OPTIMIZATION OF NITROGEN REQUIREMENT FOR BROCCOLI (*Brassica oleracea* var. *italica* L.) FROM ORGANIC AND INORGANIC SOURCES

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A Thesis
Submitted to the Department of Soil Science
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfilment of the requirement for the degree of

MASTER OF SCIENCE (MS)
IN
SOIL SCIENCE

SEMESTER: JULY-DECEMBER, 2009

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CERTIFICATE

This is to certify that the thesis entitled, "***OPTIMIZATION OF NITROGEN REQUIREMENT FOR BROCCOLI (Brassica oleracea** var. **italica L.) FROM ORGANIC AND INORGANIC SOURCES***" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka. In partial fulfilment of the requirement for the degree of ***MASTER OF SCIENCE IN SOIL SCIENCE***, embodies the result of a piece of *bonafide* research work carried out by ***MD. NAZRUL ISLAM***, Registration No.***08-03202*** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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ACKNOWLEDGEMENTS

All praises belong to the almighty Allah, the merciful, who enabled the author to complete the present work.

The author takes the opportunity to express his heartfelt respect, deepest sense of gratitude and immense indebtedness to his supervisor Prof. Dr. Gopi Nath Chandra Sutradhar, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, constructive criticism, valuable suggestions and continuous encouragement during the entire period of the research work and preparation of this thesis.

The author expresses his gratefulness and indebtedness to his teacher and research co-supervisor A. T. M. Shamsuddoha, Associate Professor, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his encouragement, co-operation, kind comments and invaluable suggestions for improvement of the thesis.

The author is thankful to Associate Professor Dr. Md. Asaduzzaman Khan, Chairman, Department of Soil Science, SAU. The author is highly grateful to Prof. Dr. Md. Nurul Islam, Department of Soil Science, SAU. The author is also thankful to Prof. Dr. Alok Kumar Paul, Department of Soil Science, SAU.

The author also expresses his heartfelt thanks to all the teachers of the Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), for their help, valuable suggestions and encouragement during the period of the study. Thanks are extended to his friends especially Rana, Manjurul, Momin, Dulal and other friends for their help and inspiration.

The author wishes to acknowledge his heartfelt indebtedness and profound respect to his father Md. Yakub Ali and mother Anzumanara Begum for their sacrifice, blessings, encouragement and continuous prays for his success.

The author expresses his sincere appreciation to his brothers, sisters, relatives and well wishers for their inspiration, help and encouragement.

The Author

Appendices

ABSTRACT

An experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2008 to February 2009 to find out the ideal Integrated Nutrient Management (INM) treatment to maximize the yield of Broccoli. The field experiment had 12 treatments each having three replications. The treatments were T_1 : No fertilizer, T_2 : 0% N from farm yard manure (FYM) + 100% N from Urea (150kg N/ha), T_3 : 10% N from FYM + 90% N from Urea, T_4 : 20% N from FYM + 80% N from Urea, T_5 : 30% N from FYM + 70% N from Urea, T_6 : 40% N from FYM + 60% N from Urea, T_7 : 50% N from FYM + 50% N from Urea, T_8 : 60% N from FYM + 40% N from Urea, T_9 : 70% N from FYM + 30% N from Urea, T_{10} : 80% N from FYM + 20% N from Urea, T_{11} : 90% N from FYM + 10% N from Urea and T_{12} : 100% N from FYM (30 ton Cowdung/ha) + 0% N from Urea. Plant height at 20, 40 and 60 days after transplanting, no. of leaves, length & breadth of leaves, diameter and height of curd, diameter of curd & stem, plant canopy, weight of primary & secondary curds and yield of broccoli were studied. The treatment combination T_6 (40%N from farm yard manure + 60%N from Urea) showed the maximum significant value of all the parameters studied. The highest yield of 17.18 t/ha was obtained in the treatment T_6. From the economic point of view the treatment T_6 (cowdung 12 ton/ha and urea 90 kg/ha) was found to be the most suitable. The treatment T_6 also had the highest nutrient concentration and nutrient uptake by broccoli. This treatment also favored significant increment of N, P and K of post harvest soil.

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LIST OF ABBREVIATED TERMS

FULL NAME	ABBREVIATION
At the rate of	@
And others	*et al.*
Bangladesh Bureau of Statistics	BBS
Benefit cost ratio	BCR
Cultivar	cv.
Degree in Celsius	^{o}C
Duncan's Multiple Range Test	DMRT
Date After Transplanting	DAT
Etcetera	etc
Food and Agricultural Organization	FAO
Hectare	ha
Hour	hr
Muriate of Potash	MOP
Number	no.
Namely	viz.
Randomized Complete Block Design	RCBD
Sher-e-Bangla Agricultural University	SAU
Ton per hectare	t/ha
Triple Super Phosphate	TSP
That is	i.e.
Least significant Difference	LSD

Chapter I

Introduction

CHAPTER I
INTRODUCTION

Broccoli (***Brassica oleracea*** var. ***italica*** L.) is an important vitamin rich winter vegetable which is newly introduced in Bangladesh and belongs to the family cruciferae. It is fairly rich in carotene and ascorbic acid and contains appreciable quantities of thiamin, riboflavin, niacin and Iron (Thompson and Kelly, 1988). Nieuwhof (1969) stated that Broccoli is more nutritious than the other Cole crops, such as cabbage, cauliflower and kohlrabi. Vegetable consumption in Bangladesh is very low and only 32 g per day against the minimum recommended quantities of 200 g (FAO, 2008). The total vegetable production in Bangladesh is below the requirement.

Broccoli is environmentally better adopted and can withstand comparatively higher temperature than cauliflower (Rashid, 1993). Broccoli is much reliable so far the environmental hazards are concerned. Broccoli produces smaller flowering shoots from the leaf axile if the main apical flower bud or curd is removed. Consequently a field of broccoli may be harvested over a considerable period of time. The stem of broccoli plant, the core of which is soft and sweet may also be eaten like vegetable. As a result, its popularity to the consumers is increasing day by day in our country. In view of the above facts, broccoli is likely to find favor with the people if it can be properly promoted as it has wider environmental adaptability, higher nutritive value, good taste and less risk to crop failure due to various biotic factors indicate enough scope for its promotional efforts.

Broccoli can be grown on a variety of soils. It makes less demand upon the soil and climate than cauliflower. Immediately after planting, they are able to develop rapidly; therefore, the less fertile soils should be adequately dressed. Broccoli demands a soil with a good moisture supply, ranging from light sand to heavy loam or even clay that are well supplied with organic matter (Katayal, 1994). Broccoli is presumably rather salt tolerant (Nieuwhof, 1969).

Successful production of Broccoli depends on various factors. Fertilizer is one of the most important factors which assure better crop production. Among the factors, nitrogen is very much essential for good plant establishment and expected growth (Uddin and Khalequzzaman, 2003). Use of inorganic and organic fertilizers has assumed a great significance in recent years in vegetables production, for two reasons. Firstly, the need for continued increase production and per hectare yield of vegetables requires the increased amount of nutrients. Secondly, the results of a large number of experiments on inorganic and organic fertilizer alone can not sustain the productivity of soil under highly intensive cropping systems (Singh and Yadav, 1992). Broccoli responds greatly to major essential nutrient element like nitrogen, cowdung in respect of its growth and yield. Nitrogen plays an important role in Broccoli production. It is evident that balanced applications of nitrogen provides higher yield of Broccoli. On the other hand manure like cowdung when applied, helps in maintaining good soil structure besides being a continuous source of nutrient. Again the early and rapid vegetative growth of the plant is also necessary for soft and succulent curd and stem for a quality crop which is believed to be influenced by the nitrogenous fertilizer added to the soil.

Application of organic matter (FYM) to soil is required for better physical, chemical & biological condition of soil. However, organic manure only is not enough to supply adequate amount of nutrients. We need to integrate the use of organic and inorganic fertilizer. We have to know precisely the amount of nutrient specially to be supplied from inorganic (Urea) sources and from organic sources for the maximum yield of Broccoli. For this reason, we are planning to investigate the best combination of organic and inorganic sources of nitrogen required for Broccoli.

The present investigation was therefore under taken with the following objectives:

OBJECTIVES:

1. To find out the ideal Integrated Nutrient Management (INM) treatment to maximize the yield of Broccoli
2. To determine the uptake of nutrients (NPK) by Broccoli plant as influenced by organic and inorganic fertilizer

Chapter II

Review of Literature

CHAPTER II
REVIEW OF LITERATURE

Optimizing nitrogen required for Broccoli has been investigated by many investigators in different part of the world. Some information are available on the effect of organic and inorganic nutrients management on the performance of broccoli. Broccoli cv. '**premium crop**' is a vegetable crop and is grown in Rabi season. Its growth and yield are remarkable, influenced by organic inorganic management. Information on this crop is very scanty in Bangladesh. Some of the relevant literatures in this regard have been reviewed and presented in this chapter.

2.1 Effect of nitrogen and other elements

Agarwal *et al.* (2007) reported the effect of N doses and spacing on Broccoli (*Brassica oleracea* L. var. *italica*) four nitrogen fertilization doses 50, 100, 150 and 200 kg ha^{-1} along with two plant densities 37037 plants/ha (S_1) and 49383 plants/ha (S_2) achieved by transplanting at a spacing of 60 cm x 45 cm and 45 cm x 45 cm, respectively, were used. Results revealed the significant effect of nitrogen fertilization on head yield and quality traits with the maximum at 200 kg ha^{-1}. Increment in head yield at higher nitrogen level was mainly due to increment in head weight. The head yield increased which was due mainly to the result of higher number of plants per unit area.

Zhang *et al.* (2007) investigated the effects of balanced application of nitrogen (N), phosphorus (P) and potassium (K) fertilizers on the yield. The results showed that the highest yield was 13592.2 kg/hm^2 and its optimal combination of applying fertilizers was 371.35 kg N, 102.66 kg P₂O₅ and 172.04 kg K₂O/hm^2. Under the highest yield, the maximum profit was 37911.35 yuan/hm^2 and its combination of applying fertilizers was 348.81 kg N, 99.27 kg P₂O₅ and 160.08 kg K₂O/hm^2. Compared to the optimal combination of applying fertilizers under the highest yield, the optimal combination of applying fertilizers under the highest rate reduced by 57.14% in N application amount and 6.98% in K₂O application amount, but made a profit increase of 44.83%.

Leja *et al.* (2006) stated that Broccoli (*Brassica oleracea* L. var. *italica*) cv. Lord F₁ was grown at the Agricultural University experimental farm in the Cracow area in the spring growing cycle of three successive years. The application of mineral N increased nitrate level in broccoli heads. The foliar nutrition with 2% urea and foliar application lowered the average nitrate content in broccoli heads but the significant effect was found only in the case of the full rate of mineral N. Strong interdependence was observed between the activity of the determined enzymes, as well as of NO₃ and NH₄ and the weather conditions accompanying the plant cultivation in the particular years of experiment.

Rozek *et al.* (2005) conducted a 3 year (1999-2001) experiment in Poland to determine the effect of mineral nitrogen fertilizer application. Four different levels of mineral nitrogen (N_{min}) in the soil were used. natural content (12-25.5 mg N dm^{-3}); fertilizer application with half of the full rate supplemented to the level of 75 mg N dm^{-3}; fertilizer application with the full rate divided into halves (75 + 75 mg N dm^{-3}); and with the single full rate of N supplemented to the level of 150 mg N dm^{-3}. Generally, no significant effect of the mineral nitrogen rate on the biological foliar urea application significantly lowered concentration of nitrates in broccoli heads compared with the plants not treated with urea. Moreover, the increase of ascorbic acid content in broccoli heads treated with urea was also observed.

Brahma *et al.* (2002) conducted a field experiment for two years at Assam Agricultural University in India during Rabi season of 1998-99 and 1999-2000 to study the effect of nitrogen, phosphorus and potassium on growth and yield of broccoli cv. Pusa Broccoli KTS-1. Treatments comprised 0:0:0, 50:30:20, 100:60:40, 150:90:60 and 200:120:80 kg NPK/ha. The growth and yield of broccoli showed marked improvement with the application of 200:120:80 kg NPK/ha.

Wange and Kale (2004) examined the growth and yield response of broccoli and lettuce to 12 different treatments of biofertilizers (Azotobacter and Azospirillum) and N level (100, 125 and 150 kg/ha) was tested separately in a medium black soil under field conditions during the rabi season of 1998 at Pune, Maharashtra, India. In broccoli, the treatment of Azotobacter + Azospirillum with 150 kg N ha^{-1} was significantly superior over the recommended fertilizer rate alone. In lettuce, the treatment with maximum rate of 50 kg N ha^{-1} + Azotobacter + Azospirillum was significantly effective over the recommended fertilizer rate. Results indicated that these crops responded better to biofertilizers at higher levels of N, suggesting more N requirements to these crops. Diazotrophs fulfilled these requirements to some extent.

Karitonas and Tremblay (2003) conducted an experiment in Lithuania during 1994-96 to evaluate soil mineral N, tissue NO₃N and foliar nutrition concentration tests as N management tools for broccoli (cv. Fiesta) production. The results showed that based on high yield data, the optimum N supply was 240 kg N ha^{-1}. In broccoli leaves, a total N content of 26.1-31.3 g kg^{-1} dry weight, P content of 3.3-4.6 g kg^{-1}, K content of 23.6-31.1 g kg^{-1}, Ca content of 34.6-55.9 g kg^{-1} and Mg content of 5.0-7.9 g kg^{-1} resulted in a yield of broccoli heads higher than 10 t ha^{-1}. High-yielding crops were supplied with an optimum amount of N when the NO₃N concentration in leaves on the 27th, 46th, and 59th day after transplanting was higher than 3500, 3000 and 2000 mg kg^{-1}, respectively.

Brahma *et al.* (2002) conducted a field experiment in Jorhat, Assam, India during the rabi seasons of 1998-2000 to determine the effects of NPK fertilizers on the nutrient uptake, yield and quality of broccoli cv, KTS-1. The treatment comprised application of 80:30:20, 100:60:40, 150:80:60 and 200:120:80 kg NPK/ha. NPK at 200:120:80 kg/ha resulted in the highest values for head diameter (19.52 cm); cull head number (7.09); head yield (13.41 t/ha); cull head yield (4.70 t/ha); total yield (18.11 t/ha); leaf N (3.90%), P (0.44%) and K (2.75%) content; and protein (3.36%), total chlorophyll (0.46 mg/g) and ascorbic acid content (128.05 mg/100 g) of the crop; and residual available N (383.84 kg/ha), P (41.58 kg/ha) and K (72.37 kg/ha).

Karitonas *et al.* (2001) carried out a study to investigate the effect of varying N supply (60 to 300 kg/ha) on the yield and quality of broccoli. An additional investigation was carried out on the distribution of nitrate in the marketable part of broccoli. The N supply at planting was closely correlated with crop yield. The optimum N supply was 240 kg/ha. The amount of dry soluble solids in broccoli heads ranged within 6.8-7.0%. An increased level of N supply slightly reduced the vitamin C content from 83 to 73 mg/100 g f. m. in broccoli flowers. The nitrate concentration in heads varied depending on the N supply, part of the head and harvesting time. The increased N supply improved chlorophyll contents in florets.

Willigen (1999) reported the effects of the rate and the method of N application on yield and quality of broccoli cv. Emperor during 3 seasons at Andijk and Lelystad, Netherlands. Different amounts of N fertilizer were applied broadcast or band placed at planting. Band placement of fertilizer increased the yield in 5 out of 8 experiments. Application of N resulted in larger heads. No relationship was found between soils mineral N at planting and optimum N application because of the narrow range of soil mineral N at planting. Split application had no or a negative effect on yield and therefore is not recommended. For optimum yields a rate of 270 kg N/ha is recommended, minus the mineral N in the 0-60 cm soil layer, band placed at planting. For broadcast application, 275 kg N minus the soil mineral N is recommended at planting, but yields will be lower than with band placement of fertilizer.

Wang *et al.* (2007) conducted pot experiments to determine the effects of N, P and K on yield and quality of broccoli. K was the most important element for yield and DW. Additive effects were observed on yield and source-sink vitamin C [ascorbic acid] content when K was applied together with N or N + P. Application of N + P gave 110.8% higher yields than N alone. N application advanced the harvest. Significant positive correlations were found between yield and DW of leaves and plant size. To obtain high yields and quality, N, P and K applications should be balanced.

Bray and Kurtz (1995) conducted a field trails on direct sown Broccoli cv. Early (Dawn) during the autumn of 1991 and 1992 and reported that the effects of replanting NPK fertilizer at a rate of 45 kg N + 59 kg P + 112 kg K and 90 kg N + 118 kg P + 224 kg/ha plus side dressed N fertilizer at 134, 196 or 258 kg/ha, either dropped on to or knifed in to the bed were determined. The marketable yield, early yield, curd weight and percentage of early to total yield were unaffected by fertilizer by rate or method of application.

Rooster *et al.* (1999) a field study was carried out to compare two applications method (broadcasting and row injection using the cultan system). N fertilizers used were calcium ammonium nitrate (KAS), urea ammonium sulfate (UAS, 25 kg N/100 liters) and urea ammonium nitrate (UAN, 39 kg N/100 liters) and found that plant uniformity and color were after fertilizer injection, while crop yields were also higher (99-107 kg/a compared to 89-93 kg/a after broadcasting of N).

Sharma *et al.* (2002) conducted a field experiment to evaluate the effects of N (60, 120, 180 and 240 kg/ha) and P (60, 120 and 180 kg/ha) on the growth and seed yield of Broccoli cv. Green curd and observed that plant height, number of branches per plant, number of seeds per siliqua, seed yield, 1000 seed weight, germination percentage, seedling length and vigor index. In general, all parameters significantly improved with increasing concentrations of N and P.

Lincoln (1987) reported that Broccoli stressed with inadequate soil nitrogen may develop button curds in which the terminal shoot fails to develop. He also reported that substantial increases in growth rate take place during the transition to reproductive growth and as the terminal curd nears maturity. Fertilization practices must ensure adequate nutrients, excessive nitrogen must be avoided it can increase the incidence of hollow stem.

Khan *et al.* (1991) conducted an experiment to show the yield and yield component of broccoli (cv. Premium) in response to nitrogen. They observed that nitrogen affected stalk diameter only when very low rates (37 and 74 kg/ha) were applied. Yield of marketable quality heads often showed no significant response to rates of applied N above 112 kg/ha.

Masson *et al.* (1991) conducted an experiment where Broccoli, cv. Premium was raised in multicellular trays at N rates of 100, 200, 300 and 400 mg/liter. Supplying nitrogen at 400 mg/liter rather then 100 mg/liter, increased shoots growth. High nitrogen rates accelerated shoot growth at the expense of root growth. High nitrogen rates (300 or 400 mg/liter) during seedling production increased yields of all species.

Thakur *et al.* (2003) conducted A field experiment in Jammu and Kashmir, India, during 2001/02 cropping season, to determine the optimum level of N (0, 75, 150 and 225 kg/ha) and P (0, 50, 100 and 150 kg/ha) for growth and yield of cauliflower. Data were recorded for plant height, plant spread, curd diameter, curd depth, average curd weight, curd formation, yield, curd yield, cultivation cost, gross return, net return and net profit per rupees invested. The highest plant height (44.742 cm) and plant spread (56.70 cm) was recorded at 225 kg N/ha. Increasing N from 0 to 225 kg/ha significantly increased the curd depth and curd weight. P at 150 kg/ha recorded significant increase in curding percentage over the control. The interaction effects of N and P fertilizers were not significant for all the characters studied. However, the highest net return (Rs 98291.16) and net profit per rupees investment (Rs 1.78) were observed at 225 kg N/ha + 100 kg P/ha followed by 225 kg N + 150 kg P/ha per rupees investment.

Dolanska (2002) conducted the effect of N fertilizer rate (0, 120, 180 and 240 kg/ha) on the nitrate contents of the florets, leaves and stalks of broccoli was investigated during 1999-2001 in Czech Republic. The highest nitrate contents were observed in stalks and leaves, while the lowest nitrate content was observed in the florets. The average weight of the florets was not significantly different among the N fertilizer treatments. A rate of 120 kg N/ha was therefore considered sufficient.

Singh and Akhilesh (2000) conducted a field experiment in Himachal Pradesh, India, to standardize the N and K requirement of broccoli. N was applied at 0, 125, 150 and 175 kg/ha, and K at 0, 25 and 50 kg/ha. Seedlings were transplanted on 2 November 1996-97 and 17 November 1997-98. A linear increase in plant height was observed with increasing N and K rates. K improved the development of roots and the utilization of N. Delay in marketable plant maturity was observed when N and K rates exceeded 150 and 50 kg/ha, respectively. The highest net head weight and yield were obtained when N at 150 kg/ha and K at 50 kg/ha were applied. Results indicate that these concentrations of N and K fertilizers are optimum for broccoli growth in Himachal Pradesh, and further increase in concentration may have negative effects on growth and yield.

2.2 Effect of organic manure

Chan *et al.* (2008) stated that 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 fertilizers) treatments can produce similar yield to the conventional practice of using a mixture of poultry manure and inorganic fertilizers. The compost treatments also significantly increased soil organic carbon and soil quality. 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.

Peyvast *et al.* (2008) stated that by using organic fertilizers in tested vegetables (Chinese cabbage, parsley, spinach, broccoli and garlic), high-risk absorption of nitrate in edible parts was prevented and therefore, their use as organic mater (OM) is recommended. Application of MSWC at more than 25 and 50 t/ha is recommended for broccoli and garlic, respectively. At 50 t/ha, cattle manure compost can be also applied for garlic.

Miura *et al.* (2006) examined a possible uptake of protein-like organic nitrogen in a soil by broccoli (*Brassica oleracea* var. *italica*). One series was grown on a pot filled with soil supplemented with organic matter, while another series was grown on solution culture or vermiculite-filled pot with chemical fertilizer only. Substances with the same molecular weight as protein-like organic nitrogen extracted with water and potassium chloride in soils were detected from the xylem saps of the plants. These results indicated that there was a possibility of a direct uptake of protein-like organic nitrogen in addition to mineral nitrogen in the soil, not only by vegetables but also by tea plants.

Sanwal *et al.* (2005) conducted a study in Meghalaya, India during 2003-04 and 2004-05 to investigate the effects of organic manures and natural growth regulators on the chemical composition of flowers and stems of broccoli cv. Hybrid Fiesta. The treatments included: farmyard manure (FYM) at 20 t/ha; poultry manure 10 t/ha; pig manure at 11 t/ha; rabbit manure at 11 t/ha; neem shield 4.5 t/ha; FYM at 16 t/ha + 4 sprays of panchakavya; FYM at 16 t/ha + 4 sprays of amritpani; poultry manure at 8 t/ha + 4 sprays of panchakavya; poultry manure at 8 t/ha + 4 sprays of amritpani and NPK. Foliar spray of panchavkaya and amritpani at 10% was made at 15, 30, 45 and 60 days after planting. Integrated use of organic manures and natural growth promoters resulted in higher dry matter content, pH, ascorbic acid content, total soluble solids, reducing sugars and total sugars, but lower fiber contents in stems and flowers than NPK treatment.

Chaterjee *et al.* (2005) conducted a field experiment in West Bengal, India during 2003-04 to evaluate the effects of organic amendments on broccoli hybrid Green Country. The treatments were: (T_1) cow dung + biofertilizer-I (Azotobacter, phosphate solubilizer and potash mobilizer); (T_2) poultry manure + biofertilizer-I; (T_3) mustard oil cakes + biofertilizer-I; (T_4) cow dung + biofertilizer-II (Azotobacter, vesicular arbuscular mycorrhiza and potash mobilizer); (T_5) poultry manure + biofertilizer-II; (T_6) mustard oil cake + biofertilizer-II and (T_7) recommended N:P:K rate, 150:60:80 kg/ha. T_6 resulted in the highest yield (103.70 q/ha) and cost: benefit ratio (1:4.46). T_2 produced curds with the highest chlorophyll, ascorbic acid and reducing sugar contents (32.80 mg/100 g, 80.30 mg/100 g and 2.20%, respectively).

Babik and Kowalczyk (2004) conducted a experiment to investigate the effects of compost of plant materials as substrate and soil amendment on the growth and yield of greenhouse lettuce and field broccoli. Addition of compost at 10% of peat substrate as growing media for greenhouse lettuce significantly increased the yield and head size of lettuce compared to mineral fertilizer application only. Higher amount of compost added to substrate did not result in higher yield of lettuce. Compost application rates of 20-40 t/ha in field production of broccoli were not sufficient for high yield, mainly due to too low content of easy available nitrogen and simultaneously high level of potassium and phosphorus. In field production of vegetables, application of compost is recommended every second year and nitrogen should be supplemented with mineral fertilizers.

Hsieh *et al.* (1996) stated that a field experiment at Datsuen in Changhua Hsien, Taiwan, on a slate alluvial neutral sandy loam soil, broccoli was grown using conventional farming, partial organic farming with effective microorganisms (EM), organic farming with pig manure compost and EM, and organic farming with poultry manure compost and EM. Growth and yield of broccoli in the organic treatments were greater than in the control. Poultry manure compost treatment gave the highest yield which was 26.2% higher than that of the control, followed by pig manure compost treatment which was 18.3% higher. However, the partial organic treatments only showed similar yield performance as the control. It was suggested that a combination of chemical fertilizers and compost with EM in the partial organic treatment caused an antagonistic effect on the mineralization and uptake of soil nutrient elements. N, Mn and Zn contents in the broccoli plants in the partial organic treatment were significantly lower than those in the control indicating deficiency.

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

Maynard (1994) used spent mushroom and chicken manure compost in broccoli cultivation. Composts were incorporated into the soil in 1989-1991 at rates of 56 and 112 t/ha. Yield of broccoli increased with increasing rate of compost application. Yields were higher in plots amended with chicken manure compost (nitrate N content 54 ppm) than with spent mushroom concentrations in ground water beneath all compost amended plots remained below 10 ppm during the study.

Shiralipour *et al.* (1996) showed the benefits of compost applications on various soil types in greenhouse studies. Compost prepared from yards waste feedstock composted with biosolids at 1:1 ratio was used to grow broccoli at 0, 15, 30 and 60 dry tons per acre. Surface soil from three dominant regional soil types (Arnold loamy sand, Goleta loam and Todos-Lodos clay loam) was increased the height and dry weight of broccoli. In loam and clay loam soil, optimal rates of compost application were 30 to 60 t/ha for broccoli. In loamy sand soil, optimal rates for broccoli was 30 t/ha. Broccoli showed less phytotoxicity symptoms to higher compost loads, probably because of more tolerance to greater salt concentrations.

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

Tamayo and Jaramillo (2005) conducted a study to evaluate the effects of the application of organic fertilizers on the production of vegetables. The experiment was established on an Andisol isothermal Typic melano aquand, located at the CI 'La Selva' of Regional CORPOICA 4 (Rionegro, Antioquia, Colombia), with cold moderate climate and altitude of 2.1 msnm, average temperature of 17 degrees C and an annual rainfall of 1.85 mm. The treatments include different organic fertilizer (champinonaza and agrosolar) rates of 5, 7.5, 10, 12.5 and 15 ton/ha on cauliflower. At the same time, a compost obtained from the decomposition of vegetable residues with two commercial products, Bacthon and Cioma, and an earthworm humus were also evaluated at the rates of 6, 8, 10 and 12 ton/ha plus the combination of 600 and 800 kg/ha of the chemical fertilizer 10-30-10 was evaluated using cabbage and lettuce. The highest cauliflower production was recorded under 7.5 ton/ha of agrosolar treatment. The addition of chemical fertilizer did not improve the efficiency of champinonaza for the cauliflower production. The highest cabbage and lettuce production was recorded under organic and chemical fertilizer application at 10 ton/ha and 800 kg/ha of 10-30-10, respectively.

Pathak and Nishi (2003) conducted Pot experiments to determine the efficacy of organic amendments i.e. oilseed cakes, pressmud [filter cake] and carbofuran, against cauliflower root-knot disease caused by Meloidogyne incognita. The treatments comprised neem seed cake, mustard cake and pressmud at 25 and 10 g/kg soil, and 10 and 20 mg carbofuran/kg soil, alone or in combination. The highest mean plant height (28.6 cm) and mean root length (19.3 cm) were obtained with 20 mg carbofuran/kg soil. The highest mean fresh shoot (30.3 g) and root weight (6.8 g) were obtained with 25 kg neem seed cake/kg soil. The lowest mean number of galls per plant root (6.67) was obtained with 25 g neem seed cake, 10 g neem seed cake + 10 mg carbofuran and 10 g mustard cake/kg soil. The lowest mean number of galls per g root (1.00) was obtained with 25 kg neem seed cake/kg soil. The lowest mean nematode population in the soil (-763) was obtained with 20 mg carbofuran/kg soil.

Mamta *et al.* (2005) conducted Experiments in Pusa, Bihar, India, during the winter season of 2001-02 to investigate the effects of organic manure, irrigation interval and cropping sequence on the yield and black scurf disease (caused by *Rhizoctonia solani*) of potato cv. Ashoka. In the first experiment, different organic manures, i.e. Jaivic, neem [*Azadirachta indica*] cake, karanze cake, castor cake and mustard cake were applied in the field at 5 q/ha in addition to recommended dose of NPK. The control plots were treated with only the recommended dose of NPK. All the organic manures, applied with the recommended dose of NPK were positively correlated with tuber yield and negatively with disease development in comparison to the control. Regarding disease development neem cake and karanze cake showed the best result, reducing the disease incidence and intensity. The second experiment comprised crops irrigated at intervals of 10, 20, 30 and 40 days and crops kept under rainfed condition. The highest tuber yield of 252 q/ha was recorded when the crop was irrigated at 30 days interval and the minimum tuber yield (122 q/ha) was recorded when the field was kept under rainfed condition. The maximum disease incidence (34.0%) and intensity (2.4) were recorded when the field was irrigated at 10 days interval and the minimum (4.0% and 1.2, respectively) when the field was kept under rainfed condition.

Morse *et al.* (1997) determined the N requirements of broccoli grown in a no-till production system in which mulches obtained by mowing cover crops provided part of the N. Mown cover crops of forage soyabean (*Glycine max*), foxtail millet (*Setaria italica*) and a mixture of soyabeans and millet, were compared with the conventional clean cultivation production system. Supplemental N (ammonium nitrate from commercial fertilizer) was applied to all treatments at 0, 112 or 224 kg ha^{-1}. Cover crop biomass ranged from 3.6 to 5.2 t ha^{-1} with N content of 10 kg t^{-1} for millet to 28 kg t^{-1} for soyabean. The cover crops provided only part of the N required by the broccoli crop. Yield and head mass increased with N application up to 224 kg ha^{-1}. Under deficient N conditions, there was preferential N mobilization to the head first and then to the leaves. Estimated N distribution in the plant among the head, leaves, stem, and roots was 22, 58, 6 and 14%, respectively. The mulch provided part of the N requirement, increased soil organic matter, and prevented soil erosion.

2.3 Integrated use of organic and inorganic fertilizers

Maurya *et al.* (2008) is compared the effect of fertilizers (RF; 120:60:60 kg NPK/ha), farmyard manure (FYM) at 20 t/ha, FYM at 10 t/ha + 50% FR, neem cake at 5 quintal/ha, neem cake at 2.5 quintal/ha + 50% RF, vermicompost at 5 t/ha, vermicompost at 2.5 t/ha + 50% RF, poultry manure at 5 t/ha, and poultry manure at 2.5 t/ha + 50% RF on Broccoli. Poultry manure + 50% RF, FYM + 50%

RF and vermicompost + 50% RF registered the greatest head weight in 2005-06, whereas poultry manure + 50% RF was superior for this trait in 2006-07. The highest yields were obtained with poultry manure + 50% RF.

Neves *et al.* (2001) conducted an experiment to assess the agronomic characteristics of broccoli cv. Legacy under different cultivation systems. The cultivation treatments consisted natural 1 (50 t elephant grass (*Pennisetum purpureum* cv. *Napier*) + 1.5 t organic fertilizer + 20 litres EM-4/ha), natural 2 (1.5 t organic fertilizer + 20 litres EM-4/ha), conventional (NPK fertilizers + borax + N fertilizer dressing), and organic (1 kg organic compost/plant). The fresh weight of leaves and stems were higher in conventional than organic cultivation. There was no significant difference in inflorescence fresh weight, dry weight of leaves and stems; and storage quality among the treatments. The inflorescence fresh and dry weight from conventional cultivation was higher than from organic and natural 1 cultivations.

Brown *et al.* (1994) carried out a field experiment on sandy loam soil in 1988-89 at Crossville, Alabama applied 20 or 40 t/ha broiler litter or recommended NPK fertilizer in sweet corn cv. Silver queen matured 1 week earlier in both years with 40 t boiler litter than with NPK fertilizer. This was related to improved P nutrition.

Maynard (1994) conducted an experiment on sustained vegetable production for three years using composted animal manures and reported that intensive Broccoli production trails in spring summer and autumn were conducted for 3 years in Connecticut Windsor (Sandy trace soil) and Mt. Carmel (SMC) or chicken manure compost (CMC) applied at either 56 or 112 t/ha as the sole source of nutrients. Yields of Broccoli from these amended plots were compared with yields from control plots receiving NPK fertilizer. Yields of Broccoli increased with the rate of compost. Compost analysis and Broccoli yields are tabulated. The average yields of spring Broccoli and autumn Broccoli on all CMC amended plots at both rates and sites in all three years were equal to or greater than yields from the control plots.

Sharma (2002) observed that integration of organic and inorganic fertilizer application on Broccoli production (variety Green curd) significantly increased the curd yield over inorganic fertilizer alone and also over control. The treatment N 175 kg/ha, P 75 kg/ha, K 60 kg/ha and FYM 12.60 ton/ha gave the maximum yield (63.12 q/ac) which was at far with N 160 kg/ha, P 75 kg/ha, K 60 kg/ha and FYM 12.60 ton/ha (57.59 q/ac) but significantly superior to rest of the treatments in terms of yield and net profit.

Murlee *et al.* (2007) conducted field experiments in Allahabad, Uttar Pradesh, India, during the 2003 and 2004 kharif seasons, to determine the influence of organic and inorganic fertilizers on growth and yield of cauliflower. Treatment T< sub>3</sub> (150 kg Gromor + 96 kg urea + 32 kg MOP/acre) showed significantly higher curd length (17.00 cm), curd weight (560 g), yield per plot (7.89 kg), yield (392 q/ha) and cost benefit ratio (1:2.88), whereas maximum plant height (53.33 cm) was recorded in treatment T₁ (104 kg urea + 32 kg DAP + 32 kg MOP/acre).

Bhardwaj *et al.* (2000) conducted a field experiment during 1995-98 at Jachh to find out the effect of organic sources of nutrients, i.e. farmyard manure, neem (*Azadirachta indica*) cake and rapeseed (*Brassica campestris* var. *toria*) cake as partial or complete alternative to chemical fertilizers on yield of tomato, okra, cabbage and cauliflower and its economic feasibility. Application of sole organic sources of nutrients recorded 11-17% lower yield in different vegetable crops. However, application of 50% recommended NPK + 50% rapeseed cake (0.72 t/ha) in tomato, 50% recommended NPK + 50% neem cake (0.72 t/ha) in okra, 33.3% recommended NPK + 33.3% farmyard manure (6.66 t/ha) + 33.3% rapeseed cake (0.48 t/ha) in cabbage, 33.3% recommended NPK + 33.3% farmyard manure (6.66

t/ha) + 33.3% neem cake (0.48 t/ha) in cauliflower recorded higher yields which were statistically at par with recommended doses of chemical fertilizers. Net returns in organic produce of different vegetables were higher as the produce received higher price in the market.

Chauhan *et al.* (2000) conducted in pot experiments, cauliflowers cv. Snowball 16 were given the equivalent of 100, 125 or 150 kg N/ha, 25, 50 or 75 kg P/ha and 0-75 t FYM/ha. Incidence of stem rot caused by *Rhizoctonia solani* was lowest with the highest P rate combined with 100 kg N/ha. Increasing FYM rate increased disease incidence and decreased plant stand.

Prestele (2000) carried out a study during 1997-99 on a sandy loam soil in Germany to compare the effects of 3 treatments with different N sources on crop yield and quality of cauliflowers, as well as soil nitrate levels. The sources of N included humus + green manure, humus + green manure + organic N fertilizer (75-300 kg N/ha), and humus + previous crop (lettuce or potatoes) + organic N fertilizer (100-120 kg N/ha). Good quality was obtained without additional N fertilizer. Approximately 100 kg N/ha remained after harvesting, while harvesting removed approximately 40 kg N/ha. Nitrate levels were low after all treatments.

Thuan and Idnani (2007) conducted a experiment in New Delhi, India, during 2003-05 to study the effects of irrigation regimes and nitrogen sources on the yield, water use parameters and soil nitrogen of cauliflower (*Brassica oleracea* var. *botrytis*) cv. Pusa Snow Ball K-1. Three irrigation regimes (20, 30 and 40 mm CPE) and seven nitrogen treatments control (0 kg N/ha); 75 kg N (urea)/ha; 75 kg N subabul (*Leucaena leucocephala*)+ farmyard manure (FYM))/ha; 25 kg N (urea)/ha + Azotobacter +5 t FYM/ha; 50 kg N (urea)/ha + Azotobacter; 50 kg N (urea)/ha + 5 t FYM/ha; and 50 kg N (urea)/ha + Azotobacter + 5 t FYM/ha) were provided. Among the N treatments, 50 kg N (urea)/ha+5 t FYM/ha recorded the highest plant height (43.5 cm), number of leaves per plant (19.0 cm), leaf area index (2.7), dry matter production (118.2 g/plant), total biomass production (50.9 t/ha), marketable yield (18.3 t/ha), total soil nitrogen (0.047%), net return (Rs 48 880) and benefit : cost ratio (3.78). Treatment with 75 kg N (urea)/ha recorded the highest stalk length (9.2 cm). Treatment with 25 kg (urea)/ha + Azotobacter + 5 t FYM/ha recorded the highest harvest index (0.400). Treatment with 50 kg N (urea)/ha + Azotobacter + 5 t FYM/ha recorded the highest days to final maturity (105.7) and available soil nitrogen (261.8 kg/ha).

Chapter III

Materials and Methods

CHAPTER III
MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in execution of the experiment. It includes a short description of experimental site, characteristics of soil, climate, materials used, data collection, statistical analysis and cost & benefit analysis. The details of these are described below:

3.1 Experimental Site

The Experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2008 to February 2009. The experimental site was previously used as vegetable garden recently developed for research work. The location of the site is $23^{o}74'$ N latitude and $90^{o}35'$ E longitude with an elevation of 8.2 m from sea level (appendices I).

3.2 Climate

The climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during rest of the year (Rabi season). The total rainfall of the experimental site was 218 mm during rest of the period of the experiment. The average maximum and the minimum temperatures were 29.45°C and 13.86°C respectively. Rabi season is characterized by plenty of sunshine. The maximum and minimum temperatures, humidity and rainfall during the study period were collected from the Bangladesh Meteorological Department (climate division) and have been presented in appendices II.

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract. The analytical data of the soil sample collected form the experimental area were determined in SRDI Soil Testing Laboratory, Dhaka.

Chapter IV

Results and Discussion

Table 1. Morphological character of experimental field

Morphological Features	Characteristics
Location	SAU farm, Dhaka
AEZ	Modhupur Tract (28)
General Soil type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon series
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Fellow-broccoli

Table 2. Physical & Chemical Properties of Initial Soil

Soil properties	Value
A. Physical properties	
1.Partical size analysis of soil	
Sand (%)	31.5
Silt (%)	45.5
Clay (%)	23
2. Soil texture	Silty-loam
3. Bulk density (g/cm^3)(0-30cm depth)	1.39
4. Particle density (g/cm^3)(0-30cm depth)	2.55
B. Chemical properties	
1. Soil pH	5.6
2. Organic carbon (%)	0.76
3. Organic matter (%)	1.23
4. Total Nitrogen (%)	0.067
5. C:N ratio	9.75:1
6. Available P (ppm)	20.77
7. Exchangeable K (meq/100g soil)	0.2

3.4 Plant Material

Broccoli cultivar 'Premium Crop' (Takki Company of Japan) was used in the experiment which was collected from Kustia seed store, Mirpur, Dhaka.

3.5 Raising of Seedlings

For raising seedlings, the soil was ploughed and converted in to loose friable and dried masses. All weeds, stubbles and dead roots were removed. Cowdung was applied to the prepared seed beds at the rate of 10 t/ha. The seeds were sown in the seed beds of 2.5 m x 1m size on 27 October 2008. After sowing, the seeds were covered with a thin layer of soil, when the seeds germinated, shade by bamboo mat (Chatai) was provided to protect the young seedlings from scorching sun-shine and rain. Light watering, weeding and mulching were done as and when necessary. No chemical fertilizers were applied for raising the seedlings. Seedlings were not attacked by any kind of insects or diseases. Twenty eight days old seedlings healthy were transplanted in the experimental field on 27 December 2008.

3.6 Land Preparation

The experimental plot was opened first on the 2nd week of November 2008 by a power tiller for growing the desired crop. It was then thoroughly prepared by ploughing and cross ploughing for several times with a power tiller followed by laddering to bring good tilth condition suitable for establishing the seedlings. Then the land was leveled and the corners of the experimental plot were shaped and the clods were broken into pieces. The land was cleaned of weeds and stubbles and was finally leveled.

3.7 Treatments of the experiment

There were 12 treatments in the experiment are as follows:

T_1 = No fertilizer

T_2 = 0% N from FYM + 100% N from Urea [150 kg N/ha]

T_3 = 10% N from FYM + 90% N from Urea

T_4 = 20% N from FYM + 80% N from Urea

T_5 = 30% N from FYM + 70% N from Urea

T_6 = 40% N from FYM + 60% N from Urea

T_7 = 50% N from FYM + 50% N from Urea

T_8 = 60% N from FYM + 40% N from Urea

T_9 = 70% N from FYM + 30% N from Urea

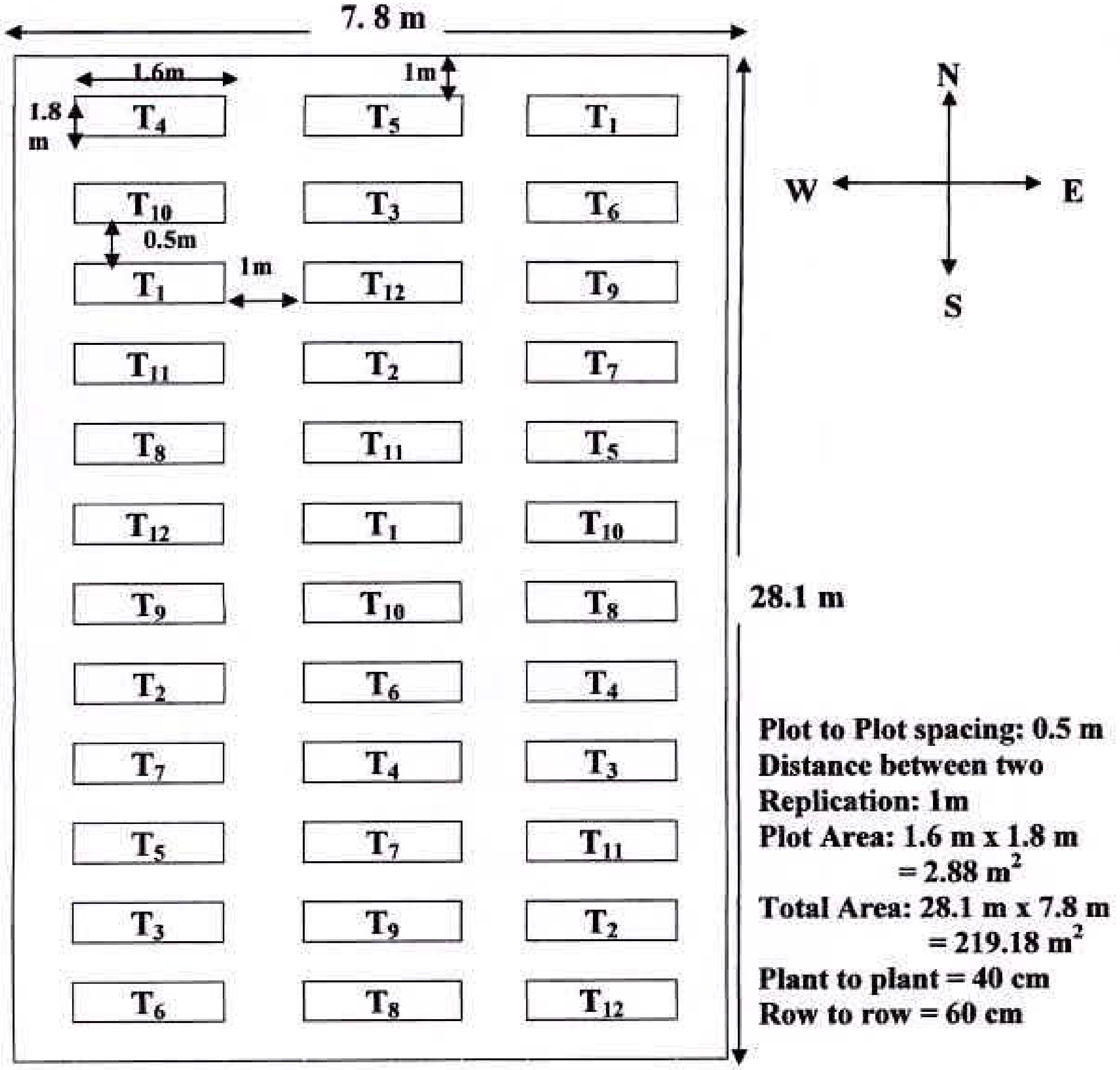
T_{10} = 80% N from FYM + 20% N from Urea

T_{11} = 90% N from FYM + 10% N from Urea

T_{12} = 100% N from FYM [cowdung 30 t/ha] + 0% N from Urea

3.8 Experimental Design and Layout

The experiment was laid out following Randomized Complete Design (RCBD) with three replications. An area of 219.18 m^2 was first divided into a total number of 36 plots. Different combinations of organic and inorganic sources were assigned randomly to each block as per design of the experiment. The size of a unit plot was 1.8 m x 1.6 m and the spacing was 60 cm x 40 cm. The distance between the two blocks and the plots were kept 1 m and 0.5 m, respectively. A layout of the experiment has been shown in figure 1.



T_1 = No fertilizer
T_2 = 0%N from FYM +100%N from Urea [150 kg N/ha]
T_3 = 10%N from FYM +90% N from Urea
T_4 = 20%N from FYM +80%N from Urea
T_5 = 30%N from FYM +70%N from Urea
T_6 = 40%N from FYM +60%N from Urea
T_7 = 50%N from FYM +50%N from Urea
T_8 = 60%N from FYM +40%N from Urea
T_9 = 70%N from FYM +30%N from Urea
T_{10} = 80%N from FYM +20%N from Urea
T_{11} = 90%N from FYM +10%N from Urea
T_{12} = 100%N from FYM [cowdung 30 t/ha] +0%N from Urea

Figure 1. Field Layout of the experiment in the Randomized Complete Block Design (RCBD)

3.9 Application of manure & fertilizer

The amount of N, P, K, S and Zn fertilizers required per plot were calculated as per treatments. Full amounts of TSP, MOP, Gypsum and Zinc Sulphate were applied as basal dose before sowing of seeds. Urea were applied in 3 equal splits, 50% were applied at basal before seedling transplanting, rest half was applied in two equal doses at before flowering stage and fruiting stage.

3.10 Transplanting and after care

Twenty seven days old Healthy seedlings were transplanted on 27th November, 2008 in the afternoon and light irrigation was given around each seedling for their better establishment. Each unit plot accommodated 18 seedlings. The transplanted seedlings were protected from scorching sun light early in the morning by providing shed using banana leaf sheath and remove just before sun set daily, until the seedlings were good established. A number of seedlings were planted in the border of the experimental plots for gap filling.

3.11 Gap filling

Dead, injured and weak seedlings were replaced by new healthy seedlings from the stock kept on the border line of the experiment.

3.12 Intercultural operation

3.12.1 Weeding

Weeding was done three times in each plot to keep weed free the crop field.

3.12.2 Irrigation

Light irrigation was given just after transplanting of the seedlings. A week after transplanting the requirement of irrigation was envisaged through visual estimation. Wherever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

3.13 Pest and Disease Control

Few plants were damaged by mole crickets and cut worms after the seedlings were transplanted in the experimental plots. Cutworms were controlled both mechanically and spraying Diazinon 60 EC @ 0.55 kg per hectare. Some of the plants were infected by *Alternaria brassicae*. To prevent the spread of the disease Rovral @ 2g/liter of water was sprayed in the field. Bird pests such as Nightingale (Common Bulbuli) visited the fields from 8 to 11 am and 4 to 6 pm. The birds were found to make puncture in the soft leaves and initiating curd and they were controlled by striking of a metallic container.

3.14 Harvesting

The harvesting was not possible on a particular date because curd initiation as well as curd maturation period in different plants were not similar probably due to use of different manures and genetic characters. The compact mature curds were only harvested. After harvesting the main curd, secondary shoots were developed from the leaf axils, and produced small secondary curds. Those were harvested over a period of time. The crop under investigation was harvested for the first time on February 7, 2009 and the last harvesting was done on February 15, 2009. The curds were harvested in compact condition before the flower buds opened (Thompson and Kelly, 1988).

3.15 Methods of Data Collection

The data pertaining to the following characters were recorded from 12 plants randomly selected from each unit plot, except yield of curds which was recorded plot wise. Data on plant height were collected on 20, 40 and 60 days after transplanting and also at harvest. All other parameters were recorded at harvest.

Data were collected on the following parameters:

1. Plant height (cm)
2. Number of leaves per plant
3. Length of leaf (cm)
4. Breadth of leaf (cm)
5. Diameter of curd (cm)
6. Diameter of stem (cm)
7. Plant canopy (cm)
8. Height of curd (cm)
9. Weight of primary curd (g)
10. Weight of secondary curd (g)
11. Number of secondary curd
12. Yield per plant (g)
13. Yield per unit plot (kg)
14. Yield per hectare (ton)
15. Dry weight of curd (g)

3.15.1 Plant height (cm)

Plant height was measured in centimeter (cm) by a meter scale at 20, 40 and 60 days after transplanting (DAT) and at harvested from the ground level up to the tip of the longest leaf or curd.

3.15.2 Number of leaves per plant

Number of leaves per plant was counted at harvest. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting.

3.15.3 Length of leaf (cm)

A meter scale was used to measure the length of leaves. Leaf lengths of ten randomly selected plants were measured in centimeter (cm) at harvest. It was measured from the base of the petiole to the tip of the leaf. All the leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

3.15.4 Breadth of leaf (cm)

Leaf breaths of ten randomly selected plants were measured in centimeter (cm) at harvest from the widest part of the lamina with a meter scale and average breadth was recorded in centimeter (cm). All the leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

3.15.5 Diameter of curd (cm)

Curd diameter was recorded in several directions with a meter scale at measured stage from ten randomly selected plants and each of plant was measured separately.

3.15.6 Diameter of stem (cm)

The diameter of stem was measured at the central curd was cut off. Stem diameter was recorded in three dimensions with scale and the average of the three values was taken in centimeter (cm).

3.15.7 Plant canopy (cm)

Plant canopy was measured by taking the diameter of the canopy of an individual plant in several directions with a meter scale and finally the average was taken and was expressed in centimeter (cm).

3.15.8 Height of curd (cm)

The height of curd was measured with a meter scale from the top of the central curd and was recorded in centimeter (cm).

3.15.9 Weight of primary curd (g)

Weight of the central curd was record excluding the weight of all secondary curds and was expressed in gram (g).

3.15.10 Weight of secondary curd (g)

Weight of secondary curd was recorded by weighing the total auxiliary curds of individual plant and was expressed in gram (g).

3.15.11 Number of secondary curds

When the secondary curds reached marketable size. They were counted the small shoots were not taken into consideration.

3.15.12 Yield per plant (g)

The yield per plant was calculated by adding the weight of central curd and the weight of the secondary curds harvested and the yield was weighed in gram (g).

3.15.13 Yield per unit plot (kg)

The Yield per unit plot was calculated by adding the weight of ventral curds and the weight of the secondary curds. The yield of all plants in each unit plot was recorded and was expressed kilogram (kg).

3.15.14 Yield per hectare (ton)

The yield per hectare was calculated by converting the per plot yield data to per hectare and was expressed in ton (t).

3.15.15 Dry weight of Broccoli curd (g)

A sample of 100 g of curd was collected and was dried under direct sunshine for 72 hours and then dried in an oven at 70°C for 3 days. After oven drying, curds were weighed. The dry matter was calculated by the following formula:

$$\% \text{ Dry matter} = \frac{\text{Weight of dry matter}}{\text{Fresh weight}} \times 100$$

3.16 Soil Analysis

a. Soil pH

Soil pH was determined by a glass electrode pH meter in soil water suspension having soil: water ratio 1: 2.5 as described by Jackson (1973).

b. Organic carbon

Soil organic carbon was determined by walkley and Black's wet oxidation method as outlined by Jackson (1973) from the soil samples collected before sowing and also after harvesting the crop.

c. Organic matter

The organic matter content was determined by multiplying the percent organic carbon with Van Bemmelen factor 1.73.

d. Total Nitrogen

Total nitrogen of soil samples were estimated by Micro-Kjeldahl method where soils were digested with 30% H_2O_2, Conc. H_2SO_4 and catalyst mixture (K_2SO_4:$CuSO_4.5H_2O$: Selenium powder in the ratio 100:10:1 respectively). Nitrogen in the digests were determined by distillation with 40% NaOH followed by titration of the distillate absorbed in H_3BO_3 with 0.01 N H_2SO_4 (Jackson, 1973.)

e. Available Phosphorous

Available phosphorus was extracted from the soil Bray-1 method (Bray & Kurtz, 1995) Phosphorus in the extract was determined by spectrophotometer.

f. Exchangeable Potassium

Exchangeable potassium in the soil sample was extracted with 1 N neutral ammonium acetate & the potassium continent was determined by flame photometer.

3.17 Chemical analysis of the plant

a. Collection of plant samples

Pant and fruit samples were collected after cleaning. The samples were finely ground by using a Wiley-Mill with stainless contact points to pass through a 60 mesh sieve. The samples were stored in plastic vial for analyses of N, P and K.

b. Preparation of plant samples

The plant samples were dried in an oven at 70^0C for 72 hours and then ground by a grinding machine to pass through a 20 mesh sieve. The plant and fruit samples were analyzed for determination of N, P and K concentrations. The methods were as follows:

c. Digestion of plant samples with sulphuric acid for N

For N determination, an amount of 0.1g plant sample (plant and fruit) was taken into a 100 ml Kjeldhal flask. An amount of 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se =100:10:1), 2 ml 30% H_2O_2 and 3 ml conc. H_2SO_4 were added into the flask. The flask was swirled and allowed to stand for about 10 minutes followed by heating at 200^0C. Heating was continued until the digest was clear, and colorless. After cooling, the contents were taken into a 100 ml volumetric flask and the volume was made with distilled water. A blank digestion was prepared in a similar way. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_4 indicator solution with 0.01 N H_2SO_4. This digest was used for determining the nitrogen contents of plant samples.

d. Digestion of plant samples with nitric per chloric acid for P & K

An amount of 0.5 g of plant was taken into a dry clean 100ml Kjeldahl flask, 10 ml of di acid mixture (HNO_3 and $HClO_4$ at the ratio of 2:1) was added and kept for few minutes. Then, the flask was heated at a temperature rising slowly up to 200^0C. Heating was instantly stopped as soon as the dense white fumes of $HClO_4$ occurred and after cooling; 6 ml of 6 N HCl were added to it. The content of the flask was boiled until they become clear and colorless. This digest was used for determining P and K.

3.18 Statistical analysis

The data obtained from the experiment were analyzed statistically to find out the significance of the difference among the treatments. The mean values of all the character were evaluated and analysis of variance was performed by the 'F' (Variance ratio) test. The significance of the differences among pairs of treatment means was estimated by the least significant difference (LSD) test at 5% and 1% level (Gomez and Gomez, 1984).

3.19 Cost and return analysis

Cost and return analysis was done in details following the procedure of Alam *et al.* (1989) which was given in Appendix IX.

CHAPTER IV

RESULTS AND DISCUSSION

Efficiency of different levels of fertilizers and manure has been described and discussed character wise. The data recorded in respect of yield and yield attributes of broccoli are presented in this chapter.

4.1 Growth, yield and Yield contributing characters

4.1.1 Plant Height

Plant height was determined by the height of stem along with curd. Plant height showed statistically significant variation due to the application of farm yard manure and inorganic fertilizer (urea) at 20, 40 and 60 DAT (Appendix III). At 20, 40 and 60 DAT different maximum plant heights (23.25 cm, 38.92 cm and 62.36 cm) were recorded from T_6 treatment (40% N from farm yard manure + 60% N from urea) which was statistically similar (22.72 cm, 38.15 cm and 62.25 cm) to T_7 treatment (50% N from farm yard manure + 50% N from urea) and T_5 andT_8. Again, at the same DAT the lowest plant heights (11.23 cm, 24.22 cm and 38.34 cm) were observed from T_1 treatment as control treatment (Table 3). All the treatments produced significantly taller plant compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the plant height compared to single application of recommended dose of farm yard manure or inorganic fertilizer (Urea). Salam (2001) showed that nitrogen enhances the protein synthesis, which allows plant to grow faster increases rate of metabolism, cell division, cell elongation and thereby stimulated apical growth. The plant height increased with the increase of period of time. The plant height reached to its maximum at harvesting time in all the treatments. That might be due to the fact that fertilizers and manures supplied adequate plant nutrients for better vegetative growth of the broccoli plants which ultimately increased plant height. The findings of the present study corroborates with the findings of Thompson and Kelly (1988).

Table 3: Effect of different levels of organic and inorganic N on plant height and number of leaves per plant in Broccoli

Treatments	Plant height (cm)			Number of leaves/plant		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
T_1	11.23g	24.22e	38.34f	4.80f	7.84g	11.20g
T_2	16.92f	31.58d	54.92e	6.03e	9.62f	14.20f
T_3	18.32ef	34.38b-d	57.05c-e	6.56cd	10.34c-f	15.10d-f
T_4	18.91ef	33.17cd	58.62b-d	6.82bc	10.52c-f	15.30c-e
T_5	21.95a-c	37.44ab	61.82ab	7.22b	11.23a-c	16.80ab
T_6	23.25a	38.92a	62.36a	7.86a	11.76a	17.60a
T_7	22.72ab	38.15ab	62.25a	7.66a	11.52ab	17.20a
T_8	21.12b-d	36.54a-c	60.12a-c	7.12b	11.05a-d	16.20bc
T_9	20.45c-e	35.63a-d	59.12a-c	6.93bc	10.81bc-e	15.70cd
T_{10}	20.17c-e	34.73b-d	57.17c-e	6.34de	10.22d-f	14.80d-f
T_{11}	19.82de	33.15cd	56.55c-e	6.28de	10.06ef	14.40ef
T_{12}	19.24de	32.24d	55.78de	6.15e	9.78f	14.10f
LSD	1.916	3.616	3.266	0.371	0.839	0.908
CV (%)	5.81	6.25	3.38	3.29	4.77	3.53

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly

T_1 = No fertilizer
T_2 = 0% N from FYM + 100% N from Urea [150 kg N/ha]
T_3 = 10% N from FYM + 90% N from Urea
T_4 = 20% N from FYM + 80% N from Urea
T_5 = 30% N from FYM + 70% N from Urea
T_6 = 40% N from FYM + 60% N from Urea
T_7 = 50% N from FYM + 50% N from Urea
T_8 = 60% N from FYM + 40% N from Urea
T_9 = 70% N from FYM + 30% N from Urea
T_{10} = 80% N from FYM + 20% N from Urea
T_{11} = 90% N from FYM + 10% N from Urea
T_{12} = 100% N from FYM [cowdung 30 t/ha] + 0% N from Urea

4.1.2 Number of leaves per plant

Farm yard manure and inorganic fertilizer (urea) showed statistically significant variation for number of leaves per plant of Broccoli at 20, 40 and 60 DAT (Appendix III). At the different days after transplanting (DAT) the highest number of leaves per plant (7.86 cm, 11.76 cm and 17.60 cm) were recorded from T_6 (40% N from farm yard manure + 60% N from urea) which was statistically identical (7.66 cm, 11.52 cm and 17.20 cm) with T_7 (50% N from farm yard manure + 50% N from urea) and treatment T_5 at 20, 40 and 60 DAT, respectively. Again, at the same DAT the lowest plant (4.80 cm, 7.84 cm and 11.20 cm) was observed from T_1 as control treatment (Table 3). All the treatments produced significantly higher number of leaves per plant compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the number of leaves per plant compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea). It has been observed that different manure and fertilizer had appreciable effect on the number of leaves per plant. Sharma *et al.* (2002) also reported that increasing level of nitrogen application increase the number of leaves per plant.

4.1.3 Length of leaf

The size of the leaf determines the photosynthetic area which has got important role in head production. The length of leaf showed significant difference among the treatments. A statistically significant variation was recorded due to the application of farm yard manure and inorganic fertilizer for length of leaf of Broccoli at 20, 40 and 60 DAT (Appendix IV). At the different days after transplanting (DAT) the longest leaf (16.53 cm, 30.93 cm and 45.08 cm) was recorded from T_6 (40% N from farm yard manure + 60% N from urea) which was statistically identical (16.51 cm, 30.82 cm and 44.87 cm) with T_7 (50% N from farm yard manure + 50% N from urea) and Treatments T_5, T_8, T_9, T_4, T_3 at 20, 40 and 60 DAT. Whereas at the same DAT the shortest leaf (12.63 cm, 22.02 cm and 37.58 cm) was observed from T_1 as control treatment (Table 4). From the data it was revealed that all the treatments produced significantly longest length of leaf compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the length of leaf compared to single application of recommended dose of farm yard manure and inorganic fertilizer (urea). Balyan *et al.* (1997) observed that nitrogen fertilizer improved the leaf size index over the control. Organic manures which increase the water holding capacity of the soil are desirable for broccoli crop. The present result is in agreement with that of Tremblay (1989) who reported greater vegetable growth, higher leaf size with higher rates of nitrogen.

4.1.4 Breadth of leaf

A statistically significant variation was recorded due to the application of farm yard manure and inorganic fertilizer for breadth of leaf of Broccoli at 20, 40 and 60 DAT (Appendix IV). At the different days after transplanting (DAT) the maximum breadth of leaf (8.32 cm, 14.23 cm and 17.46 cm) was recorded from T_6 treatment (40% N from farm yard manure + 60% N from urea) which was statistically identical (8.15 cm, 14.12 cm and 17.38 cm) to T_7 (50% N from farm yard manure + 50% N from urea) and treatment T_5, T_8 at 20, 40 and 60 DAT. Whereas, at the same DAT the lowest breadth of leaf (4.85 cm, 9.58 cm and 13.94 cm) was observed from T_1 treatment as control treatment (Table 4). All the treatments produced significantly higher breadth of leaf compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the breadth of leaf compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea). Similar result were also reported by Man and Shandhu (1955), Ram and Sharma (1969). They reported that maximum size of leaves was obtained with the higher dose of nitrogen application.

4.1.5 Plant canopy

Statistically significant variation was recorded due to the application of farm yard manure and inorganic fertilizer for plant canopy of Broccoli at 20, 40 and 60 DAT (Appendix V). At the different days after transplanting (DAT) the highest plant canopy (29.63 cm, 48.96 cm and 71.54 cm) was recorded from T_6 treatment (40% N from farm yard manure + 60% N from urea) which was statistically identical (28.83 cm, 48.93 cm and 71.26 cm) with T_7 treatment (50% N from farm yard manure + 50% N from urea) and T_5 at 20, 40 and 60 DAT. Whereas at the same DAT the lowest breadth of leaf (15.27 cm, 30.53 cm and 49.29 cm) was observed from T_1 as control treatment (Table 5). All the treatments produced significantly larger plant canopy compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the plant canopy compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea). The spread of plant canopy was equally better in all the treatments except in the control, where it showed the lowest spread. This might be due to the fact that the treatments with different sources of nitrogen received adequate nutrients and resulted in maximum vegetative growth and increased plant canopy.

4.1.6 Height of curd

The height of curd was found to be significantly different due to the different sources of fertilizers and manures (Table 5). Height of curd varied from 11.56 cm to 17.63 cm. The highest height of curd was (17.63 cm) found from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was statistically identical (16.83 cm) to T_7 (50% N from farm yard manure + 50% N from urea) and treatment T_5, T_8, T_9, T_4, T_3, T_{10}, T_{11}. The lowest height of curd (11.56 cm) was observed from T_1 as control condition. All the treatments produced significantly higher height of curd compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the height of curd

Table 4: Effect of different levels of organic and inorganic N on length of leaf and breadth of leaf in Broccoli

Treatments	Length of leaf (cm)			Breadth of leaf (cm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
T_1	12.63d	22.02d	37.58b	4.85f	9.58g	13.94e
T_2	15.08c	27.51c	43.12a	6.29e	12.13f	16.03d
T_3	15.73a-c	29.03a-c	43.78a	7.23c	12.82c-f	16.42a-d
T_4	16.27ab	29.23a-c	44.23a	7.74b	13.09c-e	16.56a-d
T_5	16.5a	30.71ab	44.71a	8.02ab	14.02ab	17.25a-c
T_6	16.53a	30.93a	45.08a	8.32a	14.23a	17.46a
T_7	16.51a	30.82ab	44.87a	8.15ab	14.12ab	17.38ab
T_8	16.45ab	30.67ab	44.62a	7.88b	13.56a-c	16.87a-d
T_9	16.23ab	30.56ab	44.53a	7.81b	13.22b-d	16.71a-d
T_{10}	15.95a-c	28.73a-c	43.26a	7.05c	12.63c-f	16.32a-d
T_{11}	15.56a-c	28.36bc	42.93a	6.86cd	12.43d-f	16.25b-d
T_{12}	15.42bc	28.12c	42.26a	6.56de	12.26ef	16.13cd
LSD	0.1934	2.168	3.361	0.4007	0.8551	1.012
CV (%)	3.42	4.44	4.57	3.29	3.93	3.63

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly

T_1 = No fertilizer
T_2 = 0% N from FYM + 100% N from Urea [150 kg N/ha]
T_3 = 10% N from FYM + 90% N from Urea
T_4 = 20% N from FYM + 80% N from Urea
T_5 = 30% N from FYM + 70% N from Urea
T_6 = 40% N from FYM + 60% N from Urea
T_7 = 50% N from FYM + 50% N from Urea
T_8 = 60% N from FYM + 40% N from Urea
T_9 = 70% N from FYM + 30% N from Urea
T_{10} = 80% N from FYM + 20% N from Urea
T_{11} = 90% N from FYM + 10% N from Urea
T_{12} = 100% N from FYM [cowdung 30 t/ha] + 0 % N from Urea

compared to single application of recommended dose of farm yard manure and inorganic fertilizer (urea). This might be due to its photosynthesis, energy storage, cell division and cell enlargement. Similar results was reported by Saimbhi *et al.* (1969).

4.1.7 Diameter of curd

The shape of the main curd in broccoli is a genetic character. The cultivar used in the experiment had round head. The head diameter in this cultivar can be taken as an appropriate measure of head size. Like other yield components of broccoli, the diameter of the curd was significantly varied with different fertilizer treatments (Appendices V). Diameter of curd varied from 9.10 cm to 15.70 cm. The highest diameter of curd was (15.70 cm) found from T_6 treatment (40% N from farm yard manure + 60% N from urea) treatment which was statistically identical (15.40 cm) to T_7 (50% N from farm yard manure + 50% N from urea) and Treatment T_5 treatment (Table 5) the lowest diameter of curd (9.10 cm) was observed from T_1 treatment as control condition. All the treatments produced significantly higher diameter of curd compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the diameter of curd compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea). Steffen *et al.* (1994) observed the effect of organic matter (spent mushroom compost at 64 mt/ha + rotten cattle manure at 57 mt/ha) on the growth and yield of broccoli. They concluded that broccoli yield and curd diameter were greater in the amended treatment.

4.1.8 Diameter of stem

Statistically significant variation was recorded due to the application of farm yard manure and inorganic fertilizer for stem diameter of Broccoli (Appendices V). The diameter of stem was equally better in all the treatments of the sources of manures except in the control. Diameter of stem varied from 2.53 cm to 3.68 cm. The highest diameter of stem was (3.68 cm) found from T_6 treatment (40% N from

Table 5: Effect of different levels of organic and inorganic N on plant canopy, height of curd, diameter of stem, diameter of curd,Primary curd weight in Broccoli

Treatments	Plant canopy (cm)			Height of curd (cm)	Diameter of curd (cm)	Diameter of stem (cm)	Primary curd weight (g)
	20 DAT	40 DAT	60 DAT				
T_1	15.27f	30.53h	49.29f	11.56c	9.10i	2.53d	262.8d
T_2	19.42e	38.24g	61.26e	14.01b	11.30h	2.88c	297.6cd
T_3	21.43de	42.37c-f	65.12c-e	15.01ab	13.10d-f	3.01c	324.2a-c
T_4	22.58cd	43.49c-e	65.92c-e	16.46ab	13.50c-e	3.07c	330.6a-c
T_5	27.36a	47.17ab	68.27a-c	16.63ab	15.20ab	3.62a	345.2ab
T_6	29.63a	48.96a	71.54a	17.63a	15.70a	3.68a	357.9a
T_7	28.83a	48.93a	71.26ab	16.83ab	15.40ab	3.64a	351.4ab
T_8	25.16b	45.24bc	67.13a-c	16.63ab	14.40bc	3.52a	340.5a-c
T_9	24.46bc	44.63b-d	66.58b-d	16.24ab	13.90cd	3.33b	334.3a-c
T_{10}	20.89de	41.58d-f	64.51c-e	15.93ab	12.70e-g	3.02c	320.3a-c
T_{11}	20.12e	40.93efg	63.87c-e	15.74ab	12.30f-h	3.01c	315.4a-c
T_{12}	3.83e	40.12fg	62.17de	14.19b	11.70gh	2.96c	307.6bc
LSD	2.168	2.962	4.399	2.709	1.027	0.1855	40.35
CV (%)	5.59	4.10	4.0	5.74	4.60	3.37	7.35

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly

T_1 = No fertilizer
T_2 = 0% N from FYM + 100% N from Urea [150 kg N/ha]
T_3 = 10% N from FYM + 90% N from Urea
T_4 = 20% N from FYM + 80% N from Urea
T_5 = 30% N from FYM + 70% N from Urea
T_6 = 40% N from FYM + 60% N from Urea
T_7 = 50% N from FYM + 50% N from Urea
T_8 = 60% N from FYM + 40% N from Urea
T_9 = 70% N from FYM + 30% N from Urea
T_{10} = 80% N from FYM + 20% N from Urea
T_{11} = 90% N from FYM + 10% N from Urea
T_{12} = 100% N from FYM [cowdung 30 t/ha] + 0% N from Urea

farm yard manure + 60% N from urea) treatment which was statistically identical (3.64 cm) to T_7 (50% N from farm yard manure + 50% N from urea) and Treatment T_5, T_8 (Table 5). The lowest diameter of stem (2.53 cm) was observed from T_1 as control condition. From the data it was revealed that all the treatments produced significantly higher diameter of stem compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the diameter of stem compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea).

4.1.9 Weight of Primary curd

The weight of primary curd varied significantly due to the different sources of fertilizers and manures (Appendices V). Weight of primary curd varied from 262.8 g to 357.4 g. The highest weight of primary curd was (357.9 g) found from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was statistically identical (351.4 g) to T_7 (50% N from farm yard manure + 50% N from urea) and treatment T_5, T_8, T_9, T_4, T_3, T_{10} (Table 5). The lowest weight of primary curd (262.8 g) was observed from T_1 as control condition. All the treatments produced significantly larger weight of primary curd compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the weight of primary curd compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea). Mitra *et al.* (1990) reported similar results where application of 112 kg N/ha gave higher curd weight.

4.1.10 Number of secondary curd

The Number of secondary curd was found to be statistically significant due to the different sources of fertilizers and manures (Appendices VI). Number of secondary curd varied from 3.04 to 5.73. The highest (5.73) number of secondary curd was found from T_6 treatment (40% N from farm yard manure + 60% N from urea) treatment which was followed by (5.12) T_7 (50% N from farm yard manure

+ 50% N from urea) and treatment T_5 (Table 6). The lowest Number of secondary curd (3.04) was observed from T_1 treatment as control condition. All the treatments produced significantly higher number of secondary curd compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the number of secondary curd compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea). Similar results were found from Wyatt (1989), Sing (2004) and Sharma (2002).

4.1.11 Weight of secondary curd

The weight of secondary curd was statistically significant due to the different sources of fertilizers and manures (Table 6). Weight of secondary curd varied from 37.73 g to 56.73 g. The highest weight of secondary curd (56.73 g) was found from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was statistically identical (55.93 g) to T_7 (50% N from farm yard manure + 50% N from urea) and Treatment T_5, T_8, T_9, T_4. The lowest weight of secondary curd (37.73 g) was observed from T_1 as control condition. All the treatments produced significantly higher weight of secondary curd compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the weight of secondary curd compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea).

4.1.12 Dry weight of broccoli curd

The results on main effects of sources of nitrogen on the production of dry matter of broccoli curd have been presented in table 6. Dry weight of broccoli curd was found to be statistically significant due to the different sources of fertilizers and manures. Dry weight of broccoli curd varied from 56.2 g to 77.6 g. The highest dry weight of broccoli curd was (77.6 g) found from T_6 treatment (40% N from farm yard manure + 60% N from urea) which was statistically identical (74.6 g) to T_7 treatment (50% N from farm yard manure + 50% N from urea) and Treatments

Table 6: Effect of different levels of organic and inorganic N on number of secondary curd, secondary curd weight, dry weight of curd, yield per plant, yield per plot and yield per hectare of Broccoli

Treatments	Number of secondary curd	Secondary curd weight (g)	Dry weight of curd (g)	Yield per plant (g)	Yield per plot (kg)	Yield ton per hectare
T_1	3.04g	37.73f	56.2c	266.1c	3.19e	11.08g
T_2	3.67f	48.02e	69.3b	370.8b	4.45d	15.45f
T_3	4.01d-f	51.09b-e	71.8b	385.4ab	4.62cd	16.04c-e
T_4	4.07 de	52.53a-e	72.2b	387.1ab	4.64cd	16.11c-e
T_5	4.88bc	55.07a-c	74.1ab	408.5ab	4.90ab	17.02bc
T_6	5.73a	56.73a	77.6a	412.6a	4.95a	17.18a
T_7	5.12b	55.93ab	74.6ab	410.1ab	4.92ab	17.08ab
T_8	4.71c	54.24a-d	73.5ab	407.6ab	4.89a-c	16.97bc
T_9	4.32d	53.15a-d	72.9ab	395.7ab	4.74b-d	16.45cd
T_{10}	3.89ef	50.91b-e	71.2b	382.1ab	4.58d	15.90c-e
T_{11}	3.83ef	50.18c-e	70.9b	378.6ab	4.54d	15.76de
T_{12}	3.76ef	49.21de	70.1b	375.2ab	4.50d	15.62ef
LSD	0.3301	4.485	0.4637	34.91	0.3552	1.086
CV (%)	4.56	5.17	3.84	5.40	5.63	4.67

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.

T_1 = No fertilizer
T_2 = 0% N from FYM + 100% N from Urea [150 kg N/ha]
T_3 = 10% N from FYM + 90% N from Urea
T_4 = 20% N from FYM + 80% N from Urea
T_5 = 30% N from FYM + 70% N from Urea
T_6 = 40% N from FYM + 60% N from Urea
T_7 = 50% N from FYM + 50% N from Urea
T_8 = 60% N from FYM + 40% N from Urea
T_9 = 70% N from FYM + 30% N from Urea
T_{10} = 80% N from FYM + 20% N from Urea
T_{11} = 90% N from FYM + 10% N from Urea
T_{12} = 100% N from FYM [cowdung 30 t/ha] +0 % N from Urea

T_5, T_8, T_9. The lowest dry weight of broccoli curd was (56.2 g) observed from T_1 treatment as control condition. All the treatments produced significantly higher dry weight of broccoli curd compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the dry weight of broccoli curd compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea).

4.1.13 Yield per Plant

Marketable yield was significantly influenced due to the application of farm yard manure and inorganic fertilizer (Table 6). For measuring the marketable yield, broccoli curds were harvested by removing the outer leaves and stem. The length of stem attached to the main curd was very small. Yield per plant of broccoli varied from 266.1 g to 412.6 g. The highest yield per plant was (412.6 g) found from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was statistically identical (410.1 g) to all other treatments except control. The lowest yield per plant was (266.1 g) observed from T_1 as control condition. All the treatments produced significantly higher marketable yield per plant compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the yield per plant compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea). Research findings from the works of Gorski and Armstrong (1985), Daufult and Watery (1988), Kowalenko and Hall (1987), Trembly (1989). Daufult and Melton (1991) reveal that with in certain limits the yield of broccoli was proportional to the quantities of nitrogenous fertilizer applied.

4.1.14 Yield per plot and hectare

Yield per plot and per hectare was significantly influenced due to the application of farm yard manure and inorganic fertilizer (Table 6). The highest yield per plot (4.95 kg) and per hectare (17.18 ton) was found from T_6 (40% N from farm yard

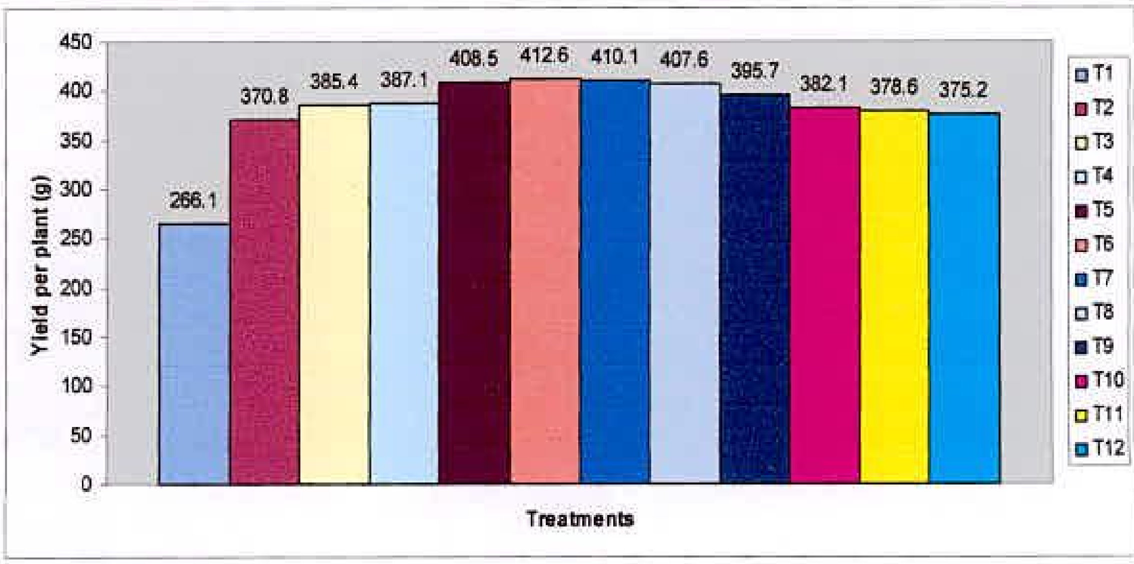


Figure 2. Effect of farm yard manure and inorganic fertilizer on broccoli yield per plant (g)

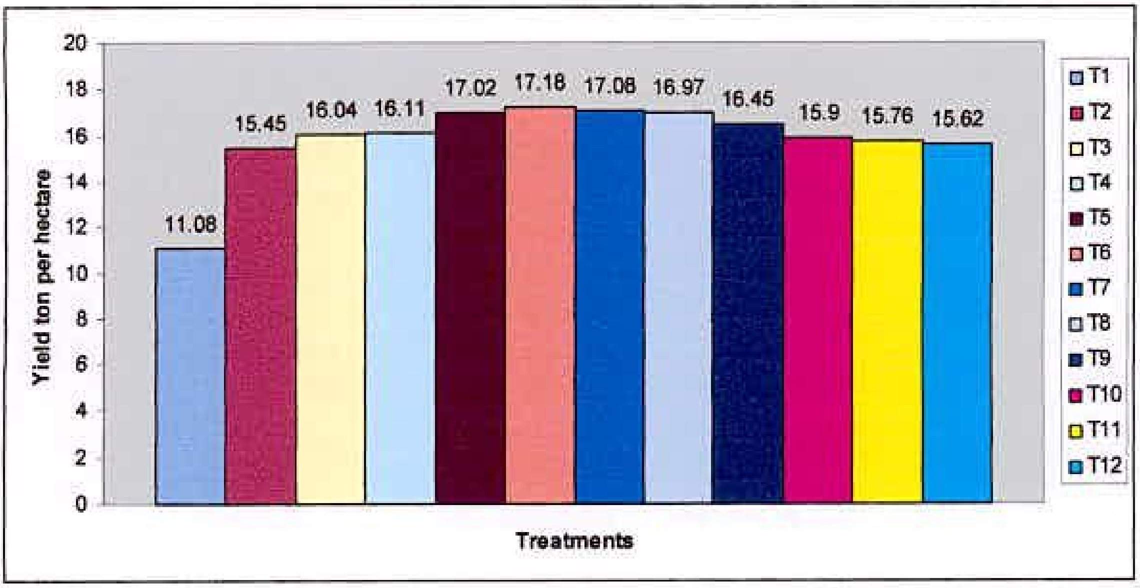


Figure 3. Effect of farm yard manure and inorganic fertilizer on broccoli yield ton per hectare

manure + 60% N from urea) treatment which was statistically identical (yield per plot 4.92 kg and per hectare 17.08 ton) to T_7 (50% N from farm yard manure + 50% N from urea). The lowest yield per plot (3.19 kg) and per hectare (11.08 ton) was observed from T_1 as control condition. All the treatments produced significantly higher yield per plot and per hectare compared to the control treatment. The combined application of farm yard manure with inorganic fertilizer (urea) increased the yield per plot and per hectare compared to single application of recommended dose of farm yard manure or inorganic fertilizer (urea). The result showed that higher doses of manure fertilizer increase the yield gradually. From the figure 3, it has been noted that yield was lower at later time. On the other hand, heavy doses of manure keeps the plants always at vegetative growth condition i.e. higher amount of nitrogen absorption transform the plant from reproductive phase to vegetative phase. Ultimately, yield may become low. The performance of the combination (40% N from farm yard manure + 60% N from urea) was the best to supply nitrogen nutrient to the crop through the season. 100% N from FYM was not able to supply enough mineral N for the growth of plant. On the other hand 100% N from urea released so much mineral N that might be lost form the system. Therefore integrated use of organic and inorganic fertilizer performed better as a source of N for the crop.

4.1.15 Cost and benefit Analysis

Total costs & return for each treatment was calculated based on the prevailing market price during the study period. The details of cost analysis have been show in Appendix IX. The benefit cost ratio was computed by dividing the total return with the total cost of production. Table 7 shows that the lowest cost for production (54530 Tk) was in T_1 where no cowdung and urea were applied and the highest cost of production (70654 Tk) was in treatments T_{11}. The gross return was obtained higher (343600 Tk) with T_6 treatment. The lowest gross return (221600 Tk) was obtained from T_1 treatment. The highest net return from T_6 was 275087 Tk and the lowest net return from T_1 was 167070 Tk. The benefit cost ratio (BCR)

Table 7: Effect of farm yard manure and inorganic fertilizers on Benefit Cost Ratio (BCR) of Broccoli

Treatments	Yield (t/ha)	Gross return (Tk/ha)	Total cost of production (Tk/ha)	Net benefit (Tk/ha)	Benefit Cost Ratio
T_1	11.08	221600	54530	167070	3.21
T_2	15.45	309000	58247	250753	4.14
T_3	16.04	320800	68277	252523	4.07
T_4	16.11	322200	68513	253687	4.12
T_5	17.02	340400	68436	271964	4.23
T_6	17.18	343600	68513	275087	4.73
T_7	17.08	341600	69044	272556	4.33
T_8	16.97	339400	69197	270203	4.49
T_9	16.45	329000	69734	259266	4.24
T_{10}	15.90	318000	70153	247847	3.91
T_{11}	15.76	315200	70654	244546	3.75
T_{12}	15.62	312400	69799	242601	3.73

Note:
Sale of Broccoli @ 20000.00/t
Total Income: Yield (t/ha) x 20000.00
BCR: Gross Income ÷ Total Cost of Production

T_1 = No fertilizer
T_2 = 0% N from FYM + 100%N from Urea [150 kg N/ha]
T_3 = 10% N from FYM + 90% N from Urea
T_4 = 20% N from FYM + 80%N from Urea
T_5 = 30% N from FYM + 70%N from Urea
T_6 = 40% N from FYM + 60%N from Urea
T_7 = 50% N from FYM + 50%N from Urea
T_8 = 60% N from FYM + 40%N from Urea
T_9 = 70% N from FYM + 30%N from Urea
T_{10} = 80% N from FYM + 20%N from Urea
T_{11} = 90% N from FYM + 10%N from Urea
T_{12} = 100% N from FYM [cowdung 30 t/ha] + 0 % N from Urea

was the highest (4.73) for T_6 treatment which as followed by T_7 (4.33). The lowest BCR was shown by T_1 treatment (3.21). The result indicated that application of cowdung and urea could increase yield. The application of 60% N from urea along with 40%N from cowdung was found to be conducive to higher yield as well as higher economic return from broccoli under the Modhupur tract Agro Ecological Region of Bangladesh.

4.2 NPK concentration in plant

4.2.1 N concentration in plant

Statistically significant variation was observed for N concentration in plant due to the application of farm yard manure and inorganic fertilizer (Appendix VII). The maximum (3.55%) N concentration in plant was recorded from T_6 treatment (40% N from farm yard manure + 60% N from urea) which was followed by (3.41%) T_7 (50% N from farm yard manure + 50% N from urea). On the other hand, the minimum N concentration in plant (1.09%) was observed from T_1 treatment as control condition (Table 8). The combined application of farm yard manure with inorganic fertilizer (urea) increased N concentration in plant compare to control treatment.

4.2.2 P concentration in plant

P concentration in plant showed a statistically significant variation due to the application of farm yard manure and inorganic fertilizer (Appendix VII). The maximum P concentration in plant was (2.83%) recorded from T_6 treatment (40% N from farm yard manure + 60% N from Urea) which was followed by (2.56%) T_7 (50% N from farm yard manure + 50% N from Urea) and treatment T_5. On the other hand, the minimum P concentration in plant was (1.03%) observed from T_1 as control condition (Table 8). The combined application of farm yard manure with inorganic fertilizer (urea) increased P concentration in plant compare to control treatment.

Table 8: Effect of farm yard manure and inorganic fertilizers on NPK nutrient concentration in plant of Broccoli.

Treatments	Concentration in plant		
	Total N (%)	Available P (ppm)	Available K (meq)
T_1	1.09l	1.03j	1.96f
T_2	2.24k	1.27i	2.70e
T_3	2.83g	1.89e	3.10a-d
T_4	2.99f	1.95d	3.11a-d
T_5	3.31c	2.49b	3.36ab
T_6	3.55a	2.83a	3.54a
T_7	3.41b	2.56b	3.45ab
T_8	3.21d	2.36c	3.26a-c
T_9	3.11e	2.24cd	3.20a-d
T_{10}	2.71h	1.74f	2.91b-e
T_{11}	2.58i	1.56g	2.73c-e
T_{12}	1.17j	1.48h	2.06de
LSD	0.092	1.614	0.508
CV (%)	2.11	3.37	10.07

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.

T_1 = No fertilizer
T_2 = 0% N from FYM + 100% N from Urea [150 kg N/ha]
T_3 = 10% N from FYM + 90% N from Urea
T_4 = 20% N from FYM + 80% N from Urea
T_5 = 30% N from FYM + 70% N from Urea
T_6 = 40% N from FYM + 60% N from Urea
T_7 = 50% N from FYM + 50% N from Urea
T_8 = 60% N from FYM + 40% N from Urea
T_9 = 70% N from FYM + 30% N from Urea
T_{10} = 80% N from FYM + 20% N from Urea
T_{11} = 90% N from FYM + 10% N from Urea
T_{12} = 100% N from FYM [cowdung 30 t/ha] + 0 % N from Urea

4.2.3 K concentration in plant

K concentration in plant showed a statistically significant variation due to the application of farm yard manure and inorganic fertilizer (Appendix VII). The maximum K in plant was (3.54%) recorded from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was statistically identical (3.45%) to T_7 (50% N from farm yard manure + 50% N from urea) and T_5, T_8, T_9, T_4, T_3 treatments. On the other hand, the minimum K concentration in plant (1.96%) was observed from T_1 as control condition (Table 8). The combined application of farm yard manure with inorganic fertilizer (urea) increased K concentration in plant compare to control treatment.

4.3 NPK uptake by plant

4.3.1 N uptake by plant

Statistically significant variation was recorded for N uptake by plant of broccoli due to the application of farm yard manure and inorganic fertilizer (Appendix VII). The maximum (159.5 kg/ha) N uptake was recorded from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was followed by (146.1 kg/ha) to T_5 (30% N from farm yard manure + 70% N from urea). On the other hand, the minimum N uptake (72.3 kg/ha) was observed from T_1 as control (Table 9). The combined application of farm yard manure with inorganic fertilizer (urea) increased N uptake compare to control treatment.

4.3.2 P uptake by plant

P uptake by plant of broccoli showed a statistically significant variation due to the application of farm yard manure and inorganic fertilizer (Appendix VII). The maximum P uptake by plant was (35.23 kg/ha) recorded from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was followed by (31.24 kg/ha) to T_7 (50% N from farm yard manure + 50% N from urea). On the other hand, the minimum P uptake by plant was (14.56 kg/ha) observed from T_1 as control condition (Table 9). The combined application of farm yard manure with

Table 9: Effect of farm yard manure and inorganic fertilizers on NPK uptake by plant of Broccoli.

Treatments	Nitrogen kg/ha	Phosphorus kg/ha	Potassium kg/ha
T_1	0.21i	14.56g	16.35g
T_2	0.36g	18.21f	26.55e
T_3	0.51e	24.31d	38.23d
T_4	0.58c	25.54d	41.52c
T_5	0.75b	30.25b	48.34b
T_6	0.87a	35.23a	54.12a
T_7	0.82c	31.24b	49.25b
T_8	0.68d	28.81c	47.14b
T_9	0.64e	27.39c	42.10c
T_{10}	0.48f	22.13e	39.21d
T_{11}	0.39f	21.02e	38.25d
T_{12}	0.27h	19.87f	17.29f
LSD	0.515	10.277	4.261
CV (%)	9.58	4.36	3.25

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.

T_1 = No fertilizer
T_2 = 0% N from FYM + 100% N from Urea [150 kg N/ha]
T_3 = 10% N from FYM + 90% N from Urea
T_4 = 20% N from FYM + 80% N from Urea
T_5 = 30% N from FYM + 70% N from Urea
T_6 = 40% N from FYM + 60% N from Urea
T_7 = 50% N from FYM + 50% N from Urea
T_8 = 60% N from FYM + 40% N from Urea
T_9 = 70% N from FYM + 30% N from Urea
T_{10} = 80% N from FYM + 20% N from Urea
T_{11} = 90% N from FYM + 10% N from Urea
T_{12} = 100% N from FYM [cowdung 30 t/ha] + 0% N from Urea

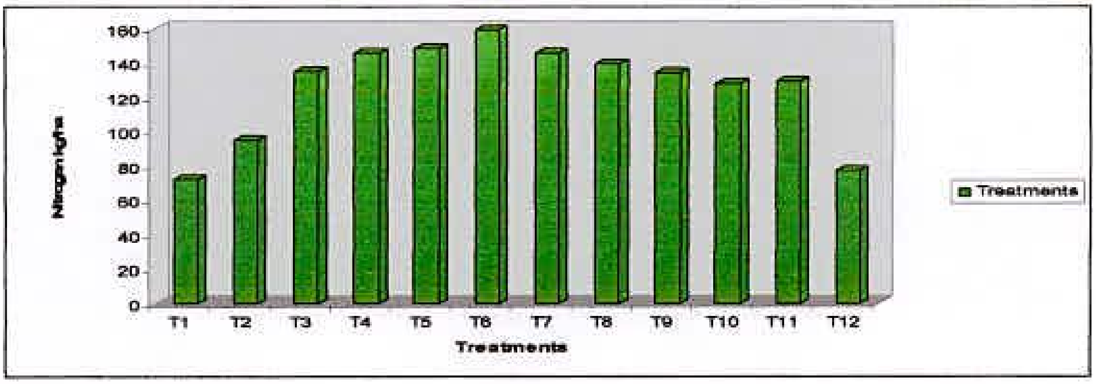


Figure 4: Effect of farm yard manure and inorganic fertilizer on nitrogen uptake by broccoli plant

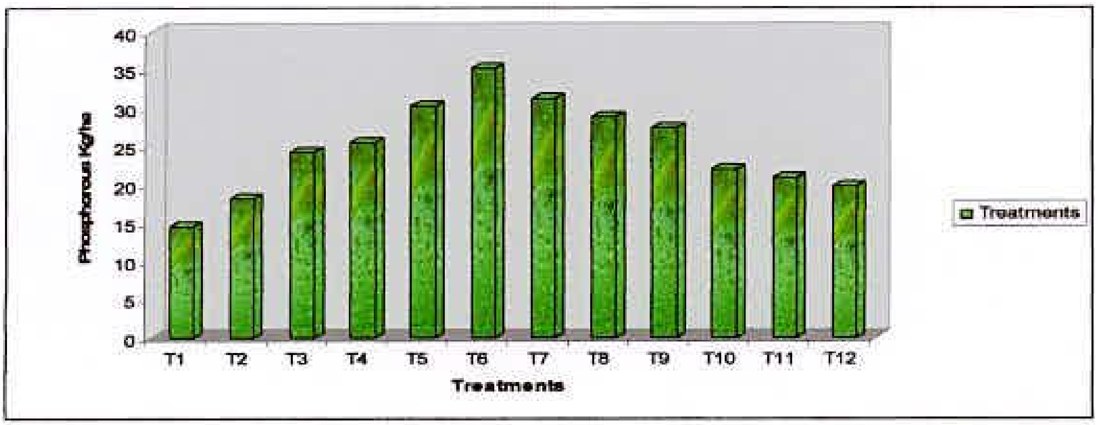


Figure 5: Effect of farm yard manure and inorganic fertilizer on phosphorous uptake by broccoli plant

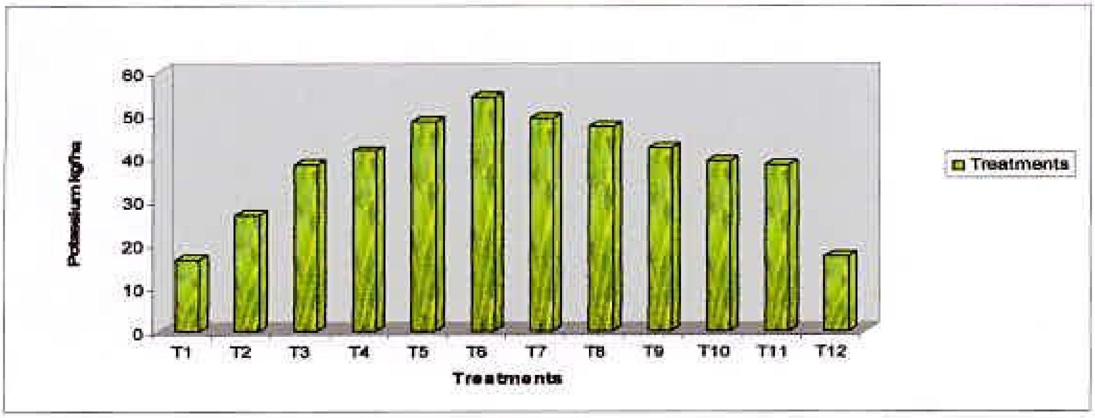


Figure 6: Effect of farm yard manure and inorganic fertilizer on Potassium uptake by broccoli plant

inorganic fertilizer (urea) increased P uptake by plant compare to control treatment.

4.3.3 K uptake by plant

K uptake by plant of broccoli showed statistically significant variations due to the application of farm yard manure and inorganic fertilizer (Appendix VII). The maximum K uptake by plant was (54.12 kg/ha) recorded from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was followed by (49.25 kg/ha) T_7 (50% N from farm yard manure + 50% N from urea) and treatment T_5, T_8. On the other hand, the minimum K uptake by plant (16.35 kg/ha) was observed from T_1 as control (Table 9). The combined application of farm yard manure with inorganic fertilizer (urea) increased K uptake by plant compare to control treatment.

4.4 Soil pH, Organic matter and NPK of Post harvest soil

4.4.1 Soil pH

Application of farm yard manure and chemical fertilizer showed a statistically significant difference for pH of post harvest soil (Appendix VIII). Soil pH varied from 5.38 to 6.10 .The highest pH (6.10) was recorded from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was statistically identical (5.96) to T_7 (50% N from farm yard manure + 50% N from urea) and T_5, T_8, T_9, T_4, T_{10}, T_{11}. On the other hand, the lowest soil pH (5.38) was observed from T_1 as control condition (Table 10).

4.4.2 Organic Matter

Statistically significant variation was observed for organic matter of post harvest soil due to the application of farm yard manure and inorganic fertilizer (Appendix VIII). Organic matter content of soil varied from 0.82% to 1.27% .The maximum (1.27%) organic matter was recorded from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was statistically identical (1.21%) to T_7 (50%

References

Table 10: Effect of farm yard manure and inorganic fertilizers on soil pH, organic matter and NPK nutrient in post harvest soil of Broccoli field

Treatments	Soil pH	Organic Matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me/100gsoil)
T_1	5.38c	0.82c	0.19f	13.041	0.03f
T_2	5.41c	0.86c	0.27e	19.37k	0.10e
T_3	5.43c	0.89c	0.41d	25.10g	0.11de
T_4	5.86ab	1.15b	0.47c	26.75f	0.17bc
T_5	5.89ab	1.12b	0.64a	31.88c	0.21ab
T_6	6.10a	1.27a	0.79a	35.94a	0.25a
T_7	5.96a	1.21ab	0.72a	34.23b	0.24a
T_8	5.88ab	1.17b	0.58b	30.02d	0.19ab
T_9	5.78ab	1.13b	0.53c	28.56e	0.18bc
T_{10}	5.77ab	0.95bc	0.37d	23.79h	0.14cd
T_{11}	5.61ab	0.91c	0.33d	22.27i	0.11de
T_{12}	5.401b	1.01bc	0.24e	20.62j	0.09de
LSD	0.207	0.15	0.51	10.16	0.043
CV (%)	2.10	6.47	8.04	2.64	11.51

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.

T_1 = No fertilizer
T_2 = 0% N from FYM + 100% N from Urea [150 kg N/ha]
T_3 = 10% N from FYM + 90% N from Urea
T_4 = 20% N from FYM + 80% N from Urea
T_5 = 30% N from FYM + 70% N from Urea
T_6 = 40% N from FYM + 60% N from Urea
T_7 = 50% N from FYM + 50% N from Urea
T_8 = 60% N from FYM + 40% N from Urea
T_9 = 70% N from FYM + 30% N from Urea
T_{10} = 80% N from FYM + 20% N from Urea
T_{11} = 90% N from FYM + 10% N from Urea
T_{12} = 100% N from FYM [cowdung 30 t/ha] + 0% N from Urea

N from farm yard manure + 50% N from Urea) and treatment T_5, T_8, T_9, T_4. On the other hand, the minimum organic matter (0.82%) was observed from T_1 as control condition (Table 10). The combined application of farm yard manure with inorganic fertilizer (urea) increased organic matter of soil compare to control treatment. Edmond *et al.* (1977) reported that organic matter increased the pore space of the soil and thus improved the rate of gas exchange. Application of compost to the soil increased water holding capacity reduced soil erosion and improved the physico-chemical and biological condition of the soil besides providing plant nutrients. Gaur *et al.* (1971) found that farm yard manure and organic residues were effective in increasing the level of organic matter even under tropical conditions.

4.4.3 Total Nitrogen

Statistically significant variation was observed for total N of post harvest soil due to the application of farm yard manure and inorganic fertilizer (Appendix VIII). Total N varied from 27.33% to 118.0%. The maximum (118.0%) total N was recorded from T_6 (40 %N from farm yard manure + 60% N from urea) treatment which was statistically identical with (114.3%) to T_7 (50% N from farm yard manure + 50% N from urea) and T_5. On the other hand, the minimum total N (27.33%) was observed from T_1 as control condition (Table 10). The combined application of farm yard manure with inorganic fertilizer (urea) increased total N of soil compare to control treatment.

4.4.4 Available Phosphorous

Available P of post harvest soil showed a statistically significant variation due to the application of farm yard manure and inorganic fertilizer (Appendix VIII). Available P varied from 13.04 ppm to 35.94 ppm. The maximum Available P was (35.94 ppm) recorded from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was followed by (34.23 ppm) to T_7 (50% N from farm yard manure + 50% N from urea). On the other hand, the minimum available P (13.04

ppm) was observed from T_1 as control condition (Table 10). The combined application of farm yard manure with inorganic fertilizer (urea) increased available P of soil compared to control treatment. Edmond *et al.* (1977) reported that P increased the physico-chemical and biological condition of the soil.

4.4.5 Exchangeable Potassium

Exchangeable K of post harvest soil showed a statistically significant variation due to the application of farm yard manure and inorganic fertilizer (Appendix VIII). Exchangeable K varied from 0.03 me % to 0.25 me %. The maximum (0.25 me %) exchangeable K was recorded from T_6 (40% N from farm yard manure + 60% N from urea) treatment which was statistically identical to (0.24 me %) to T_7 (50% N from farm yard manure + 50% N from Urea) and Treatment T_5, T_8. On the other hand, the minimum exchangeable K (0.03 me %) was observed from T_1 as control condition (Table 10). The combined application of farm yard manure with inorganic fertilizer (urea) increased exchangeable K of soil compare to control treatment.

Chapter V

Summary and Conclusion

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SUMMARY AND CONCLUSION

An experiment was conduced in the SAU farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2008 to February 2009 to find out the ideal Integrated Nutrient Management (INM) treatment to maximize the yield of Broccoli. Experiment was conducted and was laid out in Randomized Complete Block Design (RCBD). The field experiment had 12 treatments each having three replications. The treatments were T_1 : No fertilizer, T_2 : 0%N from FYM + 100%N from Urea [150 kg N/ha], T_3 : 10%N from FYM + 90% N from Urea, T_4 : 20%N from FYM + 80%N from Urea, T_5 : 30%N from FYM + 70%N from Urea, T_6 : 40%N from FYM + 60%N from Urea, T_7 : 50%N from FYM + 50%N from Urea, T_8 : 60%N from FYM + 40%N from Urea, T_9 : 70%N from FYM + 30%N from Urea, T_{10} : 80%N from FYM + 20%N from Urea, T_{11} : 90%N from FYM + 10%N from Urea and T_{12} : 100%N from FYM [cowdung 30 t/ha] + 0%N from Urea. The size of unit plot was 1.8 m x 1.6 m. twelve plants were accommodated in each plot with the spacing of 60 cm x 40 cm. Thirty five days old seedlings were planted in the field on 29th November, 2008. From each plot 5 plants were randomly selected for collection of data on growth, yield and yield contributing characters.

At 20, 40 and 60 DAT the highest plant height (23.25 cm, 38.92 cm and 62.36 cm), the maximum number of leaves per plant (7.86 cm, 11.76 cm and 17.60 cm), the longest leaf (16.53 cm, 30.93 cm and 45.08 cm), the longest breadth of leaf (8.32 cm, 14.23 cm and 17.46 cm), the maximum plant canopy (29.63 cm, 48.66 cm and 71.54 cm), the highest height of curd (17.63 cm), the maximum diameter of curd (15.70 cm), the maximum diameter of stem (3.68 cm), the maximum number of secondary curd (5.73), the maximum weight of secondary curd (56.73 g), the maximum dry weight of broccoli curd (77.6 g), the highest yield per plant (412.6 g) and the highest yield per plot (4.95 kg) and per hectare (17.18 ton) were obtained from the treatment T_6 (40% N from farm yard manure + 60% N from urea). At the same DAT, the shortest plant height (11.23 cm, 24.22 cm and 38.34 cm), the lowest number of leaf per plant (4.80 cm, 7.84 cm and 11.20 cm), the shortest leaf length (12.63 cm, 22.02 cm and 37.58 cm), the lowest breadth of leaf (4.85 cm, 9.58 cm and 13.94 cm), the lowest plant canopy (15.27 cm, 30.53 cm and 49.29 cm), the lowest height of curd (11.56 cm), the lowest diameter of curd (9.10 cm), the lowest diameter of stem (2.53 cm), the minimum weight of primary curd (262.8 g), the minimum number of secondary curd (3.04), the minimum weight of secondary curd (37.73g), the lowest dry weight of broccoli curd (56.2 g), the lowest yield per plant (266.1 g), the lowest yield per plot (3.19 kg) and hectare (11.08 ton) were found from the treatment T_1 where no organic and inorganic fertilizer were added.

The highest N concentration in plant (3.55%), the highest P concentrations in plant (2.83%), the highest K concentration in plant (3.54%) were obtained from the treatment T_6 (40% N from farm yard manure + 60% N from urea). The lowest N concentration in plant (1.09%), the lowest P concentration in plant (1.03%), the lowest K concentrations in plant (1.96%) were found from the treatment T_1 where no organic and inorganic fertilizers were added. Moreover, the highest N uptake by plant (159.5 kg/ha), the highest P uptake by plant (35.23 kg/ha), the highest K uptake (54.12 kg/ha) were obtained from the treatment T_6 (40% N from farm yard manure + 60% N from urea). The lowest N uptake by plant (72.3 kg/ha), the lowest P uptake by plant (14.56 kg/ha), the lowest K uptake by plant (16.35 kg/ha) were found from the treatment T_1 where no organic and inorganic fertilizer were added.

The highest pH (6.10), the maximum organic matter (1.27%), the maximum (118.0%) total N, the maximum available P (35.94 ppm), the maximum exchangeable K (0.25 me%) were obtained from the treatment T_6 (40% N from farm yard manure + 60% N from urea). the lowest pH (5.38), the minimum organic matter (0.82%), the minimum total N (27.33%), the minimum available P

(13.04 ppm), the minimum exchangeable K (0.03 me%) were found from the treatment T_1 where no organic and inorganic fertilizer were added. the highest cost of production Tk 70654 per ha was found from the treatments T_6. the highest gross return was obtained (Tk 341600) to T_6 treatment. the highest net return was Tk 275087 per ha from treatment T_6 (40% N from farm yard manure + 60% N from urea). the highest Benefit Cost of Ratio (BCR) was 4.73 calculated from T_6 treatment.

From the above discussion it can be concluded that integrated use of farm yard manure and inorganic fertilizer at the rate of 40% N from farm yard manure (cowdung 12 ton/ha) and 60% N from inorganic fertilizer (urea 90 kg/ha) might be optimum for profitable production of Broccoli under Madhupur Tract of Bangladesh. Control treatment (T_1) showed the worst performance in all aspect.
Fertilizer treatments evaluated in experiment were in the following order with respect to their yield performance, $T_6>T_7>T_5>T_8>T_9>T_4>T_3>T_{10}>T_{11}>T_2>T_{12}>T_1$. From the economic point of view T_6 treatment was found the most suitable for better growth and yield of Broccoli.

Considering the situation of the present experiment, the following recommendation and suggestion may be made:

- The INM combination of 40% N from farm yard manure (cowdung 12 ton/ha) and 60% N from inorganic fertilizer (urea 90 kg/ha) might be optimum for profitable production of Broccoli under Madhupur Tract of Bangladesh.
- Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.

REFERENCES

Agarwal, A., Gupta, S., Ahmed, Z. and Yadav, A. K. (2007). Nitrogen nutrition and plant density influencing marketable head yield of broccoli in cold arid desert of Ladakh. International Society for Horticultural Science (ISHS). Leuven, Belgium. **756**: 299-307.

Alam, M. S., Iqbal, M. T., Amin, M. S. and Gaffer, M. A. (1989). Krishitattik Fasaler Utpadan Unnayan (in Bengali) T. M. Jubair Bin Iqbal, Manik Potal, Meghai, Sirajgonj. pp. **231-230**.

Babik, I., and Kowalczyk, W. (2004). The use of organic fertilizer obtained from composting of plant materials in vegetables cultivation. Instytut Warzywnictwa (Research Institute of Vegetable Crops RIVC). Skierniewice, Poland. **39**: 49-54.

Balyan, D. S., Banarjee, M. K., Sing, A. and Saini, P. S. (1997). Effect of Nitrogen fertilizer and planting pattern on fruit yield of Broccoli. Crop Res. India. **14 (3)**: 441-446.

Balyan, D. S., Dhakar, D. S. and Sing, K. P. (1988). Growth and yield of cauliflower variety snow ball-16 as influenced by nitrogen, phosphorous and Zinc. *Haryana J. Hort. Sci.* **17 (3-4)**: 247-254.

Bhardwaj, M. L., Harender, R. and Koul, B. L. (2000). Yield response and economics of organic sources of nutrients as substitute to inorganic sources in tomato, okra, cabbage and cauliflower. *Indian Journal of Agricultural Science*. Indian Council of Agricultural Research. New Delhi, India. **70 (10)**: 653-656.

Brahma, S., Phookan, D. B. and Gautam, B. P. (2002). Effect of nitrogen, phosphorus and potassium on growth and yield of broccoli (*Brassica oleracea* L. var. *italica*) cv. Pusa Broccoli KTS-1. *Journal of the Agricultural Science.* Society of North East India. Jorhat, India. **15 (1)**: 104-106.

Brahma, S., Phookan, D. B., Gautam, B. P. and Bora, D. K. (2002). Effect of nitrogen, phosphorus and potassium on production of broccoli (*Brassica oleracea* L. var. *italica*) cv. KTS-1. Vegetable Science. Indian Society of Vegetable Science. Varanasi, India. **29 (2)**: 154-156.

Bray, R. H. and Kurtz, L. T. (1995). Determination of total organic & available forms of P in soil. Soil sci. **59**: 39-45.

Brown, J. E., Dangler, C. H., Gilliam, D. W., Porch, D. W. and Shumack, R. L. (1994). Comperison of broiler litter and inorganic nitrogen, phosphorus and potassium for double cropped sweet corn and broccoli. *J. Plant Nutrition.* **27 (5)**: 859-867.

Chan, K.Y., Dorahy, C., Wells, T., Fahey, D., Donovan, N., Saleh, F. and Barchia, I. (2008). Use of garden organic compost in vegetable production under contrasting soil P status. *Australian Journal of Agricultural Research.* CSIRO Publishing. Collingwood, Australia. **59 (4)**: 374-382.

Chaterjee, B., Ghanti, P., Thapa, U. and Tripathy, P. (2005). Effect of organic nutrition in sprouting broccoli (*Brassica oleracea* L. var. *italica* Plenck). Indian Society of Vegetable Science. Varanasi, India. **32 (1)**: 51-54.

Chauhan, R. S., Maheshwari, S. K. and Gandhi, S. K. (2000). Effect of nitrogen, phosphorus and farm yard manure levels on stem rot of cauliflower caused by *Rhizoctonia solani* Kuhn. Agricultural Research Communication Centre. Karnal, India. **20 (1)**: 36-38.

Dolanska, L. (2002). Study of the nitrate contents in broccoli (*Brassica oleracea* L. var. *italica* Plenck) cultivated in condition of different nitrogen doses. Jihoceska Univerzita Ceskych Budejovicich Zemedelska Fakulta. Ceske Budejovice, Czech Republic. **19 (2)**: 85-89.

Dufault, R. J. and Watery, J. L. (1985). Interaction of nitrogen fertilizer and plant populations on transplanted Broccoli and cauliflower yield. Hort. Sci. **20 (1)**: 127-128.

Dufault, R. S. and Melton, R. R. (1991). Nitrogen, phosphorous and potassium fertility regimes affect tomoto transplant growth. Hort. Sci., **26 (2)**: 141-142.

Edmond, J. B., Sen, T. L., Andrews, F. S. and Hall, R. G. (1977). Fundamentals of Horticulture. Tata Mcgraw-Hill Publishing Co. Ltd. New Delhi. pp. **237-257**.

FAO. 2008. Rice Production in Philippines Year Book. Food and Agricultural Organization. United Nation. Rome, Italy. **51-66**.

Gaur, A. C., Sadasivam, K. V., Vimal, D. P. and Mathur, R. S. (1971). A study on the decomposition of organic matter in an alluvial soil. CO_2 evolution, microbiology and chemical transformations. Plant Soil Sci. **34**: 17.

Gomez, A. K., and Gomez, A. A. (1984). Statistical procedures for Agricultural Research. Second Edition. John wiley & sons, New York, USA. p. **151-152**.

Gorski, S. F. and Armstrong, D. M. (1985). The influence of spacing and nitrogen rate yield and hollow stem in broccoli. Res. Circular, Ohio Agric. Res. and Dev. Center. **288**: 16-18.

Hsieh, C., Nan, H., Hsoeh, C. F. and HSU-KN. (1996). An experiment on the organic farming of broccoli. Bulletin of Taichung District Agriculture Improvement Station. No. **53 (35-41)**: 18.

Jackson, M. L. (1973). Soil Chemical Analysis. Constable and Co. Ltd. London. 1st ed. P. **17**.

Karitonas, R. and Tremblay, N. (2003). Development of a nitrogen management tool for broccoli. Acta-Horticulturae. International Society for Horticultural Science (ISHS). Leuven, Belgium. **627**: 125-129.

Karitonas, R., Horst, W. J., Schenk, M. K., Burkert, A., Goldbach, W. B., Olfs, H. and Romheld, V. (2001). Effect of nitrogen supply on yield and quality of broccoli. Kluwer Academic Publishers. Dordrecht, Netherland. pp. **298-299**.

Katayal, S. L. (1994). Vegetable growing in India. Mohan primiani, Oxford and IBH publishing: 66, janapath, New delhi-110001. p. **45**.

Khan, B. A., Shilling, P. G., Brusewitz, G. H. and Mc-New, R. W. (1991). For shear the stalk, stalk diameter and yield of broccoli in response to nitrogen fertilization and with in row spacing. *J. Amer. Soc. Hort. Sci.* **16 (2)**: 222-227.

Kowalenkok, C. G. and Hall, J. W. (1987). Effect of nitrogen application on direct seeded broccoli from a single harvest adjusted for maturity. *J. Amer. Soc. Hort. Sci.* **112 (1)**: 9-13.

Leja, M., Wojciechowska, R. and Rozek, S. (2006). The effect of differentiated nitrogen fertilization on nitrate reduction in broccoli heads of 'Lord F<ovid:sub>1</ovid:sub>' in spring cultivation. Polskie Towarzystwo Nauk Ogrodniczych (Polish Society for Horticultural Science). Krakow, Poland. **18 (1)**: 101-110.

Lincoln, C. P. (1987). Vegetable Characteristics, Production and Marketing. John Wiley and Sons. Inc. New York. p. **217**.

Man, K. S. and Shandu, B. S. (1955). The nitrogen requirements of cabbage. *Indian J. Hort.,* **12**: 188-195.

Mamta, J., Jha, M. M., and Sanjeev, K. (2005). Influence of organic manure, irrigation interval and cropping sequence on the yield and black scurf disease of potato. Annals of Agri. Bio. Research. Agri Bio Research Publishers, Hisar, India. **10 (1)**: 61-64.

Masson, J., Trembley, N. and Gosselin, A. (1991). Effect on nitrogen fertilization and HPS supplementary light on vegetable transplant production. 1. Transplant growth 2. Yield. *J. Amer. Soc. Hort. Sci.* **116 (4)**: 594-602.

Maurya, A.K., Singh, M. P., Srivastava, B. K., Singh, Y. V. and Singh, P. K. (2008). Effect of organic manures and inorganic fertilizers on growth characters, yield and economics of sprouting broccoli cv. Fiesta. *Indian Journal of Horticulture*. Horticultural Society of India. New Delhi, India. **65 (1)**: 116-118.

Maynard, A. A. (1994). Protecting groundwater while recycling nutrients. Biocycle. **35 (5)**: 40. [Cited from Hort. Abst., **65 (4)**: 2954, 1995].

Maynard, A. A. (1994). Sustained vegetable production for three years using composted animal manures. *Comp. Aci. Util.* **2 (1)**: 88-96. [Cited from Biol. Abst., **99 (5)**: 63186, 1995].

Mitra, S. K., Sadhu, M. K. and Bose, T. K. (1990). Nutrition of vegetable crops. Naya Prokash, Calcatta 70006, India. pp. **157-160**.

Miura, N., Uchimura, A. N. and Matsumoto, S. (2006). Possible uptake of protein like organic nitrogen in a soil by some vegetables and tea plants. *Japanese Journal of Soil Science and Plant Nutrition*. Japanese Society of Soil Science and Plant Nutrition. Tokyo, Japan. **77 (5)**: 549-554.

Morse, R. D., Abdul, B. A., Teasdale, J. R. and Devine, T. E. (1997). Nitrogen requirements of broccoli in cover crop mulches and clean cultivation. *Journal of Vegetable Crop Production.* **3 (2)**: 85-100.

Murlee, Y., Rashmi, C. and Singh, D. B. (2007). Performance of organic and inorganic fertilisers on growth and yield of cauliflower (*Brassica oleracea* var. *botrytis*) cv. Pusa Snowball K-1. Plant-Archives, Muzaffarnagar, India. **7 (1)**: 245-246.

Neves, P. M. O., Ototumi, A. and Ventura, M. U. (2001). Agronomic parameters in broccoli (*Brassica oleraceae* L. var. *italica*) in conventional, organic and natural crop systems. Semina: Ciencias Agrarias Londrina. Universidade Estadual de Londrina. Londrina, Brazil. **22 (2)**: 161-164.

Nieuwhof, M. (1969). Vegetable production. Vein Nostrand Reinhold, New york.

Pathak, K. N. and Nishi, K. (2003). Management of root-knot disease of cauliflower by organic amendments and carbofuran. *Indian Journal of Nematology*. New Delhi, India **33 (2)**: 191-193.

Peyvast, G., Olfati, J., Kharazi, P. R., Tahernia, S. and Shabani, H. (2008). Effect of organic fertilizers on nitrate accumulation by vegetables. Horticulture, Environment and Biotechnology. Korean Society for Horticultural Science Suwon, Korea Republic. **49 (1)**: 58-62.

Prestele, C. (2000). Nitrogen use in organically grown cauliflowers. BLV Verlagsgesellschaft mbH. Munchen, Germany. **36 (11)**: 13-14, 16.

Ram, K. and Sharma, R. K. (1969). Effect of nitrogen supplies on growth, yield and ascorbic acid content of cabbage. *Poona Agril. Co. J.,* **59**.

Rashid, M. M. (1993). Sabji Biggan. Text Book Division, Bangla Academy, Dhaka, Bangladesh. p. **220**.

Raut, K. R. and Keder, V. P. (1980-1981). Effect of fertilizer levels and plant growth regulators on growth and yield of cauliflower. Coll. Agric. Nagpur, Mag. **53**: 73-75.

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

Rooster, L. de. and Spiessens, K. (1999). Broccoli. Row application of nitrogen fertilizers in broccoli. Proeftuinnieuws. **9 (4)**: 17-18.

Rozek, S., Wojciechowska, R. and Rydz, A. (2005). Broccoli yield and its quality in spring growing cycle as dependent on nitrogen fertilization. Folia Horticulturae. Polskie Towarzystwo Nauk Ogrodniczych (Polish Society for Horticultural Science). Krakow, Poland. **17 (2)**: 141-152.

Saimbhi, M. S., Sing, K. and padda, D. S. (1969). Influence of nitrogen and phosphorous fertilizer on the yield and curd size of cauliflower. *Punjab. Hort. J.,* **9:** 188-202.

Salam, M. A. (2001). Effect of different doses amd time of Application of urea amd muriate of porash on the growth and yield of mukhi kachu. MS thesis, BAU. mymunsingh. p. **120**.

Sanwal, S. K., Rai, N., Yadav, D. S. and Yadav, R. K. (2005). Compositional differences of stem and floral portions of broccoli under different organic manures and natural growth promoters. Vegetable Science. Indian Society of Vegetable Science. Varanasi, India. **32 (1)**: 73-75.

Sharma, S. K., Rajender, S. and Korla, B. N. (2002). Effect of nitrogen and phosphorus on the growth and seed yield of sprouting broccoli cv. *Green*

Head. Horticultural Journal. Society for Advancement of Horticulture. Mohanpur, India. **15 (2)**: 87-90.

Shiralipour, A., Faber, B. and Chrowstowski, M. (1996). Green house broccoli growth using co-composted biosolids. Comp. Sci. Util. **4 (3)**: 38-43. [Cited from Biol. Abst., **104 (4)**: 57913, 1997].

Sing, A. K. (2004). Effect of Nitrogen and phosphorous on growth and curd yield of cauliflower var. snowball. 16 under cold arid region of Ladakh, *Haryana J. Hort. Sci.*, **32 (1&2)**: 127-129.

Singh, A. K. and Akhilesh, S. (2000). Influence of nitrogen and potassium on growth and head yield of broccoli (*Brassica oleracea* L. var. *italica*) under low hills subtropical condition of H.P. Indian Society of Vegetable Science. Varanasi, India. **27 (1)**: 99-100.

Singh, G. B., and Yadav, D. V. (1992). Itegrated lant nutrition system in sugarcane. Fertilizer News. **37** : 15-22.

Steffen, K. L., Dann, M. S., Fager, K., Fleischer, S. J. and Harper J. K. (1994). Short term and long term impact of an initial large scale SMS soil amendment on vegetable crop productivity and resource use efficiency. Comp. Sci. util. **2 (4)**: 75-83.

Tamayo, V. A. and Jaramillo, N. J. E. (2005). Effect of organic amendments on vegetables production. Suelos Ecuatoriales. Santafe de Bogota, Colombia. **35 (2)**: 78-84.

Thakur, S. K., Mohd, M., Mir, A. A., Dwivedi, H. and Namgyal, D. (2003). Influence of nitrogen and phosphorus on growth and yield of cauliflower under Ladakh condition. Horticultural Experiments and Training Centre. Chaubattia, India. **35 (1)**: 51-54.

Thompson, H. C. and Kelly, W. C. (1988). Vegetables Crops. Fifth edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, India. p. **611**.

Thuan, N. T. Q. and Idnani, L. K. (2007). Effect of irrigation regimes and sources of nitrogen on the growth, yield, economics and soil nitrogen of cauliflower

(*Brassica oleracea* var *botrytis* subvar *cauliflora*) production. *Indian Journal of Agricultural Sciences*. New Delhi, India. **77 (6)**: 369-372.

Tremblay, N. (1989). Effect of nitrogen sources and rates on yield and hollow stem development in broccoli. *Canadian Journal of plant science*. **69 (3)**: 1049-1053.

Uddin, M. K. and Khalaequzzaman, K. M. (2003). Yield and yield components of winter chilli (*Capsicum annum* L.) as affected by different levels of Nitrigen and Boron. *Pakistan J. of Bio. Sci.* **6 (6)**: 605-609.

Wang, G. Y., Zhang, C. Z. and Zhang, F. S. (2007). Effect of nitrogen, Phosphorous and potassium fertilizer on the yield and physiology target of broccoli. china veg. **1 (14-17)**: 36.

Wange, S. S. and Kale, R. H. (2004). Effects of microbial inoculants with graded levels of inorganic nitrogen on broccoli and lettuce. Association of Soils and Crops Research Scientists, *Journal of Soils and Crops*. Nagpur, India. **14 (1)**: 18-21.

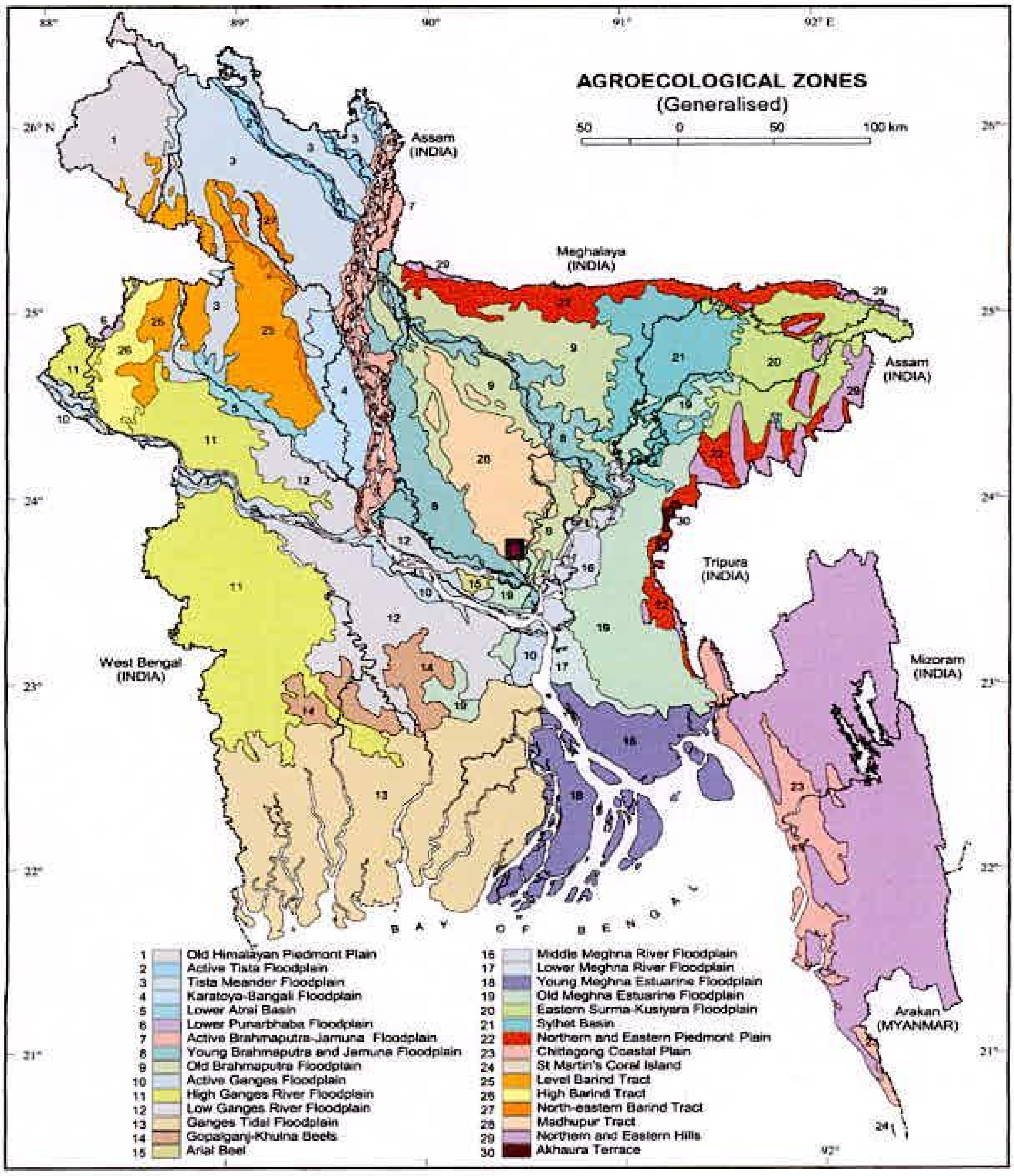
Willigen, P. de. and Everaarts, A. P. (1999). The effect of the rate and method of nitrogen application on nitrogen uptake and utilization by broccoli (*Brassica oleracea* var. *italica*). *Netherlands Journal of Agricultural Science*. Koninklijke Landbouwkundige Vereniging (Royal Society for Agricultural Science). Wageningen, Netherlands. **47 (3/4)**: 201-214.

Wyatt, J. E., Mullins, J. A. and Mullins, C. A. (1989). Potassium fertilization of Boroccoli transplants ferti. Res., **21**: 1, 13-18, 9.

Zhang C. X., Xie, Z. J., Yao, Z. and Wu, Z. (2007). Effects of balanced application of nitrogen, phosphorus and potassium fertilizers on yield and rate of finished products of export broccoli. Acta Agriculturae Shanghai. Editorial Office of Acta Agriculturae Shanghai. Shanghai, China. **23 (3)**: 22-25.

APPENDICES

Appendices I: Map showing the experimental site under the study



Appendices II: Monthly record of air temperature, relative humidity and sunshine of the Experimental site during the period from October 2008 to February 2009

Year	Month	Air Temperature (^oC)		Relative* Humidity (%)	Rainfall** (mm)	Sunshine** (hr)
		Maximum	Minimum			
2008	October	30.4	15.6	81	147	7.3
	November	32.3	16.3	79	0	7.9
	December	29.0	13.0	72	1	3.9
2009	January	28.1	11.1	55	1	5.7
	February	33.9	12.2	67	45	8.7
	March	34.6	16.5	65	88	7.3

* Monthly average ** Monthly total

Source: Bangladesh Meteorological Department (Climate & water division) Agargoan, Dhaka.

Appendices III: Mean Square values of analysis of variance of the Plant height and Number of leaves/plant as influenced by different organic and inorganic fertilizers.

Sources of variation	Degree of freedom	Plant height (cm)			Number of leaves/plant		
		20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
Replication	2	0.456	0.163	10.083	0.000	0.014	0.030
Treatment	11	330.373**	46.003**	123.304**	2.028**	3.299**	8.890**
Error	22	1.283	4.563	3.720	0.048	0.246	0.288

** 1% level of significance * 5% level of significance

Appendices IV: Mean Square values of analysis of variance of the length of leaf and breadth of leaf as influenced by different organic and inorganic fertilizers.

Sources of variation	Degree of freedom	Length of leaf (cm)			Breadth of leaf (cm)		
		20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
Replication	2	0.009	3.152	0.006	0.032	0.074	0.095
Treatment	11	3.583**	18.352**	12.487*	2.957**	4.737**	2.568**
Error	22	0.291	1.644	3.936	0.056	0.255	0.357

** 1% level of significance * 5% level of significance

Appendices V: Mean Square values of analysis of variance of the plant canopy, height of curd, diameter of stem, diameter of curd and primary curd weight as influenced by different organic and inorganic fertilizers.

Sources of variation	Degree of freedom	Plant canopy (cm)			Height of curd (cm)	Diameter of stem (cm)	Diameter of Curd (cm)	Primary curd weight (g)
		20 DAT	40 DAT	60 DAT				
Replication	2	0.052	4.514	0.837	3.308	0.007	0.007	88.100
Treatment	11	55.001**	77.522**	100.929**	24.590**	0.395**	11.141**	2062.056**
Error	22	1.640	3.055	6.745	2.562	0.012	0.368	567.748

** 1% level of significance * 5% level of significance

Appendices VI: Mean Square values of analysis of variance of the number of secondary curd, secondary curd weight, dry weight of curd (%), yield per plant (g), yield per plot (kg) and yield per hectare as influenced by different organic and inorganic fertilizers.

Sources of variation	Degree of freedom	Number of secondary curd	Secondary curd weight (g)	Dry weight of curd (g)	Yield per plant (g)	Yield per plot (kg)	Yield per hectare
Replication	2	0.027	3.876	0.001	1281.334	0.006	0.049
Treatment	11	1.636**	76.169**	0.819**	4614.334**	0.717**	11.032**
Error	22	0.038	7.014	0.075	425.153	0.044	0.411

** 1% level of significance * 5% level of significance

Appendices VII: Mean Square values of analysis of variance of the NPK concentration in plant and NPK uptake by plant as influenced by different organic and inorganic fertilizers.

Sources of variation	Degree of freedom	Concentration (%) in plant			Nutrient uptake by plant (kg/ha)		
		N	P	K	N	P	K
Replication	2	0.015	4.417	0.460	59.67	21.35	0.012
Treatment	11	1.332**	1.359**	0.621**	1825.201**	80.207**	1.284**
Error	22	0.003	0.909	0.090	27.36	0.248	0.002

** 1% level of significance * 5% level of significance

Appendices VIII: Mean Square values of analysis of variance of the soil pH, organic matter, NPK as influenced by different organic and inorganic fertilizers.

Sources of variation	Degree of freedom	Soil pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100g soil)
Replication	2	0.008	0.003	68.250	40.846	0.007
Treatment	11	0.107**	0.480**	2738.909**	132.156**	0.013**
Error	22	0.015	0.001	36.341	0.469	0.000

** 1% level of significance * 5% level of significance

Appendices IX: Cost of production of broccoli per hectare under different treatment

(A) Material cost (Tk.)

Treatment	Seed	Cost of different materials (Tk/ha)				Sub total I(A)
		Fertilizer and Manure		Insecticide	Fungicide	
		cowdung	urea			
T_1	7000	0	0	2500	2500	12000
T_2	7000	0	2500	2500	2500	14500
T_3	7000	8750	2250	2500	2500	23000
T_4	7000	9250	1950	2500	2500	23200
T_5	7000	9510	1625	2500	2500	23135
T_6	7000	9850	1350	2500	2500	23200
T_7	7000	10475	1175	2500	2500	23650
T_8	7000	10855	925	2500	2500	23780
T_9	7000	11450	785	2500	2500	24235
T_{10}	7000	11940	650	2500	2500	24590
T_{11}	7000	12500	515	2500	2500	25015
T_{12}	7000	0	0	2500	2500	24940

Broccoli seed @ 1500 Tk/100g,
Cowdung @ 2 Tk/kg,
Urea @ 14 Tk/kg,
Labor cost @ 120 Tk/day

Appendices IX: (Cont'd.)
(B) Non-material cost (Tk.)

Treatment	Land preparation	Organic manure application	Seed sowing in seed bed	Seedling transplanting	Intercultural operation	Harvesting	Sub total I(B)	Total Input cost I(A) + I(B)
T_1	7000	0	500	2000	7000	5000	21500	33500
T_2	7000	650	500	2000	7000	5000	22150	36650
T_3	7000	650	500	2000	7000	5000	22150	45150
T_4	7000	650	500	2000	7000	5000	22150	45350
T_5	7000	650	500	2000	7000	5000	22150	45285
T_6	7000	650	500	2000	7000	5000	22150	45350
T_7	7000	650	500	2000	7000	5000	22150	45800
T_8	7000	650	500	2000	7000	5000	22150	45930
T_9	7000	650	500	2000	7000	5000	22150	46385
T_{10}	7000	650	500	2000	7000	5000	22150	46740
T_{11}	7000	650	500	2000	7000	5000	22150	47165
T_{12}	7000	0	500	2000	7000	5000	21500	46440

Appendices IX: (Cont'd.)

(B) Overhead cost and total cost of production (Tk.)

Treatment	Cost of lease of land	Miscellaneous cost (5% of Input cost)	Interest on running capital for 6 months (13% of total input cost)	Total cost	Total cost of Production
T_1	15000	1675	4355	21030	54530
T_2	15000	1832	4764	21597	58247
T_3	15000	2257	5869	23127	68277
T_4	15000	2267	5895	23163	68513
T_5	15000	2264	5887	23151	68436
T_6	15000	2267	5895	23163	68513
T_7	15000	2290	5954	23244	69044
T_8	15000	2296	5970	23267	69197
T_9	15000	2319	6030	23349	69734
T_{10}	15000	2337	6076	23413	70153
T_{11}	15000	2358	6131	23490	70654
T_{12}	15000	2322	6037	23359	69799

T_1 = No fertilizer
T_2 = 0% N from FYM + 100% N from Urea [150 kg N/ha]
T_3 = 10% N from FYM + 90% N from Urea
T_4 = 20% N from FYM + 80% N from Urea
T_5 = 30% N from FYM + 70% N from Urea
T_6 = 40% N from FYM + 60% N from Urea
T_7 = 50% N from FYM + 50% N from Urea
T_8 = 60% N from FYM + 40% N from Urea
T_9 = 70% N from FYM + 30% N from Urea
T_{10} = 80% N from FYM + 20% N from Urea
T_{11} = 90% N from FYM + 10% N from Urea
T_{12} = 100% N from FYM [cowdung 30 t/ha] + 0% N from Urea