised of (i) GFT, derived from vegetable, fruit and small garden waste; (ii) Humolex, derived from GFT compost, and (iii) green compost, derived from vegetable waste. They applied the composts at 25 t dry matter/ha. They found that average plant weight was increased by GFT and Humolex but green compost had no effect.

Devliegher and Rooster (1997b) carried out another experiment in Belgium on cauliflower, using standard peat-based compost alone or supplemented with green compost or a GFT- compost. They observed that plant growth was the greatest for plants raised in standard compost and harvest date was earlier.

Alam (2000) conducted an experiment to study the effect of different forms of mustard oil cake (MOC) and its different methods of application with growth and yield of potato (cv. Diamant). He reported that higher yield of tuber (33.31t/ha) was obtained from decomposed form of MOC than powder form (32.18 t/ha).

2.3 Combined effect of organic manures and inorganic fertilizers on the growth and yield of cabbage

Organic manures are the main source of soil organic matter, which has a fundamental effect on the physical and physic-chemical properties of soil. Organic manures also an important source of plant nutrients but contains relatively small amount, which are not readily available. On the other hand inorganic fertilizer contains specific, higher and readily available plant nutrients. So the combination of organic manures and inorganic fertilizers must be more productive. A number of researchers have been conducted to investigate the combined effect of organic manures and inorganic fertilizers. Some of these research information are reviewed here.

Yu-Tzu Hsu (2009) conducted an experiment. The objective of this study was to assess the effect of fertilization (organic or synthetic) and cabbage, *Brassica oleracea* L., cultivars on the chemistry of cabbage and on the responses of a cabbage specialist *Pieris rapae crucivora* Boisduval. Cabbages were grown from seeds in the greenhouse with either organic, synthetic, or no fertilizer treatments. Trials of ovipositional preference and larval feeding were conducted to evaluate the effect of foliage quality on insect responses. In addition, the foliar chemistry (water, nitrogen, total nonstructural carbohydrates, sinigrin, and anthocyanin) was measured during the insect bioassays. The results indicated that butterflies preferred to lay eggs on foliage of fertilized plants. The larvae grew faster on plants fertilized with synthetic fertilizer, but there was no evidence that contents of sinigrin delayed the developmental time of the larvae. However, plants that received organic fertilizer had higher biomass. In summary, the results of this study suggested that proper organic treatment can increase a plants biomass production and may have a lower pest occurrence.

Bimova (2008) stated that in recent years, the agri-food sector and consumers have begun to look at food not only for basic nutrition, but also for health benefits. The purpose of this study was to investigate the variations in the total antioxidant capacity (TAC) in head cabbage according to the used type of fertilizer. Commercial brands of alternative, organic fertilizers were compared with conventional, mineral fertilizers in culture of head cabbage. There were seven different treatments: Agormin, Agro, farmyard manure, horticultural compost, Dvorecky agroferm, mineral fertilizer, and an unfertilized control. All the treatments assured approximately the same level of nutrients. The level of TAC was measured by the FRAP assay and the effect of storage on TAC was also studied. Average value of TAC in fresh cabbage was 236 ± 60 mg GA/100 g in the year 2005 and 295 ± 27 mg GA/100 g in the year 2006. The TAC value decreased in the course of storage. The average value of TAC after a five-month period of storage was 56 ± 18 mg GA/100 g in the year 2005 and 33 ± 5 mg GA/100 g in the year 2006. This study shows that alternative, organic fertilizers have similar or even better qualities than farmyard manure and that they can contribute to the improvement of nutritional values of vegetable.

Souza *et al*. (2008) indicated that nutrient deficiency and higher rate of nutrient release for crop growth and yield both are less efficient for growth and yield of crop production. An experiment was conducted by them to evaluate the effect of organic and chemical fertilizer on characteristics of cabbage growth (plant height, leaf number, leaf size, stem length and root length) and yield (thickness of head, head diameter and weight of head). The first factor consisted of doses of organic compost: 0, 5, 10, 15 and 20 t/ha and the second factor consisted of mineral fertilizers: 50, 100 and 150 kg/ha of mixed fertilizers. Experiment showed that 15 and 20 t/ha organic compost with 100 kg/ha mixed fertilizer gained best results of plant height, leaf number and size, stem length, thickness, diameter and weight of head. The protein, phosphorus, potassium and magnesium contents in cabbage cultivar increased with the increased doses of organic compost.

Experiments were carried out in Iran to determine the effects of organic and fertilizer amendments on severity of M. javanica in cucumber cv. PS. The treatments were undecomposed farmyard manure (10 t/ha) poultry manure (40 t/ha), green manure i.e. cabbage leaf waste (40 t/ha), compost (40 t/ha), and chemical fertilizers including urea (500 Kg/ha), ammonium phosphate (500 Kg/ha), and potassium sulfate (500 Kg/ha) which were used alone and/or in combination with the organic amendments. The combination of poultry manure and chemical fertilizers (NPK) resulted in greatest reduction of number of eggs and juveniles in soil and roots of cucumber and also of few other tylenchids: Tylenchus, Paratylenchus, Psilenchus and Helicotylenchus. Whereas the population of saprophytic nematodes viz. aphelenchids, rhabditids, diplogasterids and cephalobids was increased. The growth of cucumber plants was also highest under this treatment compared with the other treatments. The treatments of poultry manure, combinations of farm yard manure, waste cabbage leaf with chemical fertilizers and farm yard manure were the next effective ones in reduction of egg and juvenile numbers of M. javanica, respectively. Cabbage leaf waste, compost and the chemical fertilizer treatments were the least effective treatments (Nasr and Ahmadi, 2005).

Pankaj (2006) conducted a field experiment during the 2003/04 and 2004/05 kharif seasons in Varanasi, Uttar Pradesh, India, to study the integrated effect of bioinoculants (Azotobacter and phosphorus solubilizing microorganisms (PSM)), organic fertilizer (farmyard manure and digested sludge) and inorganic fertilizers (NPK), alone and in combination, on the growth and yield of cabbage seedlings. Data were recorded for plant height, stem length, number of primary roots, number of wrapper leaves, number of non-wrapper leaves, weight of non-wrapper leaves, head length, head diameter, fresh weight of head, weight per plant and head yield. The results are presented. Data represented that Azotobacter + farmyard manure + NPK and phosphorus solubilizing microorganisms + digested

sludge + NPK were was more effective than Azotobacter + farmyard manure, phosphorus solubilizing microorganisms + digested sludge, Azotobacter + digested sludge, phosphorus solubilizing microorganisms + farmyard manure incase of growth (plant height, stem length, number of primary roots, number of wrapper leaves, number of non-wrapper leaves, weight of non-wrapper leaves) and yield (head length, head diameter, fresh weight of head, total weight/plant and head yield) contributing characters of cabbage.

The effects of organic-inorganic compound fertilizers and inorganic nitrogen fertilizers on the quality and yields of Chinese cabbage cv. Luxing Studied by Zhang (2004). The results show that application of organic-inorganic compound fertilizer I produced the highest yield among all treatments; the yield was higher by 14.4, 6.3, 10.6, 4.6 and 33.6% compared with the treatments of ammonium nitrate, ammonium sulfate, urea, organic-inorganic compound fertilizer II and the control, respectively. Among the three inorganic nitrogen fertilizers, the treatment of ammonium sulfate resulted in the highest yield. No significant difference in nitrate content of Chinese cabbage was observed between the treatments with nitrogen fertilizers of different N forms ($P>0.05$). Of all the nitrogen fertilizers of different N forms, organic-inorganic compound fertilizer I was absorbed by Chinese cabbage cv. Luxing at the highest apparent utilization rate of 29.7% (Zhang, 2004).

Cabbage cv. Vignesh plants were supplied with 100 and 75% recommended N rate, alone or in combination with biofertilizers (*Azospirillum brasilense* or *Azotobacter chroococcum*); 75 and 50% recommended N rate and/or cowdung manure, neem cake or poultry manure, alone or in combination with biofertilizers in a field experiment conducted in Mohanpur, West Bengal, India during the rabi season of 2000-01. Crop yield was highest (55.82 t/ha) with the application of 50% recommended N + 25% poultry manure + biofertilizers, whereas benefit cost

ratio was highest (4.30) was recorded with the application of 75% N + biofertilizers (Devi and Maity, 2003).

Greenhouse 15N isotope dilution was adopted to study nitrogen fertilizer utilization efficiency of organic and inorganic compound fertilizer. Results showed that nitrogen utilization efficiency of organic and inorganic compound fertilizers for Chinese cabbage (6.5-11.9%) was higher than that of inorganic compound fertilization. Application of organic and inorganic compound fertilizers increased yield of Chinese cabbage by 6.0-20%. Optimum proportion of organic fertilizer: inorganic fertilizer were 73:27 and 53:47, whereas optimum total nutrients (N-P2O5-K2O) was selected as 15-20%. Application of such organic and inorganic compound fertilizer obtained the highest nitrogen fertilizer utilization efficiency (38.75%) (Jiang, 2005).

Six heat-tolerant cabbage cultivars were evaluated under plastic rain-shelters on mineral soils at MARDI Kluang, Johor, Malaysia. The cultivars were ‘KK cross’, ‘Summer Autumn’, ‘King of Kings’, ‘Beijing Siji’, ‘Orient Express’ and 'Magic Ball'. The normal fertilizer application system using 5 tons/ha of organic fertilizer (oil palm empty fruit bunch or EFB compost) as basal dressing supplemented with 1.5 tons/ha of NPK 12:12:17:2 compound fertilizer was compared to 20 tons/ha EFB compost and 0.3 ton/ha of NPK compound fertilizer. The results showed that 20 tons EFB compost/ha with 0.3 ton/ha inorganic fertilizer supplements resulted in higher yield and lower disease incidence compared to 5 tons compost/ha and 1.5 tons/ha of NPK fertilizer. Although 'Summer Autumn' resulted in highest yield of 25.8 tons/ha, its yield showed no significant difference with that of ‘Beijing Siji’, ‘KK cross’ and ‘King of Kings’, with yields ranging from 23.8 tons/ha to 24.6 tons/ha. ‘Magic Ball’ and ‘Orient Express’ produced significantly lower yields (13.3 tons/ha and 15.9 tons/ha respectively) than the rest. However, ‘Magic Ball’ and ‘Orient Express’ cultivars were relatively very tolerant to bacterial soft rot

(*Erwinia carotovora*) attacks. The lowest tolerance to bacterial soft rot attacks was observed in 'Beijing Siji' (Yau, 2006).

Szafranek and Koterowa (1974) carried out an experiment to study the effect of commercial fertilizers in the presence or absence of FYM and legumes in rotation on yield and chemical composition of autumn white cabbage "Amager". The highest yield of cabbage was recorded with the full fertilizer (NPK) treatment combined with liming every four years and with FYM and legumes in rotation. FYM and legumes increased the yield of cabbage by 378 q/ha.

Silva (1986) planted cabbage in hydromorphic soil treated with 100 kg /ha N, 100 kg/ha P_2O_5, 200 kg/ha K_2O or 50 t/ha cattle manure, alone or in combination. N increased the total yield but decreased commercial to total yield ratio. K_2O alone decreased total yields. Cattle manure increased commercial and total yields but decreased commercial to total yield ratio. The highest commercial yield (49 t/ha) was achieved with cattle manure or N + K_2O but there was no response to P_2O_5.

Farooque and Islam (1989) carried out an experiment at the Horticulture Farm BAU, Mymensingh during 1987-88 to study the effect of spacing and different fertilizer management practices on the growth and yield of cabbage. The plants were spaced at 60 cm × 30 cm, 60 cm × 45 cm or 60 cm × 60 cm and were subjected to 3 different fertilization schedules. Application of cowdung 8.3 t/ha, mustard oil cake 200 kg, urea 326 kg, triple superphosphate 125 kg and 200 kg muriate of potash per hectare combinedly gave the highest marketable yield of cabbage.

The effects of composted cattle manure, rapeseed meal and mineral fertilizer applications on vegetables and soil fertility were examined from 1978 to 1987 by Yamada and Kamata (1989). They described that cabbage yields weere higher with mineral fertilizer than other treatments, however, cabbage yields on the mineral fertilizer plot decreased without the application of agricultural chemicals,

whereas yields on cattle manure and rapeseed meal plots were not affected. Lettuce and onion yields were the same with rapeseed meals as with mineral fertilizers. Lettuce yield was lower, and onion yields varied annually with the cattle manure treatment. Cattle manure plots showed pH value of 6.8 whereas pH values decreased on the other plots having fertilizer + cattle manure. Total C and N also increased in the cattle manured plot, but were constant on the fertilizer treated ones. Available N and biomass C increased on the cattle manure plot but decreased on the fertilized plot. Soil density and solid phase ratio decreased and porosity increased on the manure plot. The results showed the benefit of using organic soil conditioner with manures compared with manures alone.

It was reported that the highest cabbage yield (76.60 t/ha) was found from the combined effect of 180 kg N, 60 kg P, 180 kg K per hectare and cowdung @ 5 t/ha (Anon., 1990) and it was also stated that a combination of organic and inorganic fertilizer was better than a single fertilizer for cabbage production.

In another study (Anon., 1991), it was found that fertilizer at the rate of 240 kg N/ha, 60 kg P/ha and 120 kg K/ha along with 5 t/ha cowdung gave the highest head yield (75 t/ha) of cabbage var.Atlas-70.

Kolota *et al*. (1992) reported that yields of three crops (cabbage, celery and beet) were higher on plots receiving 50 t/ha FYM + mineral fertilizers compared with plots receiving only mineral fertilizers.

Use of organic fertilizers ensures the sustainable agriculture as has been reported by Abedin *et al*. (1994). They conducted a study to find out the sustainable practices using data collected from 85 selected farmers in Cameroon, involved in pest (insect, disease, weed) control, fertilization and soil erosion control. Results indicated that use of less agricultural chemicals and inorganic fertilizers were more sustainable practices and farmers who used these did not suffer yield losses.

Suchorska (1996) conducted a field experiment to test the sustainability of some unconventional fertilizers obtained from brown coal, brown coal ash, poultry manure, cattle manure and fertilizer made from mushroom substrate. In the 3 years trial, the yield and content of P, K, Ca and Mg in cabbages, carrots and spinach were determined and found that the highest yield of white cabbage and spinach was obtained from the plots fertilized with brown coal ash. The mineral organ fertilizers tested increased the P content of the vegetables.

During winter season, an experiment was conducted by Asumus and Gorltiz (1986) at Gross Kretutz, Germany to find out the effect of equivalent rates of mineral fertilizer, FYM and mixture of two nitrogen forms on yield, N uptake and utilization in the rotation potatoes/winter wheat/sugarbeet/spring barely. They observed that combined application of FYM and mineral fertilizer increased yield and decreased uptake compared with FYM or mineral fertilizer alone.

Only one experiment for 16 years conducted by Rauhe *et al*. (1987) at Sechausen near, Peipzig, and applied an average amount of 0, 51, 102 or 153 kg FYM and 0, 53, 106 or 159 kg mineral N/ha. They observed that the combination of about 100 kg FYM + 120 kg mineral N ensure both high yield and maintained soil N content.

An experiment was conducted for 3 years considering five replications of two treatments (organic and conventional) annually where yield and vitamin content of carrot and cabbage were not affected by treatments (Worman and Havard , 1997).

Kropisz (1992) carried out an experiment using composted pine bark (CPB) + vegetable matter, composted sawdust (CS) + vegetable matter (added to CPB and CS at 10, 20 or 30% by volume) and FYM were applied at 25 t/ha in 3-year field trials with cabbage, onion and carrot. All the 'organic fertilizers were applied in the first year only. NPK fertilizers were applied annually and there were plots where NPK alone was applied. Organic fertilizers in all cases improved cropping,

with the highest average yields being obtained on plots receiving FYM + NPK. These were 50.2, 28.3 and 31.5 t/ha for cabbage, onions and carrots, respectively.

While conducting and experiment in Bangladesh Agricultural University, Mymesingh Aditya (1993) reported that the highest (60 t/ha) yield of cabbage (var. Atlas-70) was obtained by the application of 375 kg N/ha 225 kg P/ha and 225 kg K/ha along with cowdung at the rate of 10 t/ha

Kamiyama *et al*. (1995) carried out experiment in upland fields and lowland fields, over 15 and 17 years respectively. Mineral fertilizers were applied with or without FYM to cabbage, sweet corn and rice. In the upland fields, cabbage and sweet corn yields were maximum when chemical fertilizers were applied with FYM. In the lowland rice fields, yields were similar with and without FYM.

Hsieh *et al*. (1996) investigated the continuous use of organic manure on the growth and yield of cabbage and showed that the increase in cabbage yields in the organic plots compared with chemical plots were greater, especially when the micro-organism mixture was included to the manures. Among the compost, cabbage performed best with chicken manure compost combined with microorganisms (5 kg/m^2).

Asiegbu and Oikeh (1995) showed that NPK fertilizer were more efficient than the organic manures in supplying N, P and K at least in the short run, while the organic manure had an advantage in supply of other macro and micro nutrient elements not contained in NPK fertilizer.

Aktar *et al*. (1996) carried out an experiment at Joydebpur during the rabi season of 1993-94 and 1994-95 to find out the effects of poultry manure (PM) and cowdung (CD) in presence and absence of chemical fertilizer on growth and yield of broccoli and reported that 10 t/ha of poultry manure with recommended dose of nutrients produced the highest curd yield of broccoli. The application of only PM

and CD caused yield depression even at higher doses. The highest curd yield of 20.70 and 16.7 tons per hectare were obtained with PM and CD against 9.0 tons per hectare in the control treatment. In absence of NPKs only organic manure could not produce higher yield of curd.

Wang-Xiude *et al*. (1996) conducted an experiment on 5 formulations of fertilizer on 4 vegetables namely cucumber, cabbage, tomato and cauliflower. The formulation containing 88% powdered poultry manure, 4% urea, 4% KCl and 4% boron sulphate was the best for vegetable growth. This formulation was applied to autumn cabbage, autumn cucumber and white gourd at different application rates (0, 112.5, 225, 337.5 or 450 kg/100m2) where 337.5 kg/m2 gave the best results.

Dixit (1997) showed that the yield of cabbage increased with increasing N (from 136.8 to 175.1 q/ha after addition of 0 and 160 kg N/ha respectively) and FYM rate (from 129.5 to 144 q/ha). Addition of FYM to N treatments further increased yield (Yields of 176.1 q/ha in presence of FYM + 160 kg N/ha).

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

Farid *et al*. (1998) conducted an experiment at Joydebpur to study the efficiency of poultry manure and cowdung alone and in combination with mineral fertilizers on the yield of cabbage (var. Atals-70). They mentioned that the head yield of cabbage was increased both by cowdung and poultry manure with macro and micro-nutrients added to the treatments. But the increase due to poultry manure was always higher than that of cowdung. Poultry manure alone increased the yield significantly when it was applied at the rate of 20 t/ha.

Economically the treatments using 5 t/ha of poultry manure along with 200, 120, 100 and 50 kg/ha of N, P_2O_5, K_2O and S, respectively. Thus organic manures gave significantly higher yield of cabbage and more profit when applied in combination with mineral fertilizers.

Quattrucci and Canali (1998) conducted an experiment with traditional mineral fertilizers and mixture of organic and mineral fertilizers to evaluate their effects on cabbage. They reported that mixture of organic and mineral fertilizers gave the highest total and marketable yields.

Kabir (1998) carried out an experiment at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh to find out the effect of poultry manure and cowdung in presence and absence of chemical fertilizer on growth and yield of cabbage and reported that combination of poultry drops and inorganic fertilizer performed the best in respect of number of leaves, head diameter, plant height, number of folded leaves, head weight and percent of dry matter.

Azad (2000) conducted an experiment at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh, during the period from November to March 2000. He found the maximum plant height, plant spread, number of total loose and healthy leaves, diameter and thickness of head, length and diameter of stem. number of roots, fresh and dry weight of roots, gross and marketable yield of cabbage when organic manures and inorganic fertilizers were used in combination.

Hague (2000) studied the effect of differ fertilizer management practices on the growth and yield of cabbage at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh. The experiment was consisted of different combinations of organic and inorganic fertilizers. He reported that 1/4cowdung +1/4 mustard oil cake +1/4 poultry drop +1/4 NPK performed the best in respect of plant height and spread, days required for head formation and maturity, number of loose leaves,

diameter and thickness of head, fresh and dry weight of head, marketable yield per plant and per hectare.

Sannigrahi and Borah (2000) conducted a field experiment in Assam with tomatoes, French beans and cabbage by the application of organic manures (FYM or compost) with or without NPK fertilizer and root inoculation with mycorrhizas. They reported that tomato yield was the highest (17.3 t/ha) with the application of recommended NPK fertilizer, while the yield of French hears (36.1 t/ha) and cabbage (26.6 t) were highest with 10 t FYM/ha + Inoculation + 15 kg N + 10 kg K_2O and 10 t compost + Inoculation + 40 kg N + 30 kg K_2O, respectively.

Considering the available information so far collected from home and abroad it was evident that the different sources of nutrient (NPK fertilizers, cowdung; poultry manure etc.) greatly influenced the growth and yield of some vegetables including cabbage. The organic nutrient sources increased soil humus and organic matter content, conserved soil moisture and increased soil fertility and inorganic fertilizers use efficiency. Various kinds of nutrient sources are available which are easily applicable in vegetable crops as well as field crops. But in Bangladesh context, the illiterate farmers have no sound knowledge on nutrient sources and in most case they only use inorganic fertilizer without considering nutrient source, crop, environmental interactions and cost benefit ratio.

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2008 to March 2009 to study the Growth and Yield of Cabbage Cultivars as Influenced by Fertilizers. The materials and methods that were used for conducting the experiment are presented under the following headings:

3.1 Experimental Site

The present experiment was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^0 74^/$N latitude and $90^0 35^/$E longitude and at an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Climate

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the 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 (Edris *et al*., 1979). Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix I.

3.3 Characteristics of Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. It had shallow red brown terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). Details of the recorded soil characteristics were presented in Appendix II.

3.4 Planting Materials

Three varieties were used as planting materials viz. (i) Atlas – 70, (ii) Keifu – 65 and (iii) Autumn – 60. Seeds of cabbage cultivars, were used in the experiment and the seeds were collected from a commercial seed trader named Manik seed traders, Siddique Bazar, Dhaka.

3.5 Treatment of the experiment

The experiment was conducted to find out **Growth and yield of Cabbage as Influenced by Fertilizers**. The experiment consisted of two factors.

Factor A: Cultivars (3 cultivars)

(i) V_1: Atlas – 70

(ii) V_2: Keifu – 65

(iii) V_3: Autumn – 60

Factor B: Fertilizers (4 levels)

(i) F_0: Control : No manures and fertilizer were applied

(ii) F_1: Cowdung : 15 t/ha, so 0.486 kg/plot

(iii) F_2: Poultry manure : 15 t/ha, so 0.486 kg/plot

(iv) F_3: Inorganic fertilizer :

(a) Urea – 330 kg/ha, so 0.16038 kg/plot

(b) TSP – 200 kg/ha, so 0.0972 kg/plot

(c) MP – 250 kg/ha, so 0.1215kg/plot

There were 12 treatment combinations that are as follows:

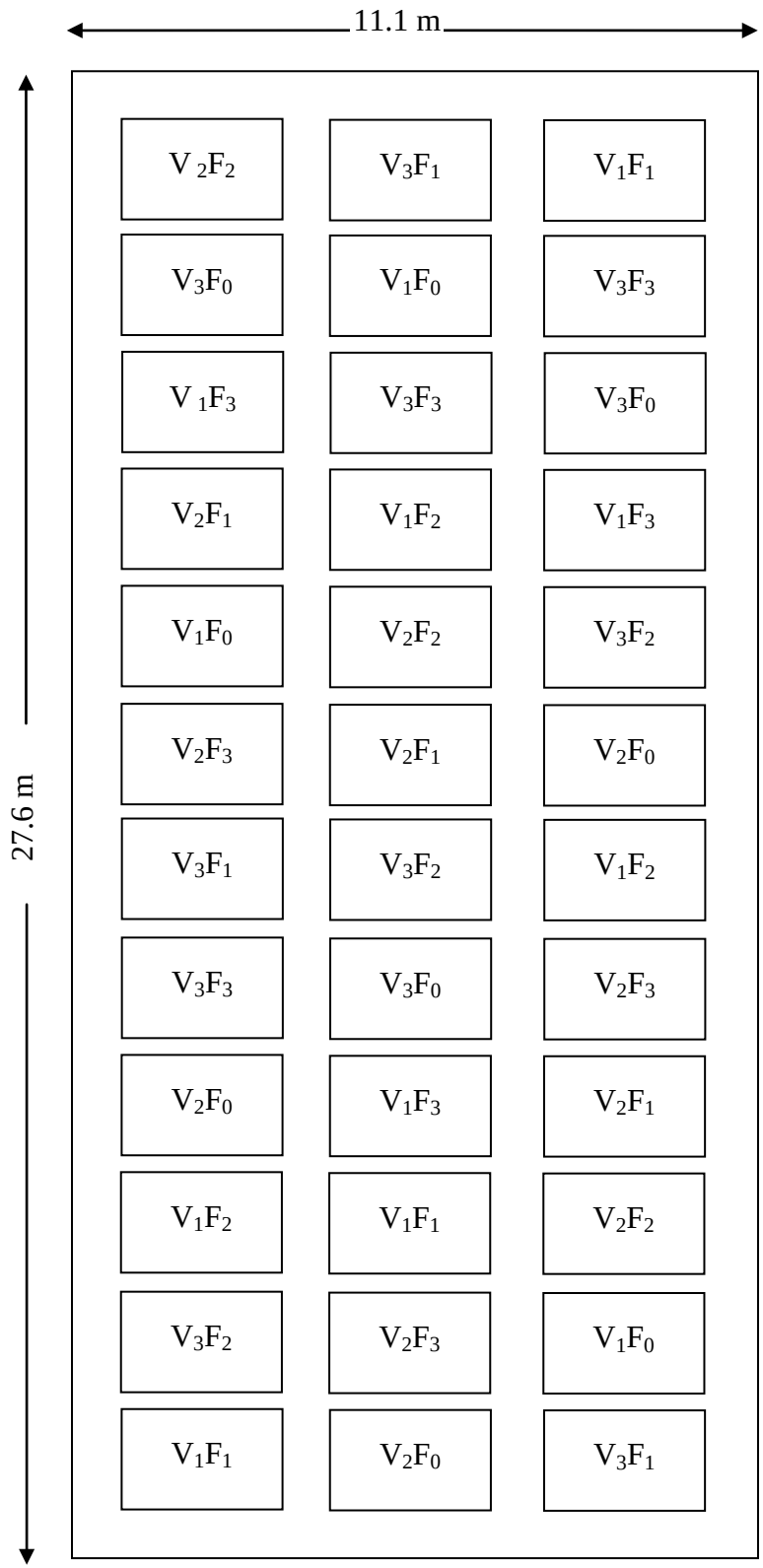
V_1F_0	V_2F_0	V_3F_0
V_1F_1	V_2F_1	V_3F_1
V_1F_2	V_2F_2	V_3F_2
V_1F_3	V_2F_3	V_3F_3

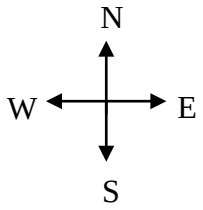
3.6 Experimental design and layout

The two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 27.60 m × 11.1 m was divided into three equal blocks. Each block was divided into 12 plots where 12 treatment combinations were allotted at random. There were 36 unit plots and the size of the each unit plot was 2.7 m × 1.8 m. The distance maintained between two blocks and two plots were 0.5 m and 0.25 m, respectively. The seeds were sown with maintaining distance row to row 60 cm and plant to plant 45 cm. The layout of the experiment is shown in Figure 1.

3.7 Raising of seedlings

The seedlings were raised at Hort. Farm of the Sher-e-Bangla Agricultural University, Dhaka under special care in a 1 m × 1 m size 3 seed beds for 3 cultivars. The soil of the seed bed was well ploughed with a spade and prepared into loose friable dried masses and to obtain good tilth to provide a favorable condition for the vigorous growth of young seedlings. Weeds, stubbles and dead roots of the previous crop were removed. The seedbed was dried in the sun to destroy the soil insect and protect the young seedlings from the attack of damping off disease. To control damping off disease cupravit fungicide were applied. Decomposed cowdung was applied to the prepared seedbed at the rate of 10 t/ha. Cabbage seeds were soaked in water for 48 hours and then seeds were mixed with soil and sown in seed bed.





Plot size: 2.7 m × 1.8 m

Plot spacing: 25 cm

Between replication: 50 cm

Plant spacing:

Plant to plant: 45 cm

Row to row: 60 cm

Factor A: Cultivars

V_1: Atlas – 70

V_2: Keifu – 65

V_3: Autumn – 60

Factor B: Fertilizer

F_0: Control

F_1: Cowdung

F_2: Poultry manure

F_3: Inorganic fertilizer

3.8 Preparation of the main field

The selected experimental plot was opened in the 1st December 2008 with a power tiller and was exposed to the sun for a week. After 2 days the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil for planting of Cabbage seedlings. The experimental plot was partitioned into the unit plots in accordance with the experimental design and organic and inorganic fertilizers were applied as per treatments of each unit plot. The soil was treated with fungicide cupravit against the fungal attack.

3.9 Application of manure and fertilizers

Application of manure and fertilizers were applied as per treatment. Doses of organic manures and inorganic fertilizers applied in the field according to the treatments were as follows:

(i) Control : No manures and fertilizer were applied

(ii) Cowdung : 15 t/ha, so 0.486 kg/plot

(iii) Poultry manure : 15 t/ha, so 0.486 kg/plot

(iv) Inorganic fertilizer :

Urea – 330 kg/ha, so 0.16038 kg/plot

TSP – 200 kg/ha, so 0.0972 kg/plot

MP – 250 kg/ha, so 0.1215 kg/plot

3.10 Transplanting of seedlings in the main field

Healthy and uniform sized seedlings were transplanted in the main field. The seedlings were uprooted carefully from the seedbed to avoid any damage to the root system. To minimize the roots damage of the seedlings, the seedbed was watered one hour before uprooting the seedlings. Transplanting was done in the afternoon carefully. A considerable number of seedlings were also planted in the border of the experimental plots for gap filling if necessary later on.

3.11 Intercultural operation

When the seedlings established in the beds it was always kept under careful observation. Various intercultural operations viz. irrigation and drainage, gap filling, weeding, top dressing was accomplished for better growth and development of cabbage seedlings.

3.11.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after transplanting in every alternate day in the evening upto 1st harvest. Further irrigation was done and when needed. Stagnant water was effectively drained out at the time of excess irrigation.

3.11.2 Gap filling

Gap filling were done after 6 days of transplanting from border side transplanted plant.

3.11.3 Weeding

Weeding was done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. Breaking the crust of the soil was done when needed.

3.12 Plant Protection

For controlling leaf caterpillars Nogos @ 1 ml/L water were applied two times at an interval of 10 days starting soon after the appearance of infestation. No remarkable attack of disease was found in cabbage field under study.

3.13 Harvesting

All cabbage head were not matured at a same time, it could not be done at a time from the whole field. Harvesting was done when necessary. Different yield

contributing data have been recorded from the mean of five harvested plants which was selected at random of each unit plot of every harvesting stage.

3.14 Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Five plants were randomly selected from each unit plot for the collection of data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect.

3.14.1 Plant height

The height of plant was recorded in centimeter (cm) at 15, 30, 45 and 60 days after transplanting (DAT) or above in the experimental plots. The height was measured from the attachment of the ground level up to the tip of the growing point.

3.14.2 Number of leaves per plant

The total number of leaves per plant was counted. Data were recorded as the average of five plants selected at random from the inner rows of each plot starting from 15 to 60 DAT or above at 15 days interval.

3.14.3 Leaf length with petiole

The length of leaf with petiole was measured by using a meter scale. The measurement was taken from base of leaf to tip of the petiole. Average length of leaves with petiole was taken from five random selected plants from inner rows of each plot. Data was recorded from 15 to 60 DAT or above at 15 days interval. Mean was expressed in centimeter (cm).

3.14.4 Breadth of leaf

Breadth of leaf was recorded as the average of five leaves selected at random from the plant of inner rows of each plot starting from 15 to 60 DAT or above at 15 days interval. Thus mean was recorded and expressed in centimeter (cm).

3.14.5 Root length at harvest (cm)

Root length was recorded as the average of five plants when it was harvested. Thus mean was recorded and expressed in centimeter (cm).

3.14.6 Stem length

Stem length at harvest was recorded as the average of five plants from base to top of stem at random at the time of harvest when necessary in inner rows of each plot. Thus mean was recorded and expressed in centimeter (cm).

3.14.7 Thickness of head

Thickness of head was measured from five plants when it was harvested and then mean was recorded and expressed in centimeter (cm).

3.14.8 Diameter of head (cm) at harvest

Diameter of head was measured from five plants when it was harvested and then mean was recorded and expressed in centimeter (cm).

3.14.9 Weight of whole plant (kg/plant)

At the time of harvest of plant, whole plant weight was taken before separating head of the plant from five and then mean was recorded and expressed in centimeter (cm).

3.14.10 Yield (t/ha)

Total head yield/plot was taken gradually from each plot and averaged yield/plot was converted to tone per hectare. Gross yield and marketable yield were measured from each plot and averaged and then converted to t/ha.

3.14.11 Economic production (kg/plant)

Economic production is an activity carried out under the control and responsibility of an institutional unit that uses inputs of labour, capital and goods and services to produce outputs of goods or services. Economic production was measured from whole plants of each plot and than average Economic production was expressed in kg/plant.

3.14.12 Cost analysis

The cost of production was analyzed in order to find out the most economic treatment in respect of variety and different sources of nutrients regarding organic and inorganic fertilizers. All input cost, cost of land and running capital were considered for computing cost of production. The cost and return analysis was done in details according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Net return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}} \times 100$$

3.15 Statistical Analysis

The data obtained for different parameters were statistically analyzed to find out the significance difference of variety and different fertilizer application on yield and yield contributing characters of cabbage. The mean values of all the characters were calculated and analysis of variance was performing by the ‘F’ (variance ratio) test. The significance of the difference among the treatment combinations means was estimated by the Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

The experiment was conducted on 'growth and yield of cabbage cultivars as influenced by fertilizers' and the results on effectiveness of various treatments including an untreated control for the management of cabbage catterpiller have been described and discussed below in detail under the following heading:

4.1 Growth parameters

4.1.1 Plant height

4.1.1.1 Effect of variety

Variety is an important factor considering plant height. Under the present study, plant height was significantly influenced by different varieties of cabbage cultivar at different days after transplanting (DAT) (Figure 1 and Appendix III). Results showed that the cabbage cultivar Atlas 70 (V_1) was evident for highest plant height at all growth stages. The tallest plant at 15, 30, 45 DAT and at harvest were 26.81, 29.29, 30.88 and 31.94 cm respectively was obtained with Atlas 70 (V_1). The competition in accordance with plant height among the cultivars the smallest plant was demonstrated with Autumn 60 (V_3) and the lowest plant height at 15, 30, 45 DAT and at harvest were 23.83, 27.68, 29.58 and 31.04 cm respectively which was statistically identical with Keifu 65 (V_2) at 30, 45 DAT and at harvest respectively. The varietal effect on plant height was supported by Haque (2005)

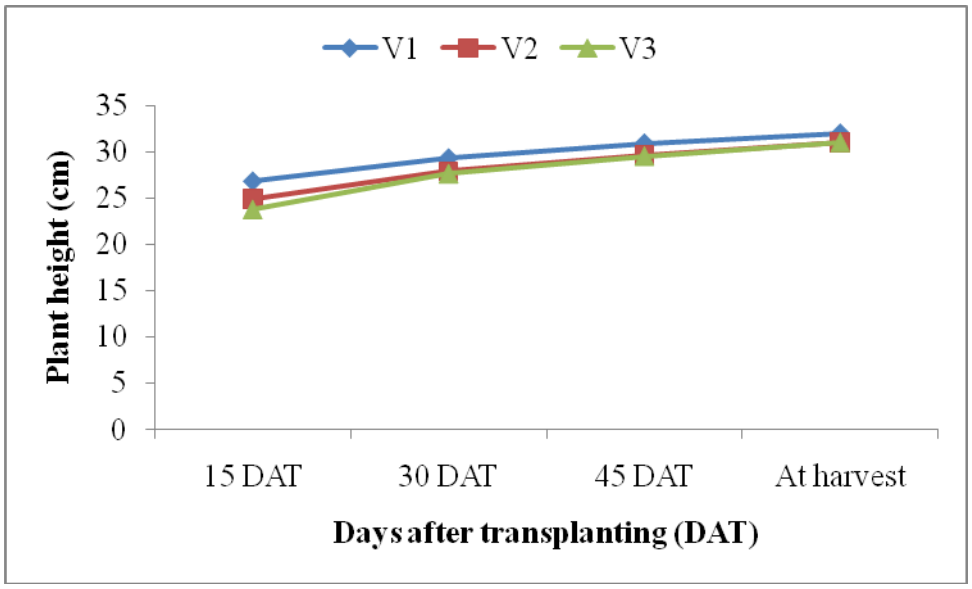


Fig.1:Plant height at different growth stages of three Cabbage Cultivars($LSD_{0.05}$ = 1.961, 1.243, 0.845 and 0.2395, at 15, 30, 45 DAT and at harvest respectively)

4.1.1.2 Effect of fertilizer

Fertilizer is the most important factor for achieving best yield of crop. Plant height was significantly affected by different manures and fertilizers under the present study (Figure 2 and Appendix III). It is evident that plant height was the highest with inorganic fertilizer (F_3) at different growth stages of different varieties of cabbage cultivars. The highest plant height was 26.00, 29.39, 31.03 and 32.55 cm at 15, 30, 45 DAT and at harvest respectively. On the other hand, the lowest plant height (24.48, 26.98, 29.12 and 30.52 cm at 15, 30, 45 DAT and at harvest respectively) was with control treatment (F_0) which was statistically identical with cowdung (F_1) treated crop at harvest. This result might be due to cause of rapid performance on growth characters and rapid release of nutrients of inorganic fertilizer for plant height where organic fertilizer has slow nutrient release capacity that caused lower plant height. Results under the present experiment on plant height was supported by Souza *et al*. (2008).

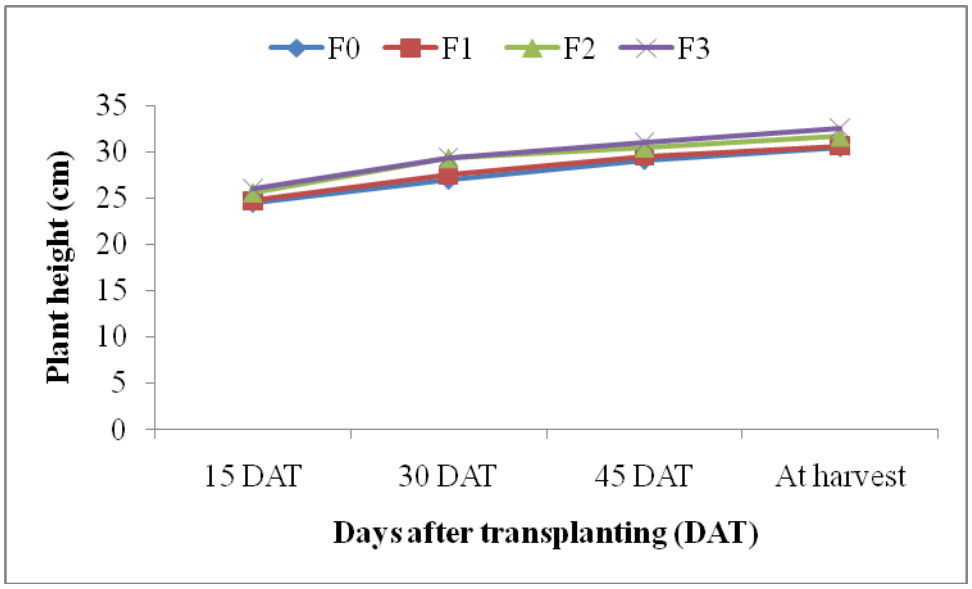


Fig 2: Effect of different fertilizer on plant height of different cabbage cultivar at different growth stages ($LSD_{0.05}$ = 1.141, 1.436, 0.9757 and 0.2765 at 15, 30, 45 DAT and at harvest respectively)

4.1.1.3 Interaction effect of variety and fertilizer

Interaction effect of variety and different type manure and fertilizer affected plant height significantly under the present study (Table 1 and Appendix III). Different treatment combination viewed different plant height at different days after transplanting (DAT). It was observed that highest plant height was achieved with V_1F_3 and that was 28.30, 30.37, 32.00 and 33.11 cm at 15, 30, 45 DAT and at harvest respectively which was closely followed by V_1F_2 at 15, 30 DAT and V_3F_3 at harvest. On the other hand the lowest plant height; 22.46, 25.60, 27.80 and 29.93 cm at 15, 30, 45 DAT and at harvest respectively was obtained with V_3F_0 which was statistically identical with V_2F_1 and V_3F_1 at harvest.

Table 1: Interaction effect of fertilizer management and three different cabbage cultivars on plant height at different growth stages

Treatments	Plant height (cm)			
	15 DAT	30 DAT	45 DAT	At harvest
Interaction effect of variety and fertilizer				
V_1F_0	25.97 bc	28.40 de	30.10 cd	31.12 de
V_1F_1	26.03 bc	28.40 de	30.32 bc	31.51 cd
V_1F_2	26.92 ab	30.00 ab	31.10 b	32.03 bc
V_1F_3	28.30 a	30.37 a	32.00 a	33.11 a
V_2F_0	25.02 bc	26.93 f	29.47 de	30.51 ef
V_2F_1	24.18 cd	26.37 f	29.10 e	30.13 f
V_2F_2	25.63 bc	28.97 cd	30.10 cd	31.52 cd
V_2F_3	24.95 bc	28.47 d	30.00 cd	32.03 bc
V_3F_0	22.46 d	25.60 g	27.80 f	29.93 f
V_3F_1	23.91 cd	27.73 e	29.20 e	30.31 f
V_3F_2	24.20 cd	29.03 cd	30.20 cd	31.40 cd
V_3F_3	24.77 bc	29.35 bc	31.10 b	32.52 ab
$LSD_{0.05}$	1.976	0.6709	0.7497	0.7184
CV (%)	5.62	7.19	6.44	8.24

4.1.2 Number of leaves/plant

4.1.2.1 Effect of variety

Number of leaves/plant is an important parameter considering the highest performance of cabbage yield (Figure 3 and Appendix IV). Autumn – 60 (V_3) gave an idea about highest number of leaves/plant at all growth stages of cabbage cultivar. The highest number of leaves/plant at 15, 30, 45 DAT and at harvest (17.58, 20.50, 22.00 and 22.75 respectively) was with Autumn – 60 which was statistically identical with Keifu – 65 (V_2) at all growth stages. On the contrary the lowest number of leaves/plant at 15, 30, 45 DAT and at harvest (16.50, 17.42, 18.77 and 18.75 respectively) was obtained with Atlas – 70 (V_1). These results might be due to cause of genetical characters of cultivars that caused higher and lower number of leaves/plant.

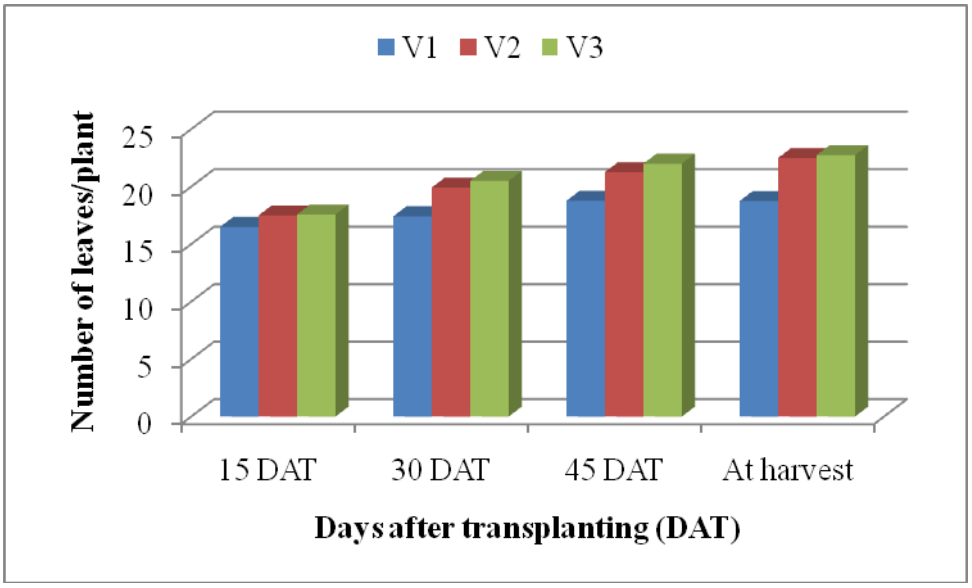


Fig 3: number of leaves/plant at different growth stages of three different cabbage cultivars ($LSD_{0.05}$ = 0.996, 1.756, 1.442 and 1.081 at 15, 30, 45 DAT and at harvest respectively).

4.1.2.2 Effect of fertilizer

Significant variation was observed in the case of number of leaves/plant at different days after transplanting (DAT) (Figure 4 and Appendix IV). It was measured that the highest number of leaves/plant was obtained with inorganic fertilizer (F_3) and the highest number of leaves/plant was 18.00, 20.44, 21.35 and 22.02 at 15, 30, 45 DAT and at harvest respectively which was statistically identical with treatment of Poultry manure (F_2) at all growth stages of cabbage cultivars. The lowest number of leaves/plant was found to be at 15, 30, 45 DAT and at harvest 15.78, 18.11, 19.01 and 19.67 respectively with control treatment (F_0). The results obtained from the experiment on number of leaves/plant was conformity with Vimala (2006), Pankaj (2006) and Muhammad and Javed (2001).

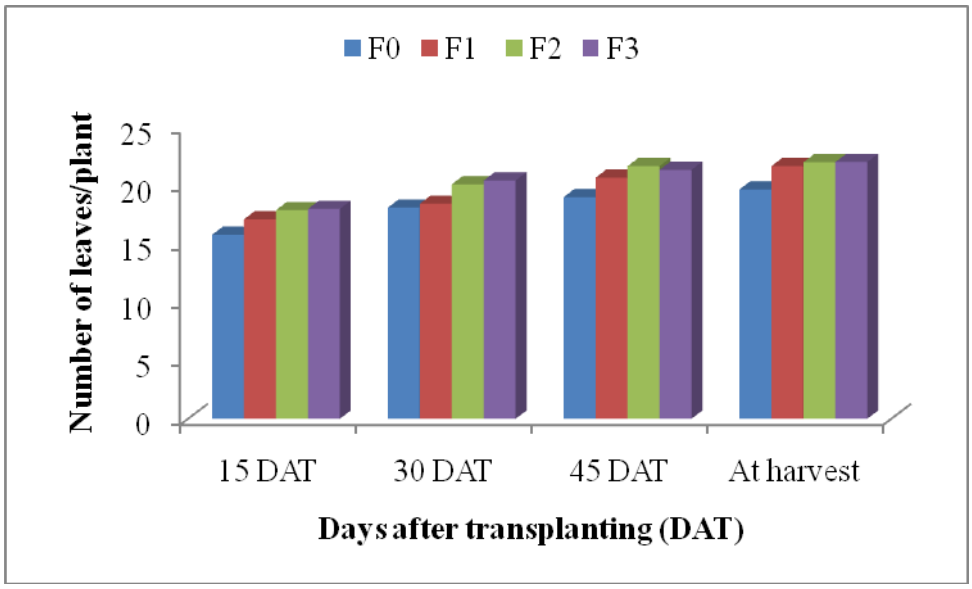


Fig 4: Effect of different fertilizer on number of leaves/plant of different cabbage cultivar at different growth stages ($LSD_{0.05}$ = 0.884, 1.027, 0.965 and 0.848 at 15, 30, 45 DAT and at harvest respectively)

4.1.2.3 Interaction effect of variety and fertilizer

Interaction effect of variety and different types manure and fertilizer affected number of leaves/plant significantly under the present study (Table 2 and Appendix IV). Different treatment combination viewed different number of leaves/plant according to the treatment at different days after transplanting (DAT). It was observed that highest number of leaves/plant was achieved with V_3F_3 and that was 18.33, 22.33, 24.00 and 25.00 at 15, 30, 45 DAT and at harvest respectively which was closely followed by V_2F_1, V_2F_2, V_3F_1 and V_3F_2 at harvest. On the other hand the lowest number of leaves/plant; 15.33, 16.67, 18.03 and 18.00 at 15, 30, 45 DAT and at harvest respectively was obtained with V_1F_0 which was statistically identical with V_1F_1 at all growth stages of cabbage cultivars.

Table 2: Interaction effect of fertilizer management and three different cabbage cultivars on number of leaves/plant at different growth stages

Treatments	Number of leaves/plant			
	15 DAT	30 DAT	45 DAT	At harvest
Interaction effect of variety and fertilizer				
V_1F_0	15.33 d	16.67 f	18.03 e	18.00 d
V_1F_1	15.35 d	15.67 f	17.03 e	18.04 d
V_1F_2	18.33 a	18.67 e	20.00 d	20.00 cd
V_1F_3	17.00 a-d	18.67 e	20.00 d	19.00 d
V_2F_0	15.67 cd	19.33 c-e	21.00 cd	22.00 bc
V_2F_1	17.68 ab	19.00 de	22.00 bc	23.00 ab
V_2F_2	18.00 ab	21.00 b	22.00 bc	23.00 ab
V_2F_3	18.36 a	20.33 b-d	20.04 d	22.00 bc
V_3F_0	16.33 b-d	18.33 e	18.00 e	19.00 d
V_3F_1	18.33 a	20.67 bc	23.00 ab	24.00 ab
V_3F_2	17.33 a-c	20.67 bc	23.00 ab	23.00 ab
V_3F_3	18.69 a	22.33 a	24.00 a	25.00 a
$LSD_{0.05}$	1.704	1.313	1.607	2.161
CV (%)	5.78	4.24	7.11	8.42

4.1.3 Leaf length with petiole

4.1.3.1 Effect of variety

Leaf length/plant is one of the important parameter for measuring yield performance of cabbage variety (Figure 5 and Appendix V). Under the present study, leaf length/plant with petiole was significantly influenced by different cabbage cultivars. Different varieties showed different leaf length with petiole at different growth stages. It was measured that Atlas – 70 (V_1) demonstrated the highest leaf length/plant with petiole at 15, 30, 45 DAT and at harvest (20.70, 27.09, 29.45 and 32.00 cm respectively) which was closely followed by Keifu – 65 (V_2) at 15 DAT. But at 15, 30, 45 DAT and at harvest (19.14, 25.33, 27.96 and 29.82 cm respectively) Autumn – 60 (V_3) showed lowest leaf length/plant with petiole which was statistically identical with Keifu – 65 (V_2) at 30 and 45 DAT. The results obtained from the experiment on leaf length/plant with petiole might be due to cause of varietal effect, soil type, nutrient availability etc. and this results are agreement with Muhammad and Javed (2001)

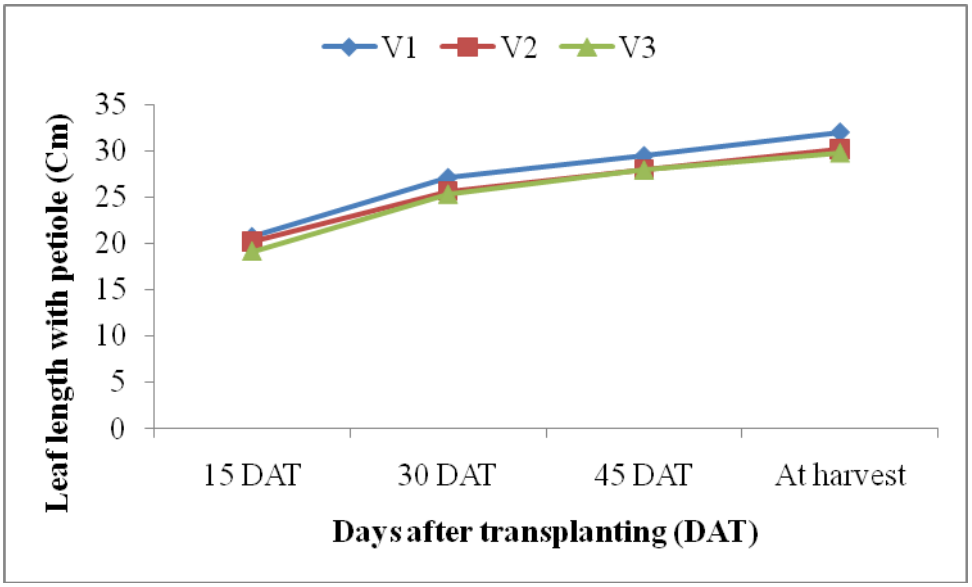


Fig 5: Leaf length with petiole at different growth stages of three different cabbage cultivars ($LSD_{0.05}$ = 0.9978, 1.088, 0.04637 and 0.0379 at 15, 30, 45 DAT and at harvest respectively)

4.1.3.2 Effect of fertilizer

Significant variation was observed for leaf length/plant with petiole at different days after transplanting (DAT) (Figure 6 and Appendix V). It was considered that the highest leaf length/plant with petiole was obtained with inorganic fertilizer (F_3) and the highest value was 20.71, 27.13, 29.37 and 31.48 at 15, 30, 45 DAT and at harvest respectively which was statistically identical with the treatment of Poultry manure (F_2) at all growth stages of cabbage cultivars. The lowest leaf length/plant with petiole was 19.26, 24.83, 27.28 and 29.78 at 15, 30, 45 DAT and at harvest respectively. The results obtained under the present experiment was supported by Souza *et al*. (2008).

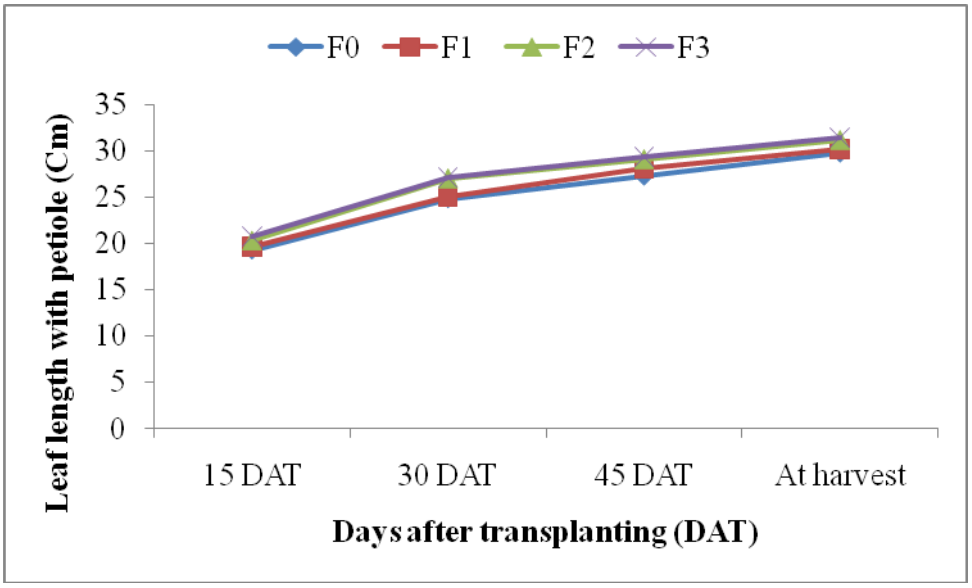


Fig 6: Effect of different fertilizer on leaf length with petiole of different cabbage cultivar at different growth stages ($LSD_{0.05}$ = 0.6097, 1.257, 0.3592 and 0.3437 at 15, 30, 45 DAT and at harvest respectively)

4.1.3.3 Interaction effect of variety and fertilizer

Leaf length/plant with petiole varied significantly with interaction effect of variety and different type manure and fertilizer under the present study (Table 3 and Appendix V). Different treatment combination viewed different leaf length/plant with petiole at different days after transplanting (DAT). It was observed that highest leaf length/plant with petiole was achieved with V_1F_3 and that was 22.10, 27.73, 30.07 and 33.41 cm at 15, 30, 45 DAT and at harvest respectively which was statistically identical at 45 DAT and closely followed at 15, 30 DAT by V_1F_2. On the other hand the lowest leaf length/plant with petiole; 18.40, 23.27, 26.21 and 28.92 cm at 15, 30, 45 DAT and at harvest respectively was obtained with V_3F_0 which was statistically identical with V_2F_0 and V_2F_1 at harvest.

Table 3: Interaction effect of fertilizer management and three different cabbage cultivars on leaf length with petiole at different growth stages

Treatments	Leaf length with petiole (Cm)			
	15 DAT	30 DAT	45 DAT	At harvest
Interaction effect of variety and fertilizer				
V_1F_0	19.08 bc	26.57 cd	28.82 c	32.07 b
V_1F_1	20.37 a-c	26.40 d	28.13 d	30.32 d
V_1F_2	21.24 ab	27.67 ab	30.00 a	32.22 b
V_1F_3	22.10 a	27.73 a	30.07 a	33.41 a
V_2F_0	20.30 a-c	23.80 f	27.13 e	29.20 e
V_2F_1	19.79 bc	24.73 e	27.11 e	29.31 e
V_2F_2	20.55 a-c	27.07 bc	29.60 ab	31.13 c
V_2F_3	19.83 bc	26.27 d	29.72 ab	29.90 d
V_3F_0	18.40 c	23.27 f	26.21 f	28.92 e
V_3F_1	18.75 c	24.83 e	27.52 e	30.11 d
V_3F_2	19.23 bc	26.60 cd	28.10 d	31.10 c
V_3F_3	20.19 a-c	27.23 ab	29.22 bc	30.32 d
$LSD_{0.05}$	1.996	0.5817	0.5692	0.5408
CV (%)	4.81	6.58	5.14	7.33

4.1.4 Leaf breadth

4.1.4.1 Effect of variety

Leaf breadth/plant is also another important parameter for measuring yield performance of cabbage variety (Figure 7 and Appendix VI). Under the present study, leaf breadth/plant was significantly influenced by different cabbage cultivars. Different varieties showed different leaf breadth at different growth stages. It was precise that Keifu – 65 (V_2) demonstrated the highest leaf breadth/plant at 15, 30, 45 DAT and at harvest (12.69, 19.90, 21.21 and 22.39 cm respectively) but the lowest was obtained with Atlas – 70 (V_1) at 15, 30, 45 DAT and at harvest (10.93, 16.75, 18.59 and 19.84 cm respectively). The results obtained from the experiment on leaf breadth might be due to cause of varietal effect, soil type, nutrient availability etc.

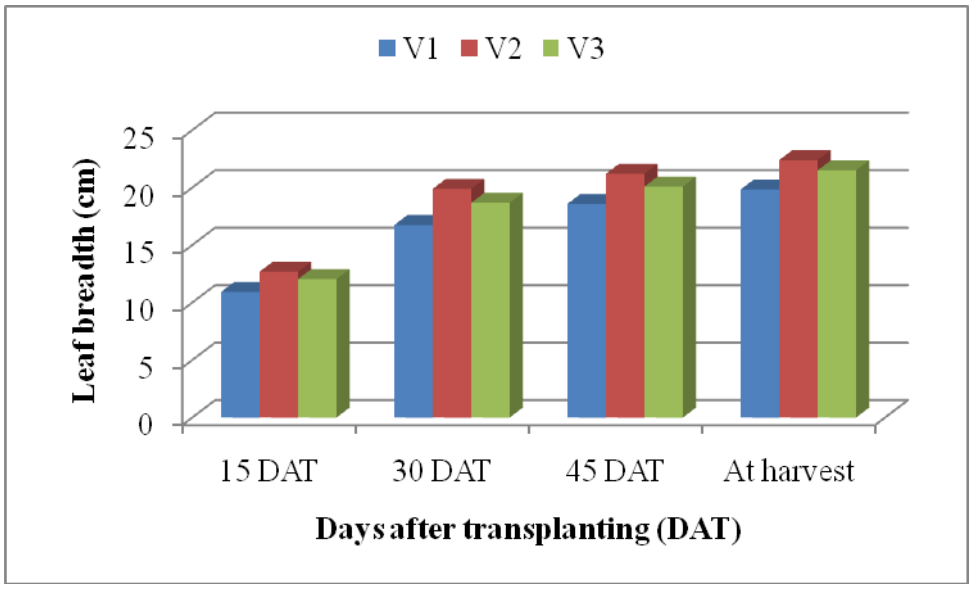


Fig 7: Leaf breadth at different growth stages of three different cabbage cultivars ($LSD_{0.05}$ = 1.465, 1.575, 0.0803 and 0.1136 at 15, 30, 45 DAT and at harvest respectively)

4.4.4.2 Effect of fertilizer

Leaf breadth/plant was significantly varied with different types of fertilizer and manure application for growth and development of cabbage cultivars at different days after transplanting (DAT) (Figure 8 and Appendix VI). It was measured that the highest leaf breadth/plant was obtained with inorganic fertilizer (F_3) and that was 12.64, 19.76, 21.39 and 22.59 at 15, 30, 45 DAT and at harvest respectively which was statistically identical with treatment of poultry manure (F_2) at 30 DAT. On the other hand, the lowest leaf breadth/plant was found; 11.26, 17.13, 18.70 and 19.78 cm at 15, 30, 45 DAT and at harvest respectively with control treatment (F_0). . The results obtained under the present experiment was supported by Souza *et al*. (2008).

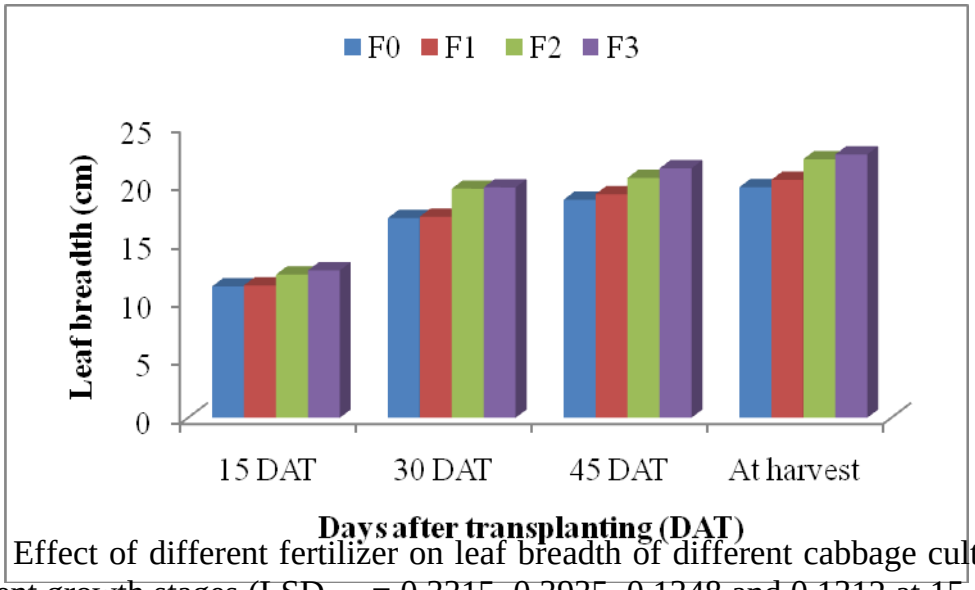


Fig 8: Effect of different fertilizer on leaf breadth of different cabbage cultivar at different growth stages ($LSD_{0.05}$ = 0.3315, 0.3935, 0.1348 and 0.1312 at 15, 30, 45 DAT and at harvest respectively)

4.1.4.3 Interaction effect of variety and fertilizer

Significant variation was observed incase of leaf breadth/plant with interaction effect of variety and different type manure and fertilizer under the present study (Table 4 and Appendix VI). Different treatment combination viewed different leaf breadth/plant at different days after transplanting (DAT). It was observed that the highest leaf breadth/plant was achieved with V_2F_3 and that was 13.23, 21.12, 22.11 and 23.30 cm at 15, 30, 45 DAT and at harvest respectively which was closely followed at 15 and statistically identical at 30 DAT with V_2F_2. On the other hand the lowest leaf breadth/plant; 10.08, 15.58, 17.21 and 18.21 cm at 15, 30, 45 DAT and at harvest respectively was obtained with V_1F_0 which was statistically identical at 30 DAT and at harvest and closely followed at 15 and 45 DAT by V_1F_1.

Table 4: Interaction effect of fertilizer management and three different cabbage cultivars on leaf breadth at different growth stages

Treatments	Leaf breadth (cm)			
	15 DAT	30 DAT	45 DAT	At harvest
Interaction effect of variety and fertilizer				
V_1F_0	10.08 g	15.58 f	17.21 g	18.21 g
V_1F_1	10.47 fg	15.71 f	17.52 fg	18.50 g
V_1F_2	11.76 cd	18.49 bc	19.52 e	21.12 de
V_1F_3	11.39 de	17.23 de	20.10 de	21.53 cd
V_2F_0	12.35 bc	19.04 bc	20.70 c	22.00 bc
V_2F_1	12.11 cd	18.36 bcd	20.50 cd	21.83 bc
V_2F_2	13.06 ab	21.09 a	21.53 b	22.41 b
V_2F_3	13.23 a	21.12 a	22.11 a	23.30 a
V_3F_0	10.97 ef	16.65 ef	17.89 f	19.12 f
V_3F_1	11.88 cd	17.80 cde	19.83 e	20.91 e
V_3F_2	12.02 cd	19.33 b	20.10 cde	22.13 bc
V_3F_3	13.30 a	20.95 a	22.53 a	23.82 a
$LSD_{0.05}$	0.7477	1.151	0.5590	0.5817
CV (%)	7.23	6.18	6.42	8.13

4.1.5 Root length

4.1.5.1 Effect of variety

Root length is an important plant character for contributing higher yield performance and it differs with varieties in accordance with genetical characters of the cultivar. Under the present study, root length was significantly influenced by different cabbage cultivars (Table 5 and Appendix VII). Different varieties showed different root length and it was measured at the time of harvest. It was defined that Autumn – 60 (V_3) verified the highest root length at harvest (22.62 cm) which was statistically identical with Keifu – 65 (V_2). But the lowest root length (18.03 cm) among the cultivars was obtained with Atlas – 70 (V_1) at harvest. The results was represented under the present experiment might be due to cause of water and nutrient availability on soil characteristic that cause higher and lower root length of plants.

4.1.5.2 Effect of fertilizer

Manure and fertilizer effect on root length was significant under the present study. It is evident that different types of manure and fertilizer showed different root length (Table 5 and Appendix VII). The highest root length was indicated with the treatment of Poultry manure (F_2) which was statistically identical with control (F_0) treatment and statistically similar with Inorganic fertilizer (F_3) treated plot. On the other hand, the lowest root length was measured with cowdung (F_1) treatment. The results obtained under the present experiment was in agreement with Souza *et al*. (2008).

4.1.5.3 Interaction effect of variety and fertilizer

Interaction effect of different variety and manures and fertilizer had significant effect on root length. Different treatment combination showed different root length (Table 5 and Appendix VII). The highest root length (23.22 cm) was observed whit V_3F_2 which was statistically identical with V_2F_0, V_2F_1, V_2F_2, V_3F_0, V_3F_1, V_3F_2 and V_3F_3. On the other hand, the lowest root length (16.11 cm) was observed with V_1F_1.

4.1.6 Stem length

4.1.6.1 Effect of variety

Stem length is also an important phenotypic plant character controlled genetically which differs within the varieties. Under the present study, stem length was significantly influenced by different cabbage cultivars (Table 5 and Appendix VII). Different varieties showed different stem length and it was deliberate at the time of harvest. It was defined that Atlas – 70 (V_1) verified the highest stem length at harvest (4.194 cm) which was closely followed by Keifu – 65 (V_2) and the lowest stem length (3.678 cm) among the cultivars was obtained Autumn – 60 (V_3) at harvest. Varietal effect was observed on shoot/stem length due to it's phenotypical characters (Haque, 2005) and this result on stem length is supported by Haque, 2005.

4.1.6.2 Effect of fertilizer

Manure and fertilizer effect on stem length was significant under the present study. It is evident that different types of manure and fertilizer showed different stem length (Table 5 and Appendix VII). The highest stem length (4.203 cm) was indicated with the treatment of Cowdung (F_1) which was statistically identical with control (F_0) treatment and Inorganic fertilizer (F_3) treated plot. On the other hand, the lowest root length was measured with poultry manure (F_2) treatment. Data of stem length under the present study was in agreement with Souza *et al*. (2008).

4.1.6.3 Interaction effect of variety and fertilizer

Interaction effect of different variety and manures and fertilizer had significant effect on stem length. Different treatment combination showed different root length (Table 5 and Appendix VII). The highest root length (4.557 cm) was observed whit V_1F_1 which was statistically identical with V_2F_1 and statistically similar with V_3F_0. On the other hand, the lowest stem length (3 cm) was observed with V_3F_2 which was closely followed by V_2F_0.

Table 5: Effect of fertilizer management and cabbage cultivars on growth parameters; root length and stem length at harvest

Treatments	Root length at harvest (cm)	Stem length at harvest (cm)
Effect variety		
V_1	18.03 b	4.194 a
V_2	22.31 a	3.938 ab
V_3	22.62 a	3.678 b
$LSD_{0.05}$	1.319	0.4300
Effect of fertilizer		
F_0	21.22 a	4.019 a
F_1	20.26 b	4.203 a
F_2	21.67 a	3.481 b
F_3	20.79 ab	4.043 a
$LSD_{0.05}$	1.167	0.4966
Interaction effect of variety and fertilizer		
V_1F_0	18.45 c	4.333 ab
V_1F_1	16.11 d	4.557 a
V_1F_2	18.89 c	3.777 c-e
V_1F_3	18.67 c	4.110 a-c
V_2F_0	22.94 a	3.333 fg
V_2F_1	22.39 a	4.546 a
V_2F_2	22.89 a	3.667 d-f
V_2F_3	21.00 b	4.193 a-c
V_3F_0	22.27 a	4.390 ab
V_3F_1	22.27 a	3.943 b-d
V_3F_2	23.22 a	3.000 g
V_3F_3	22.71 a	3.380 e-g
$LSD_{0.05}$	1.105	0.4078
CV (%)	5.33	7.58

4.2 Yield contributing parameters

4.2.1 Thickness of head

4.2.1.1 Effect of variety

Generally thickness of head of cabbage cultivar control yield and quality of the crop and it is greatly influenced by different varietal characters. Result showed that there was no significant effect among the there cabbage cultivar considering thickness of head (Table 6 and Appendix VII). In spite of non-significant variation, the highest (13.44 cm) and lowest (12.76 cm) thickness of head was

achieved by Autumn – 60 (V_3) and Keifu – 65 (V_2) respectively. The data obtained on thickness of head was conformity with Haque (2005).

4.2.1.2 Effect of fertilizer

Thickness of head was significantly influenced by manure and fertilizer under the present study (Table 6 and Appendix VII). It is evident that the highest thickness of head (13.78 cm) was obtained with the treatment of Inorganic fertilizer (F_3) which was significantly different from all other treatment. On the other hand, the lowest thickness of head (12.55 cm) was measured with Control (F_0) treatment which was significantly same with cowdung (F_1). Souza *et al*. (2008), Bimova (2008) showed the similar results which supported the data on thickness of head under the present study.

4.2.1.3 Interaction effect of variety and fertilizer

Interaction effect of different variety and manures and fertilizer had significant effect on thickness of head. Different treatment combination showed different thickness of head (Table 6 and Appendix VII). The highest thickness of head (14.44 cm) was observed whit V_3F_3 and the lowest thickness of head (11.83 cm) was with V_1F_0. The results obtained from all other treatments was significantly different from highest and lowest thickness of head.

4.2.2 Diameter of head

4.2.2.1 Effect of variety

Diameter of head is a measurement of the size of actual cabbage shape which indicates yield amount and/or market value. Significant variation was observed incase of diameter of head among the cabbage cultivar (Table 6 and Appendix VII). Result revealed that the highest diameter of head (2024 cm) was achieved with Atlas – 70 (V_1) where the lowest (18.03 cm) was with Autumn – 60 (V_3). Similar results were obtained by Haque (2005) and Muhammad and Javed (2001) with their experiments.

4.2.2.2 Effect of fertilizer

Diameter of head was significantly influenced by manure and fertilizer under the present study (Table 6 and Appendix VII). It is evident that the highest diameter of head (20.25 cm) was obtained with the treatment of Inorganic fertilizer (F_3) which was significantly different from all other treatment. On the other hand, the lowest diameter of head (18.06 cm) was measured with control (F_0) treatment. Data measurement on head diameter was in agreement with Souza *et al*. (2008) and Vimala (2006).

4.2.2.3 Interaction effect of variety and fertilizer

Interaction effect of different variety and manures and fertilizer had significant effect on diameter of head. Different treatment combination showed different diameter of head (Table 6 and Appendix VII). The highest diameter of head (21.44 cm) was observed whit V_1F_3 which was statistically same with V_1F_2 and the lowest diameter of head (16.56 cm). The results obtained from all other treatment was significantly different from highest and lowest diameter of head.

Table 6: Effect of fertilizer management and cabbage cultivars on yield contributing parameters; Thickness of head and Diameter of head at harvest

Treatments	Thickness of head (cm) at harvest	Diameter of head (cm) at harvest
Effect variety		
V_1	13.03	20.24 a
V_2	12.76	18.85 b
V_3	13.44	18.03 c
$LSD_{0.05}$	NS	0.8160
Effect of fertilizer		
F_0	12.55 c	18.06 d
F_1	12.63 c	18.46 c
F_2	13.36 b	19.37 b
F_3	13.78 a	20.25 a
$LSD_{0.05}$	0.2375	0.3511
Interaction effect of variety and fertilizer		
V_1F_0	11.83 f	19.45 bc
V_1F_1	12.48 e	19.17 c
V_1F_2	13.48 bc	20.89 a
V_1F_3	13.89 b	21.44 a
V_2F_0	13.09 cd	18.18 d
V_2F_1	12.28 e	18.11 d
V_2F_2	13.11 cd	19.11 c
V_2F_3	13.01 d	19.99 b
V_3F_0	12.52 e	16.56 e
V_3F_1	13.33 cd	18.11 d
V_3F_2	13.48 bc	18.11 d
V_3F_3	14.44 a	19.33 c
$LSD_{0.05}$	0.4113	0.6082
CV (%)	4.48	5.66

4.2.3 Weight of whole plant

4.2.3.1 Effect of variety

Determination of whole plant weight is an important measurement for comparing yield performance among the cabbage cultivars under the present study. Weight of whole plant was significantly influenced by different cabbage cultivar (Table 7 and Appendix VIII). Results showed that the highest whole plant weight (2.23 kg/plant) was with Atlas – 70 (V_1) where the lowest (1.96 kg/plant) was with Autumn – 60 (V_3). Supported results with the present study was achieved by Haque (2005), Muhammad and Javed (2001).

4.2.3.2 Effect of fertilizer

Weight of whole plant was significantly influenced by manure and fertilizer under the present study (Table 7 and Appendix VIII). It is evident that the highest whole plant weight (2.41 kg/plant) was obtained with the treatment of Inorganic fertilizer (F_3) which was significantly same with Poultry manure (F_2) treated plot. On the other hand, the lowest whole plant weight (1.80 kg/plant) was measured with Control (F_0) treatment which was significantly same with cowdung (F_1) treated plot that is suggested by Pankaj (2006) and Hsieh (2004)

4.2.3.3 Interaction effect of variety and fertilizer

Interaction effect of different variety and manures and fertilizer had significant effect on whole plant weight. Different treatment combination showed different whole plant weight (Table 7 and Appendix VIII). The highest whole plant weight (2.56 kg/plant) was observed with the treatment combination of V_1F_2. The lowest s whole plant weight (1.57 kg/plant) was obtained with V_3F_0 which was statistically identical with V_3F_1. The results obtained from all other treatment was significantly different from highest and lowest whole plant weight.

4.3 Yield parameters

4.3.1 Gross yield

4.3.1.1 Effect of variety

Yield is the main achievement for performing production of a crop. Highest and quality yield is the main goal of crop production. Under the present, gross yield was significantly affected by different cabbage cultivar (Table 7 and Appendix VIII). The yield (28.00 kg/plot and 46.67 t/ha) obtained from Atlas – 70 (V_1) was the highest but the variety, Autumn – 60 (V_3) viewed lowest yield (22.75 kg/plot and 37.91 t/ha) which was statistically identical with Keifu – 65 (V_2) incase of kg/plot production. The results achieved by Haque (2005), Muhammad and Javed (2001) was similar to the present study.

4.3.1.2 Effect of fertilizer

Gross yield was significantly influenced by manure and fertilizer under the present study (Table 7 and Appendix VIII). It is evident that the highest gross yield (29.61 kg/plot and 49.34 t/ha) was obtained with the treatment of poultry manure (F_2) which was statistically identical with inorganic fertilizer treated plot (F_3). On the other hand, the lowest yield (15.65 kg/plot) was measured with control (F_0) treatment which was significantly different from all other treatment. The results obtained from the experiment was partially conformed with Hsieh (2004) and Chan *et al*. (2008).

4.3.1.3 Interaction effect of variety and fertilizer

Interaction effect of different variety and manures and fertilizer had significant effect on gross yield (kg/plot) of cabbage cultivars (Table 7 and Appendix VIII). Different treatment combination showed different yield (Table). The highest gross yield (37.28 kg/plot and 62.14 t/ha) was observed with the treatment combination of V_1F_2. The treatment combination, V_1F_3 and V_3F_3 also showed higher yield but significantly lower than V_1F_2. The lowest gross yield (14.60 kg/plot and 24.34 t/ha) was obtained with V_3F_0 which was closely related to V_1F_0 and V_2F_0 incase of kg/plot production. The results obtained from all other treatments was significantly different from highest and lowest yield. Similar findings are observed with Yau (2006).

4.3.2 Marketable yield

4.3.2.1 Effect of variety

Marketable yield was significantly affected by different variety used in the present experiment (Table 7 and Appendix VIII). The highest marketable yield (27.42 kg/plot and 45.29 t/ha) was obtained from Atlas – 70 (V_1) but the variety, Autumn – 60 (V_3) viewed lowest marketable yield (21.57 kg/plot and 35.95 t/ha) which was statistically different from another two varieties. The results achieved by Haque (2005), Muhammad and Javed (2001) was similar to the present study.

4.3.2.2 Effect of fertilizer

Marketable yield was significantly influenced by application of different manure and fertilizer according to the treatment under the present study (Table 7 and Appendix VIII). It is evident that the highest marketable yield (28.92 kg/plot and 47.92 t/ha) was obtained with the treatment of poultry manure (F_2) which was statistically identical with inorganic fertilizer treated plot (F_3). On the other hand, the lowest marketable yield (14.34 kg/plot 23.90 t/ha) was measured with Control (F_0) treatment. The results obtained from the experiment was conformity with Hsieh (2004) and Chan *et al*. (2008).

4.3.2.3 Interaction effect of variety and fertilizer

Interaction effect of different variety and manures and fertilizer had significant effect on marketable yield of cabbage cultivars. Different treatment combination showed different yield (Table 7 and Appendix VIII). The highest marketable yield (36.91 kg/plot and 61.52 t/ha) was observed with the treatment combination of V_1F_2. The treatment combination, V_1F_3 and V_3F_3 also showed higher yield but significantly lower than V_1F_2. The lowest marketable yield (13.28 kg/plot and 22.13 t/ha) was obtained with V_3F_0 which was closely related to V_2F_0. The results obtained from all other treatments was significantly different from highest and lowest yield. Similar findings are observed with Yau (2006).

4.3.3 Economic production

4.3.3.1 Effect of variety

Economic production is considered as small unit production i.e. per plant production/yield and it is termed as kg/plant yield. Under the present, economic production was significantly affected by different cabbage cultivar (Table 7 and Appendix VIII). The highest result (1.576 kg/plant) was obtained from Atlas – 70 (V_1). But the variety, Autumn – 60 (V_3) viewed lowest economic production (1.58 kg/plant) which was significantly identical with Autumn – 60 (V_3).

4.3.3.2 Effect of fertilizer

Economic production was significantly influenced by manure and fertilizer under the present study (Table 7 and Appendix VIII). It is evident that the highest economic production (1.584 kg/plant) was obtained with the treatment of Inorganic fertilizer (F_3) which was significantly same with Poultry manure (F_2) treated plot. On the other hand, the lowest economic production (1.178 kg/plant) was measured with Control (F_0) treatment which was significantly same with cowdung (F_1) treated plot.

4.3.3.3 Interaction effect of variety and fertilizer

Interaction effect of different variety and manures and fertilizer had significant effect on economic production. Different treatment combination showed different economic production (Table 7 and Appendix VIII). The highest economic production (1.853 kg/plant) was observed with the treatment combination of V_1F_2 which was statistically similar with V_1F_3. The lowest economic production (0.977 kg/plant) was obtained with V_3F_0 which was closely followed by V_2F_0 and V_3F_1. The results obtained from all other treatment was significantly different from highest and lowest whole plant weight.

Table 7: Effect of fertilizer management and cabbage cultivars on yield parameters; weight of whole plant at harvest, gross yield, marketable yield and economic production (kg/plant) at harvest

Treatments	Weight of whole plant at harvest (kg/plant)	Gross yield (kg/plot)	Marketable yield (kg/plot)	Gross yield (t/ha)	Marketable yield (t/ha)	Economic production (kg/plant) at harvest
Effect of variety						
V_1	2.23 a	28.00 a	27.42 a	46.67 a	45.29 a	1.576 a
V_2	2.10 b	23.57 b	22.51 b	39.27 b	37.51 b	1.311 b
V_3	1.96 c	22.75 b	21.57 c	37.91 c	35.95 c	1.226 b
$LSD_{0.05}$	0.093	0.9466	0.8169	1.100	1.199	0.2159
Effect of fertilizer						
F_0	1.80 b	15.65 c	14.34 c	26.08 c	23.90 c	1.178 b
F_1	1.86 b	24.38 b	23.32 b	40.64 b	38.87 b	1.198 b
F_2	2.30 a	29.61 a	28.92 a	49.34 a	47.92 a	1.523 a
F_3	2.41 a	29.45 a	28.75 a	49.09 a	47.64 a	1.584 a
$LSD_{0.05}$	0.339	1.093	0.9433	1.270	1.384	0.2492
Interaction effect of variety and fertilizer						
V_1F_0	2.09 de	16.57 e	15.31 g	27.61 f	25.52 f	1.450 cd
V_1F_1	1.88 f	26.93 c	26.17 d	44.89 c	43.62 c	1.257 de
V_1F_2	2.56 a	37.28 a	36.91 a	62.14 a	61.52 a	1.853 a
V_1F_3	2.39 a-c	31.24 b	31.31 b	52.06 b	50.51 b	1.743 ab
V_2F_0	1.87 f	15.77 e	14.43 gh	26.28 fg	24.05 fg	1.107 ef
V_2F_1	1.97 ef	23.86 d	22.79 e	39.76 d	37.98 d	1.250 de
V_2F_2	2.23 cd	27.53 c	26.50 d	45.88 c	44.17 c	1.463 cd
V_2F_3	2.34 bc	27.10 c	26.30 d	45.16 c	43.84 c	1.423 cd
V_3F_0	1.57 g	14.60 e	13.28 h	24.34 g	22.13 g	0.977 f
V_3F_1	1.63 g	22.36 d	21.01 f	37.26 e	35.02 e	1.087 ef
V_3F_2	2.11 de	24.01 d	22.85 e	40.01 d	38.08 d	1.253 de
V_3F_3	2.51 ab	30.02 b	29.15 c	50.04 b	48.58 b	1.587 bc
$LSD_{0.05}$	0.186	1.893	1.634	2.199	2.398	0.2074
CV (%)	6.14	4.51	5.83	7.18	4.62	7.46

4.4 Economic analysis of cabbage production

Economic analysis in details was done according to the procedure of Alam *et al.* (1989). Material, non-material and overhead cost including harvesting of the marketable head were recorded for all the treatments and calculated on per hectare basis. The price of cabbage in Dhaka local market was monitored. The

cost and return were worked out and the data were presented in Table 8 and appendix IX and X.

4.4.1 Cost of production

Total cost of production ranged from Tk. 57291 to Tk. 92811/ha. Among the treatments the variation was due to the cost of different fertilizers and manures (Table 8 and Appendix IX and Appendix X). The total production cost was the lowest for the treatment V_3F_0 (Variety: Autumn – 60 with no fertilizer application) and the highest for treatment V_1F_2 (Variety: Atlas – 70 with poultry manure application @ 15 t/ha).

4.4.2 Gross return

Gross return from different treatments ranged from Tk. 110650 to Tk. 307600 per hectare (Table 8). The highest gross return was obtained from the treatment V_1F_2 (Variety: Atlas – 70 with poultry manure application @ 15 t/ha) and the lowest gross return from V_3F_0 (Variety: Autumn – 60 with no fertilizer application).

4.4.3 Net return

Net return or net profit was calculated through excluding the production cost from the gross return (Table 8). It varied from Tk. 53359.00 to Tk. 214789.00/ha. The highest net return was obtained from the treatment of V_1F_2 (Variety: Atlas – 70 with poultry manure application @ 15 t/ha) followed by the treatment V_1F_3 (Variety: Atlas – 70 with inorganic fertilizer) while the lowest net return was found from V_3F_0 (Variety: Autumn – 60 with no fertilizer application).

4.4.4 Benefit cost ratio (BCR)

The benefit cost ratio was the highest (3.31) in the treatment V_1F_2 (Variety: Atlas – 70 with poultry manure application @ 15 t/ha) (Table 8). The second and third highest benefit cost ratio (2.99 and 2.90) were found in the treatments V_1F_3

(Variety: Atlas – 70 with inorganic fertilizer application) and V_3F_3 (Variety: Autumn – 60 with inorganic fertilizer application), respectively while the lowest (1.93) benefit cost ratio was recorded from V_3F_0 (Variety: Autumn – 60 with no fertilizer application). From the economic point of view the above results indicated that treatment V_1F_2 (Variety: Atlas – 70 with poultry manure application @ 15 t/ha) was more profitable than the other treatments for the cabbage production.

Table 8: Cost and return analysis of cabbage production due to use of different fertilizer with combination of different variety

Treatments	**Marketable yield (t/ha)**	**Gross Return**	**Cost of production**	**Net return**	**BCR**
V_1F_0	25.52	127600	57957.00	69643.00	2.21
V_1F_1	43.62	218100	84819.00	133281.00	2.57
V_1F_2	61.52	307600	92811.00	214789.00	3.31
V_1F_3	50.51	252550	84330.60	168219.40	2.99
V_2F_0	24.05	120250	57402.00	62848.00	2.09
V_2F_1	37.98	189900	84264.00	105636.00	2.25
V_2F_2	44.17	220850	92256.00	128594.00	2.39
V_2F_3	43.84	219200	83775.60	135424.40	2.62
V_3F_0	22.13	110650	57291.00	53359.00	1.93
V_3F_1	35.02	175100	84153.00	90947.00	2.08
V_3F_2	38.08	190400	92145.00	98255.00	2.07
V_3F_3	48.58	242900	83664.60	159235.40	2.90

Sale of marketable cabbage head @ Tk. 5000/t, Gross return = Marketable yield × 5000, BCR = Gross return ÷ cost of production

CHAPTER 5

SUMMARY AND CONCLUSION

Summary:

An experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the Growth and Yield of Cabbage Cultivars as Influenced by Fertilizers. The experiment comprised of two different factors such as (1) three varieties viz. V_1 (Atlas – 70), V_2 (Keifu – 65) and V_3 (Autumn – 60) (2) Four levels of fertilizer application viz. F_0 (Control), F_1 (Cowdung), F_2 (Poultry manure), and F_3 (Inorganic fertilizer).

The experiment was set up in Randomized Complete Block Design (factorial) with three replications. There were 12 treatment combinations. The experimental plot was fertilized as per treatment with organic and inorganic fertilizer. Data on different growth and yield parameters were recorded and analyzed statistically.

Data were collected on Plant height, Number of leaves/plant, Leaf length with petiole (cm), Leaf breadth (cm), Root length at harvest (cm), Stem length at harvest (cm), Thickness of head (cm) at harvest, Diameter of head (cm) at harvest, Weight of whole plant at harvest (kg/plant), Yield (gross yield and marketable yield) and Economic production (kg/plant) at harvest. Cost of production, gross return, net return and benefit cost ration (BCR) were also evaluated to identify the higher performance of variety and fertilizer (organic and inorganic) effect in respective of highest return. Three effects have been considered to evaluate the experiment such as (i) Effect of variety, (ii) Effect of fertilizer and (iii) Interaction effect of variety and fertilizer. Results showed all the parameters studied in the present experiment were significantly influenced by different varieties of cabbage cultivars, different fertilizers (organic and inorganic) and their combination.

It was observed that the highest results on plant character parameters; Plant height (31.94 cm), Leaf length with petiole (32.00 cm), Stem length (4.194 cm), Diameter of head (20.24 cm), Weight of whole plant (2.23 kg/plant), gross yield (28.00 kg/plot and 46.67 t/ha), marketable yield (27.42 kg/plot and 45.29 t/ha)

and Economic production (1.576 kg/plant) at the time of harvest were with the variety of Atlas – 70 (V_1). But the highest results on Number of leaves/plant (22.75) and Root length (22.62 cm) were obtained with Autumn – 60 (V_3) and leaf breadth (22.39 cm) was by Keifu – 65 (V_2) cultivars. Growth and yield performance of different cabbage cultivar was the lowest incase of Plant height (31.04 cm), Leaf length with petiole (29.82 cm), Stem length (3.678 cm), Diameter of head (18.03 cm), Weight of whole plant (1.96 kg/plant, gross yield (22.75 kg/plot and 37.91 t/ha), marketable yield (21.57 kg/plot and 35.95 t/ha) and Economic production (1.226 kg/plant) at harvest were with Autumn – 60 (V_3) and for Number of leaves/plant (18.75), Leaf breadth (19.84 cm), Root length (18.03 cm) at harvest were with Atlas – 70 (V_1).

Different fertilizers (organic and inorganic) had also significant effect on different parameters as considering under the present study. The highest results on Plant height (32.55 cm), Number of leaves/plant (22.02), Leaf length with petiole (31.48 cm), Leaf breadth (22.59 cm), Root length (20.79 cm), Stem length (4.043 cm), Thickness of head (13.78 cm), Diameter of head (20.25 cm), Weight of whole plant (2.41 kg/plant) and Economic production (1.58 kg/plant) at the time of harvest were observed with the treatment of Inorganic fertilizer (F_3) where incase of Leaf length with petiole (31.21 cm), Weight of whole plant (2.30 kg/plant) and Economic production (1.523 kg/plant) fertilized with Poultry manure (F_2) showed non-significant difference with F_3. Again, the best yield performance; gross yield (29.61 kg/plot and 49.34 t/ha), marketable yield (28.92 kg/plot and 47.92t/ha) was achieved by Poultry manure (F_2) treated plot where inorganic fertilizer (F_3) showed non-significant difference with F_2. But among all the parameters, incase of fertilizer application, the lowest results were obtained with control treatment (F_0).

Interaction effect of variety and fertilizer managed under the present study were significant incase of all parameters considered for the experiment. Considering growth parameters of the study i.e. Plant height, Number of leaves/plant, Leaf length with petiole, Leaf breadth, Root length and Stem length and yield

contributing parameters i.e. Thickness of head and Diameter of head under the present study showed diversified results comparing highest and lowest results.

The highest Plant height (33.11 cm), Leaf length with petiole (33.41 cm) and Diameter of head (21.44 cm) were obtained with V_1F_3 (Atlas – 70 × Inorganic fertilizer) but the highest Number of leaves/plant (25.00), Leaf breadth (23.82 cm) and Thickness of head (14.44 cm) were obtained with V_3F_3 (Autumn – 60 × Inorganic fertilizer). Again the highest Root length (23.22 cm) and Stem length (4.58 cm) were achieved with V_3F_2 and V_1F_1 respectively. On the other hand the lowest Plant height (29.93 cm), Leaf length with petiole (28.92 cm) and Diameter of head (16.56 cm) were obtained with V_3F_0 (Autumn – 60 × Control) but the lowest Number of leaves/plant (18.00), Leaf breadth (18.21 cm) and Thickness of head (11.83 cm) were obtained with V_1F_0 (Atlas – 70 × Control). Again the lowest Root length (16.11 cm) and Stem length (3.00 cm) were achieved with V_1F_1 and V_3F_2 respectively.

Yield parameters of the study in respect of combined effect of variety and fertilizer, the highest weight of whole plant (2.56 kg/plant), gross yield (37.28 kg/plot and 62.14 t/ha), marketable yield (36.91 kg/plot and 61.52 t/ha) and Economic production (1.85 kg/plant); were obtained by V_1F_2 (Atlas – 70 × Poultry manure) where the lowest; 1.57, 29.13 and 0.98 respectively were obtained by V_3F_0 (Autumn – 60 × Control).

The economic analysis showed that the highest net return (Tk. 214789.00) and benefit cost ratio (3.31) were obtained from the combination of V_1F_2 (Variety: Atlas – 70 with poultry manure application @ 15 t/ha). The second and third highest net return (Tk. 168219.40 and 159235.40) and benefit cost ration (2.99 and 2.90) were obtained from the combination of V_1F_3 (Variety: Atlas – 70 with inorganic fertilizer application) and V_3F_3 (Variety: Autumn – 60 with inorganic fertilizer application) respectively.

Conclusion:

It may be concluded from the result that V_1F_2 (Atlas – 70 × Poultry manure) performed best in producing higher yield than other treatments comprised with other variety and fertilizer application under the present study. On the other hand interactions of variety (Atlas – 70) and organic fertilizer (Poultry manure) showed its superiority in producing higher cabbage yield and economic production.

Recommendation:

The present research work was carried out at the Sher-e-Bangla Agricultural University and one season only. Further trial of this work in different locations of the country is needed to justify the result for economic return.

CHAPTER 6

REFERENCES

Abedin, Z. M., M. G. Mohayidin, D. C. Tailor, M. N. Shamsuddin and E. F. C. Chiew. 1994. Adoption of sustainable production practices of English cabbage farmers in Malaysia. J. Sust. Agric., 4(4) : 57-76.

Aditya, D. K. 1993. Vegetable Production and Development in Bangladesh. Rep. Agric. Res. Project Phase 11, BAKC/BARI, AVRDC, Dhaka. pp. 68-70.

Aktar, S., S. Noor, M. Rahman, S. Sultana and S. K. Nandi. 1996. Effect of organic manure and chemical fertilizer on the yield of broccoli. Bangladesh Hort., 24 (1, 2): 59-64.

Alam, K. M. 2000. Performance of potato as influenced by IOC application in different forms and methods. An M. S. thesis, Department of Horticulture, BAU, Mymensingh. p. 41.

Alam, M. S., T. M. T. Iqbal, M. Amin and M. A. Gaffer. 1989. Krishitattik Fasaler Utpadan O Unnayan (in Bangla). T. M. Jubair Bin Igbal, Sirajgonj. pp. 231239.

Altieri, M. and Nicholls, F. N. 2003. Tolerance and effect of leaf fertilization treatments on vegetables. *Gartebauwissenscharf*t. 51 (2): 58-62.

Anonymous. 1989. Annual Report. 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

Anonymous. 1990. Effect of chemical fertilizer and organic manure on the yield of cabbage. Annual Rep. BARI, Joydebpur. p. 203.

Anonymous. 1991. Effect of chemical fertilizer and organic manure on the yield of cabbage. Annual Rep., BARI, Joydebpur. pp. 254-287.

Anonymous. (2006). Effect of chemical fertilizer and organic manure on the yield and quality of cabbage. Annual Rep., BARI, Joydebpur. pp. 186-189.

Asiegbu, J. E. and S.O. Oikeh. 1995. Evaluation of the chemical composition of manures from different organic wastes and their potential for supply of nutrient to tomato in a tropical ultisol. Bull.Agric. Hort., 12 (1): 47-60.

Asumus, F. and H. Gorlitz. 1986. Studies on the effect and utilization of N from farmyard manure and mineral fertilizer. Archiv fair Acte-und pflazenbau and Boderkund 32(2) : 115-121 [Cited from CAB Abst.1995]

Azad, A. K. 2000. Effects of plant spacing, sources of nutrients and mulching on growth and yield of cabbage. An M.S. thesis. Dept. of Hort. Bangladesh Agricultural University; Mymensingh. pp. 15-40.

BARC. 1997. Fertilizer Recommendation Guide 1997. Bangladesh Agricultural Research Council, Farnlgate, Dhaka. 196 p.

Batsei, S. L, A. A. Polyakov and R. F. Nedbal. 1979. Effects of organic and mineral fertilizers on the yield and quality of irrigated later white cabbage in the Steppe region of the Crimea. Khimiya V Selskom Khozyaistve, 17(3): 18-20 [Cited from Hon. Abst., 49(11): 8487, 1979]

Beresniewiez, A. and O. Nowosielski. 1985. Influence of increasing mineral fertilization level accompanied by organic manuring and liming on yields of vegetable crops and soil salinization. Bull. Veg. Crop Res. Work, 28: 71-78.

Bimova (2008). Impact of organic fertilizers on total antioxidant capacity in head cabbage. Faculty of Horticulture, Mendel University of Agriculture and Forestry in Brno, Lednice, Czech Republic.

Busayong, E. A. 1996. Comparative analysis on the effects of compost and inorganic fertilizers on the growth, yield and pest damage on cabbage intercropped with tomatoes. Philippines J. Crop Sci., 9(1) : 55-60.

Chan, K.Y., Dorahy, C. and Wells, T. (2008). Use of garden organic compost in vegetable production under contrasting soil P status. Collingwood,

Australia: CSIRO Publishing. Australian-Journal-of-Agricultural-Research. 2008; 59(4): 374-382

Cheung, Y. H. and M. H. Wong. 1983. Utilization of animal manures and sewage sludges for vegetables. Agricultural Wastes, 5(2) : 63-8 1.

Ciszinsky, A. A. and D. J. Schuster. 1985. Response of cabbage to insecticide schedule plant spacing and fertilizer rates. J. Amer. Soc. Hort. Sci., 110 (6) 888-893.

Devi, H.J. and Maity, T.K. (2003). Effect of different sources of nitrogen on yield and economics of cabbage. Calcutta, India: MKK Publication. Environment-and-Ecology. 2003; 21(4):

Devliegher, W. and L. D. Rooster (1997a). Intensive Vegetable Culture: Compost Confirmed. Proeftuinnieuws, 7(16) : 20-21 [Cited from Hort. Abst., 68(6) -x-933. 1998].

Devliegher, W. and L. D. Rooster. 1997b. Cauliflotil er in continuous culture : Add supplementary GFT- compost sparingly. Proeftuinnieuws, 7(18) : 22 [Cited from Hort. Abst., 68(6): 4956, 1998].

Dixit, S. P. 1997. Effect of nitrogen and farmyard manure on the productivity of cabbage in a dry temperature high lull zone of Himachal Pradesh. Ann. Agric. Res., 18(2) : 258-261.

Dragland, S. 1976. Nitrogen requirement for cabbage grown with a high soil moisture status. Land Bruket, 27 (3) : 375-391 [Cited from Hort. Abst., 47(3) : 2551, 1977]

Edris, K. M., Islam, A. T. M. T., Chowdhury, M. S. and Haque, A. K. M. 1979. Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh. Dept. Soil Survey, Govt. People's Republic of Bangladesh. 118 p.

FAO. 1988. Food and Agricultural Organization of the United Nations, Soil Survey Project of Bangladesh. Soil Resources Tech. Rep. pp. 101-159.

FAO. 1988. Production Year Book. Food and Agricultural of the United Nations. Rome, Italy. 42: 190-193.

Farid, A. T. M., M. Rahman, K. H. Talukder, M. Shahidullah and M. S. Islam. 1998. Efficiency of poultry manure and cowdung alone in combination with mineral fertilizers on the yield of cabbage. Bangladesh J. Agril. Res., 23 (1) 157-165.

Farooque, A. M. and A. F. M. S. Islam. 1989. Effect of spacing and different management practices on the growth and yield of cabbage. Bangladesh Hort., 17(l): 45-47.

Farooque, A. M. and I11. F. Mondal. 1987. Effect of spacing and levels of nitrogen on growth and yield of cabbage. Bangladesh Hort., 15(2) :1-6.

Flynn, R. P., C. VV. Wood and E. A. Guertal. 1995. Lettuce response to composted broiler as a potting substrate component. J. Amer. Soc. Hort. Sci., 120 (6) 964-970.

Ghanti, P., G. Sounda, P. K. Jana and M. G. Som. 1982. Effect of levels of nitrogen, phosphorus and spacing on yield characters of cabbage. Veg. Sci., 9(l): 1-4.

Gibson, J.L. and Whipker, B.E. (2003). Ornamental cabbage quality improved by continual fertilization through center-head coloration. Alexandria, USA: American Society for Horticultural Science. HortScience-. 2003; 38(7): 1381-1384

Gomez, K. A. and A. A. Gomez. 1984. Statistical Procedure for Agricultural Research (2nd ed.), A Wiley Inter Science Publication, John Wiley and Sons, New York. 680p.

Hague, M.O. 2000. Effects of different fertilizer management practices on the growth and yield of main and ratoon crop of cabbage. An MS thesis, Dept. of Hort.. Bangladesh Agricultural University, Mymensingh.96 p.

Halim, G. M. A., S. M. Ahmed, A. Islam and S. Hossain. 1994. Effect of different doses of NPK on growth and yield of cabbage. Ann. Bangladesh Agric., 4(2): 157-160.

Haque, K.M.F. (2005). Influence of variety and time of planting on the yield performance and nutrient contents of cabbage (Brassica oleracea L.). Dhaka, Bangladesh: Bangladesh Council of Scientific and Industrial Research. Bangladesh-Journal-of-Scientific-and-Industrial-Research. 2005; 40(3/4): 211-218

Hellwing, A., M. Osinska and R. Tutor. 1976. The effect of irrigation and increasing nitrogen rates on the productivity of early cabbage and cauliflo«,er. Rotniezych, 181: 19-43 [Cited from CAB Abst., 48(2) : 1372, 1978]

Hill, T. R. 1990. Effect of plant spacing and nitrogenous fertilizer on the yield and plant confirmation of Chinese cabbage. Australian J. Exp. Agric., 30(3) 437-439.

Hochmuth, R. C., G. J. Hochmuth and M. E. Donley. 1993. Response of cabbage yields, head quality and leaf nutrient status and of second crop squash to poultry manure fertilization, Proc. Soil. Soc., Florida, 52 : 126-130.

Hsieh Chingfang, (2004). An xperiment on the organic farming of broccoli. Bulletin of Taichung District Agriculture Improvement Station. No.53 (35-40): 18.

Hsieh, C. F., H. C. Fang, K. Nan and K. N. Hsu. 1995. Effect of continuous use of organic manures on the growth and yield of vegetable soybean' and cabbage. Bulletin of Taichung District. Agric. Improvement Sta., Japan, 46: 1-10.

Huang, F. (2006). Varietal influence in organic farming on autumn cabbage. Hangzhou, China: Zhejiang Academy of Agricultural Sciences. Acta-Agriculturae-Zhejiangensis. 2006; 18(1): 58-61.

Jaiswal, N. K., V. K. Khare, B. K. Sharma and S. S. Shrivastava. 1992. Effect of nitrogen levels, method of application and spacing on growth and productivity of cabbage. Adv. Hort. For., 2: 158-164.

Jiang, Li Na (2005). Study on nitrogen fertilizer utilization efficiency of organic and inorganic compound fertilizer with 15N isotope. Hangzhou, China: Zhejiang Academy of Agricultural Sciences. Acta-Agriculturae-Zhejiangensis. 2005; 17(5): 287-291

Kabir, H. T. 1998. Effect of sources of nutrients on yield and quality of cabbage. An M. S. Thesis, Department of Hort. BAU, Mymensingh. pp. 13-39.

Kamiyama, K. S. Fujiwara and H. Funahashi. 1995. Effect of successive application of cowdung manure compost on growth crops and the chemical properties of the soil. Bull. Agril. Res. Inst. Kanagawa Prefect., 136 :31-42. [Cited from CAB. Abst.,1997]

Kolota, E., J. Krezel and 0. Nowosielski. 1992. Evaluation of compound fertilizer in a 3-year vegetable crop rotation. Bull. Warzywiniczy, 39: 93-115 [Cited from Hort. Abst., 64(10): 7857, 1998 J.

Kropisz, A. 1992. Influence of fertilization with compost on yield of vegetables and their content of mineral elements. Ann.Warsaw Agril. Univ., 16 :9-13.

Krupkin, P. L, Kil-bi-I-Ya, I. A. Makrinova, M. A. Yaltonskii, I. Ya. Kilby and M. A. Yaltonsky. 1994. Effectiveness of lignin based fertilizers in Siberia. Agrokhixniya, 12: 53-64[Cited from Hort.Abst.,64(11): 8539, 1994]

Lathiff, M. and Maraikar, J. (2003). Studies on the performance of some vegetable crops in organic farming systems. Peradeniya, Sri Lanka: Department of Agriculture. Annals-of-the-Sri-Lanka-Department-of-Agriculture. 2003; 5: 141-148

Lawande, K. E., D. P. Bhore, P. N. Kale and J. D. Patil. 1986. Effect of spacing, nitrogen, phosphorus and potassium on yield and yield contributing characters of cabbage. J. Maharashtra Agril. Univ., 11(2) : 192-196.

Letourneau, A. F. 1996. The characteristics of mineral nutrition and yield formation in cabbage cultivar in relation to fertilizers and mineral uptake by cabbage plants. Agrokhimiya, 9: 61-67 [Cited from Hort. Abst., 59(12): 9964, 1989].

Lopandic, D., D. Zaric, S. Jevtic and B. Laic. 1997. The effect of nitrogen rates and application dates on cabbage yield. Proceedings of the first Balkan Symposium on Vegetables and Potatoes. Belgrade, Yugoslavia, 462 : 595 598 [Cited from CAB Abst., 1998.]

Lu, N. and J. H. Edwards. 1994. Poultry litter quality influences collard growth in pots and affects cabbage growth and nutrient uptake. Hort. Sci., 29 (10) 1143-1148.

Mallik, S. C. and B. Bhattacharya. 1996. Effect of different levels of nitrogen and different spacing on growth and yield of cabbage. Environ. Ecol., 14(2) 304-306.

Maslo, A. V. and A.T. Gamayunov. 1989. The effect of prolonged application of fertilizers on the fertility of grey podzolized soil and the productivity of a vegetable crop relation. Agrokhimiya, 1: 73-76.

Muhammad, I. and Javed, U. (2001). Response of Chinese cabbage cultivars to different levels of nitrogen with constant doses of phosphorus and potassium under the agro-climatic conditions of Chilas (Diamer). Peshawar, Pakistan: NWFP Agricultural University. Sarhad-Journal-of-Agriculture. 2001; 17(1): 81-85

Nasr, E.M. and Ahmadi, A.R. (2005). Effect of organic amendments and chemical fertilizers on Meloidogyne javanica in cucumber. Tehran, Iran: Iranian Phytopathological Society. Iranian-Journal-of-Plant-Pathology. 2005; 41(1): 56-59

Nishimune, A., Y. Yumuna, Y. Asakawa and T.Yosida. 1994. Effects of continuous cropping on cabbage yield in relation to compost application. Bull. Veg. Ornamental Crops Res. Sta., 12: 141-154.

Omori, S., M. Sugimoto and L Ogura. 1972. Studies on the utilization of larger quantities of animal manure for horticultural crops. I. Experiments on the application of fresh manure to vegetable crops. Bull. Kanagawa Hort. Expt. Sta., 20: 58-66.

Pankaj, S. (2006). Integrated effect of bio-inoculants, organic and inorganic fertilizer on growth and yield of cabbage. Hisar, India: Agricultural Research Information Centre. Crop-Research-Hisar. 2006; 32(2): 188-191

Pant, T., K. Narendra and N. Kumar. 1996. Response of different doses of nitrogen on the yield of cabbage. New Agriculturist, 7(1): 21-24.

Pravakar, B. S. and K. Srinivas. 1987. Response of cabbage to spacing and fertilization. Indian J. Agron., 32(1) : 113.

Quattrucci, M., S. Canali. 1998. Technical-economic comparison of fertilizer lines in Tuscany. Informatore Agrarion, 54(10) : 63-66 [Cited from Hort. Abst., 68(8) : 6765, 1998]

Rauhe, K., J. Hoberuck and B. Sigest. 1987. Studies on the long term effects of farm yard manure and mineral fertilizer nitrogen within the plant-soil system. Archiv fair Actes Und pflazenbau and Bodenkunde, 31(1) : 711-7 18 [Cited from potato Abst., 13(5) : 65, 1998]

Roe, N. 1998. Analysing results on lawns and farm crops. Biocycle, 39 (20): 62-63 [Cited from Hort. Abst. 68(8): 3927, 1998]

Salminen, E. (2001). Anaerobically digested poultry slaughterhouse wastes as fertiliser in agriculture. Oxford, UK: Elsevier Science Ltd. Bioresource-Technology. 2001; 78(1): 81-88

Samant, P.K. S., S. K. Sahu and D. N. Singh. 1993. Studies on balanced fertilizer use for cabbage in acid clay loam soils of Orissa. Orissa J. Agric. Res. Sta., 5(1-2) : 45-49.

Sannigrahi, A. K. and B. C. Borah. 2000. Effect of organic manures and vesicular arbuscular mycorrhizal fungi on yield in tomato, French bean and cabbage in Assam. Environ. Ecol., 18(4): 895-898.

Saxena, G. K., S. J. Locascio and J. B. Lucas. 1975. Effect of NPK rates in response of cabbage and tomato on a coastal clay soil of Guyana. Trop. Agric., 52(2) : 149-156.

Shchelkunova, A. S. 1974. The effect of mineral fertilizer on white cabbage grown on a flood plain soil. Khimiya V. Selskom Khozvaistve, 12(5) : 8-9 [Cited from Hort. Abst., 44(12) : 9507, 1975].

Silva, A. A. Jr. 1986. Mineral and organic fertilizing in cabbage. Commercial quality and the occurrence of Xanthomonas campestries cv. Campestris. Hort. Bras., 4(2) : 10-12.

Singh, R. V. and L. B. Naik. 1958. Response of cabbage -to plant spacing, nitrogen and phosphorus levels. Indian J. Hort., 45 (3-4) : ;?5-328.

Singh, S.K. and Lal, S. (2001). Nutrient management in potato-vegetables sequence under rainfed conditions of Meghalaya. Shimla, India: Indian

Potato Association. Journal-of-the-Indian-Potato-Association. 2001; 28(1): 38-39

Souza, P. A., Souza, G. L. F. M., Menezes, J. B. and Bezerra, N. F. (2008). Evaluations of cabbage cultivar grown under organic compost and mixed mineral fertilizers. *Horticultura Brasileira*. 26(1): 143-145. [Cited from cab abstract]

Subhan. 1988. Effect of organic materials on growth and production of cabbage (*Brassica oleracea* L.). Bull. Peletitian Hort., 16(4): 37--11.

Suchorska, O. J. 1996. The use of unconventional fertilizers for vegetable crop fertilization in three-year crop rotation. Zeszyty- Naukowe-AkademiiRolniczej-W-Szezecinie, - Rolnictwo, Katedna chemii ogolnej, Poland, 63: 2001-210. [Cited from CAB Abst., 1999]

Szafranek, R. F. And D. Koterowa. 1974. Effect of farmyard manure and rotation with legumes on yield and chemical composition of autumn white cabbage. Zeszly Naukowe Akademii Ralniozo Technizenej-w-Olsztynie. Poland, 9(131) : 133-144[Cited from Hort. Abst., 45 (12): 10070,1975]

Tindall, M. 2000. Mineral and organic fertilizing in cabbage. Residual effect for commercial cultivation on yield and quality performance with organic farming. Hort. Bras., 6(1) : 15-20.

UNDP. 1988. Land Resource Apprisal of Bangladesh for Agricultural Development Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome, Italy, p. 577.

Vidigal, S. M., M. A. N. Sediyama, N. C. P. Gareia and A. T. D. Mator. 1997. Yield of lettuce grown with different organic compounds and pig manures. Hort. Bras., l5(1) : 35-39 [Cited from Hort. Abst., 68(8) : 6646, 1998]

Vimala, P. (2006). Effect of rates of organic fertilizer on growth, yield and nutrient content of cabbage (Brassica oleracea var. capitata) grown under shelter. Leuven, Belgium: International Society for Horticultural Science (ISHS). Acta-Horticulturae. 2006; (710): 391-397

Vleck, F. and J. Polach. 1977. Effect of the principal plant nutrients on cabbage yield and quality. Zashradnictvi, 4(314) : 153-160 [Cited from Hort. Abst., 50(6) : 4193, 1980]

Waltert, B. and Theiler, R. (2003). Cauliflower and broccoli: growth pattern and potential yield. Agrarforschung. German.10 (7-9): 276-281.

Wang-Xiude, D., F. T. Wang, Z. X. Liao, J. Yuan and P. Mao. 1996. Study on formula selection and rational application amount of organic, inorganic granular fertilizer for some vegetable species. Acta Agril., Shanghai, 12(1) 61-65.

Westerveld, M.R. McDonald and A.W. McKeown (2005). Optimum Nitrogen Fertilization of Summer Cabbage in Ontario. Department of Plant Agriculture University of Guelph Guelph, Ontario Canada.

Westerveld, S.M. (2003). Optimum nitrogen fertilization of summer cabbage in Ontario. Leuven, Belgium: International Society for Horticultural Science (ISHS). Acta-Horticulturae. 2003; (627): 211-215

White, J. M. and R. B. Forbes. 1977. Effect of spacing and fertilizer rates on cabbage yield and head weight. Proc. of the Florida State Hort. Soc., 89: 118-120 [Cited from Hort. Abstr., 48(1) :392, 1978].

Worman, P. R., K.A. Havard. 1997. The effect of organic and conventional fertilizers on yield and quality of carrot and cabbage. Agric.Ecos. Environ., 61(2-3): 155-162.

Yamada, H. and H. Kamata. 1989. Agricultural technical evaluation of organic farming and gardening. 1. Effects of organic farming on yields of vegetables and soil physical and chemical properties. Bull. Agric. Res. Inst. Kanagawa Prefect., 131 : 1-13.

Yau, P.Y. (2006). Evaluation of cabbage cultivars (Brassica oleracea var. capitata) under plastic rain-shelter on mineral soils in the lowlands. Leuven, Belgium: International Society for Horticultural Science (ISHS). Acta-Horticulturae. 2006; (710): 343-345

Yetistiren, G. and H. Vural. 1991. A study of Yalova 1 cabbage variet~' (Brussica oleracea var. capitata) for development, head formation and the uptake of nutrients. Fen Bilinlliri Enstitusu Dergisi, 2(1): 151-154 [Cited from Hort., Abst., 64(7) : 5381, 1994]

Yu-Tzu Hsu (2009). Soil Fertility Management and Pest Responses: A Comparison of Organic and Synthetic Fertilization. Department of Entomology, National Chung Hsing University, Taichung, Taiwan 402

Zahradnik, A. and Petrikova, K. (2007). Effect of alternative organic fertilizers on the nutritional value and yield of head cabbage. Zahradnictvi-Horticultural-Science. 2007; 34(2): 65-71.

Zalewska, K. and Kalbarczyk, J. (2001). Influence of cabbage variety on chemical composition of juice. Lublin, Poland: Wydawnictwo Uniwersytetu Marii Curie-Skodowskiej. Annales Universitatis Mariae Curie Skodowska Sectio EEE, Horticultura. 2001; 9 (Supplementum): 221-226.

Zarate, N. A. H., M. D. C. Vieria and J. O. Cabecas. 1997. Lettuce yield as affected by rates and the methods of application of semi-decomposed poultry manure. Hort. Bras., 15(1) : 65-67 [Cited from Hort. Abst. 68(8) 66-17, 1998].

Zhang, Y.C. (2004). Effects of application of nitrogen fertilizers of different N forms on yields and quality of Chinese cabbage. Jiangsu-Journal-of-Agricultural-Sciences. 2004; 20(3): 184-188

Appendices

Appendix I. Monthly average air temperature, relative humidity and total rainfall of the experimental site during the period from October 2008 to March 2009

Month	RH (%)	Max. Temp. (°C)	Min. Temp. (°C)	Rain fall (mm)
October	73.36	29.46	19.19	Terract
November	71.15	26.98	14.88	Terrace
December	68.30	25.78	14.21	Terace
January	69.53	25.00	13.46	0
February	50.31	29.50	18.49	0
March	44.95	33.80	20.28	0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

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

Soil Characteristics	**Analytical results**
Agrological Zone	Madhupur Tract
P^H	5.47 – 5.63
Total N (%)	0.43
Available phosphorous	22 ppm
Exchangeable K	0.42 meq / 100 g soil

Appendix III: Effect of fertilizer management of different cabbage cultivar on plant height at different growth stages

Source of variation	Degrees of Freedom	Mean square			
		Plant height (cm)			
		15 DAT	30 DAT	45 DAT	At harvest
Replication	2	5.823	3.577	2.537	1.125
Factor A	2	12.05*	9.011*	6.367*	3.213*
Factor B	3	4.660*	13.95*	6.783*	8.129*
AB	6	1.424*	1.271*	1.055**	0.242**
Error	22	5.362	2.157	0.996	0.080

Appendix IV: Effect of fertilizer management of different cabbage cultivar on number of leaves/plant at different growth stages

Source of variation	Degrees of Freedom	Mean square			
		Number of leaves/plant			
		15 DAT	30 DAT	45 DAT	At harvest
Replication	2	1.194	1.028	0.108	0.083
Factor A	2	4.361*	12.19*	3.457*	6.250*
Factor B	3	9.435*	6.333*	12.60*	11.33*
AB	6	2.324*	2.528*	9.319*	6.583*
Error	22	2.013	3.301	2.900	1.629

Appendix V: Effect of fertilizer management of different cabbage cultivar on leaf length with petiole at different growth stages

Source of variation	Degrees of Freedom	Mean square			
		Leaf length with petiole (cm)			
		15 DAT	30 DAT	45 DAT	At harvest
Replication	2	0.238	0.238	0.004	0.003
Factor A	2	7.404*	7.404*	8.666*	6.471*
Factor B	3	3.881*	3.881*	4.435*	5.908*
AB	6	1.656*	1.656*	2.059*	1.800**
Error	22	1.389	1.389	0.233	0.112

Appendix VI: Effect of fertilizer management of different cabbage cultivar on leaf breadth at different growth stages

Source of variation	Degrees of Freedom	Mean square			
		Leaf breadth (cm)			
		15 DAT	30 DAT	45 DAT	At harvest
Replication	2	1.274	0.745	0.012	0.009
Factor A	2	9.552*	14.26*	9.751*	10.03*
Factor B	3	4.176*	8.979*	6.806*	7.626*
AB	6	0.649**	1.618*	2.460*	2.723*
Error	22	2.995	3.462	0.009	0.018

Appendix VII: Effect of fertilizer management of different cabbage cultivar on yield contributing parameters; root length, stem length, thickness of head and diameter of head at harvest

Source of variation	Degrees of Freedom	Mean square			
		Root length at harvest (cm)	Stem length at harvest (cm)	Thickness of head (cm) at harvest	Diameter of head (cm) at harvest
Replication	2	0.705	1.031	0.551	1.395
Factor A	2	14.92*	1.798*	NS	14.95*
Factor B	3	3.267*	4.890*	3.166*	8.632*
AB	6	2.407*	2.727*	0.837**	0.632**
Error	22	2.426	0.258	1.059	2.929

Appendix VIII: Effect of fertilizer management of different cabbage cultivar on yield parameters; weight of whole plant at harvest, gross yield, marketable yield and economic production (kg/plant) at harvest

Source of variation	Degrees of Freedom	Mean square					
		Weight of whole pant (kg/ plant)	Gross yield (k/ha)	Marketable yield (kg/ha)	Gross yield (t/ha)	Marketable yield (t/ha)	Economic production (kg/plant)
Replication	2	0.732	1.25	1.87	1.470	0.400	0.289
Factor A	2	3.223*	6.04*	8.66*	6.917*	3.457*	2.400*
Factor B	3	6.850*	8.14*	21.39*	10.54*	11.97*	4.408*
AB	6	5.082**	2.17*	27.89*	2.877*	8.530*	5.054*
Error	22	0.120	1.25	0.931	1.687	2.055	0.065

Appendix IX: Production cost of cabbage per hectare due to use of cowdung, poultry manure and inorganic fertilizer in combination with different cultivars

A. Input cost

a. Material cost

Treatments	Inorganic fertilizers			Organic manures		Cost of seedlings	Cost of irrigation	Cost of pesticide	Subtotal (a)
	Urea	TSP	MP	Cowdung	Poultry manure				
V_1F_0						9500	4500	2500	16500
V_1F_1				22500		9500	4500	2500	39000
V_1F_2					30000	9500	4500	2500	46500
V_1F_3	3960	8400	9500			9500	4500	2500	38360
V_2F_0						9000	4500	2500	16000
V_2F_1				22500		9000	4500	2500	38500
V_2F_2					30000	9000	4500	2500	46000
V_2F_3	3960	8400	9500			9000	4500	2500	37860
V_3F_0						8900	4500	2500	15900
V_3F_1				22500		8900	4500	2500	38400
V_3F_2					30000	8900	4500	2500	45900
V_3F_3	3960	8400	9500			8900	4500	2500	37760

b. Non- material cost

Treatment	Land preparation	Fertilizer and manure application	Removal of weeds and stubbles	Lay out, seedling transplantation, shadding and watering	Earthing up and weeding	Top dressing	Harvesting and marketing	Sub total (b)
V_1F_0	4000		2000	4200	3000		9000	22200
V_1F_1	4000	1700	2000	4200	3000		9000	23900
V_1F_2	4000	1400	2000	4200	3000		9000	23600
V_1F_3	4000	500	2000	4200	3000	1400	9000	24100
V_2F_0	4000		2000	4200	3000		9000	22200
V_2F_1	4000	1700	2000	4200	3000		9000	23900
V_2F_2	4000	1400	2000	4200	3000		9000	23600
V_2F_3	4000	500	2000	4200	3000	1400	9000	24100
V_3F_0	4000		2000	4200	3000		9000	22200
V_3F_1	4000	1700	2000	4200	3000		9000	23900
V_3F_2	4000	1400	2000	4200	3000		9000	23600
V_3F_3	4000	500	2000	4200	3000	1400	9000	24100

B. Overhead cost

Treatments	Overhead cost (B)			
	Cost for land lease (Tk 200000 for 6 months @ 50%	Interest on running capital (For 6 months @ 12%)	Miscellaneous cost (5% of input cost)	Total
V_1F_0	15000	2322	1935	19257
V_1F_1	15000	3774	3145	21919
V_1F_2	15000	4206	3505	22711
V_1F_3	15000	3747.6	3123	21870.6
V_2F_0	15000	2292	1910	19202
V_2F_1	15000	3744	3120	21864
V_2F_2	15000	4176	3480	22656
V_2F_3	15000	3717.6	3098	21815.6
V_3F_0	15000	2286	1905	19191
V_3F_1	15000	3738	3115	21853
V_3F_2	15000	4170	3475	22645
V_3F_3	15000	3711.6	3093	21804.6

Appendix X: Total input cost (Tk/ha), overhead cost (Tk/ha) and total cost of production (Tk/ha)

Treatments	Total input cost (A)			Overhead cost (B)				Total cost of production (A + B)
	Material cost (a)	Non-material cost (b)	Total (a + b)	Cost for land lease (Tk 200000 for 6 months @ 50%)	Interest on running capital (For 6 months @ 12%)	Miscellaneous cost (5% of input cost)	Total	
V_1F_0	16500	22200	38700	15000	2322	1935	19257	57957
V_1F_1	39000	23900	62900	15000	3774	3145	21919	84819
V_1F_2	46500	23600	70100	15000	4206	3505	22711	92811
V_1F_3	38360	24100	62460	15000	3747.6	3123	21870.6	84330.6
V_2F_0	16000	22200	38200	15000	2292	1910	19202	57402
V_2F_1	38500	23900	62400	15000	3744	3120	21864	84264
V_2F_2	46000	23600	69600	15000	4176	3480	22656	92256
V_2F_3	37860	24100	61960	15000	3717.6	3098	21815.6	83775.6
V_3F_0	15900	22200	38100	15000	2286	1905	19191	57291
V_3F_1	38400	23900	62300	15000	3738	3115	21853	84153
V_3F_2	45900	23600	69500	15000	4170	3475	22645	92145
V_3F_3	37760	24100	61860	15000	3711.6	3093	21804.6	83664.6