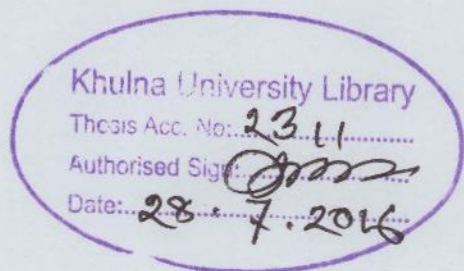


**EFFECT OF DIFFERENT ORGANIC AND INORGANIC FERTILIZERS ON THE
GROWTH AND YIELD OF GARLIC (*Allium sativum* L) IN BATIAGHATA OF
BANGLADESH**



A dissertation/thesis Submitted to Agrotechnology Discipline, Khulna University, Khulna,
Bangladesh in partial fulfillment of the requirements for the degree of Master of Science in
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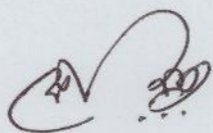
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A THESIS

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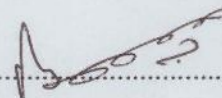
IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN HORTICULTURE



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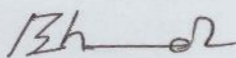
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DEDICATED TO
MY BELOVED
PARENTS



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ABSTRACT

The experiment was carried out at the Professor Purnendu Gain Field laboratory, Agrotechnology Discipline, Khulna University, Khulna during the period from November, 2013 to April, 2014 in an attempt to evaluate the effect of different organic and inorganic fertilizers and there combination on growth and yield of garlic (local variety). There were ten treatments consisting of Control (Without manures and fertilizers), Vermicompost, Trichoderma compost, Cowdung, Farmyard manure, Recommended fertilizer dose of NPK (N 99.82, P 53.40, K 166.50 kg/ha) , CD 5 t/ha), 50% Trichoderma + 50% Recommended fertilizer , 50% Vermicompost + 50% Recommended fertilizer, 50% Cowdung + 50% Recommended fertilizer, 50% Farmyard manure + 50% Recommended fertilizer. The experiment was laid out in Randomized Complete Block design (RCBD) with three replications. The results of the experiment demonstrated that organic and inorganic fertilizers had significant influences on almost all the parameters. The longest plant (65.58 cm) and highest number of leaves (8.33) were obtained from the treatment of 50% Farmyard manure + 50% recommended fertilizer. The shortest plant (43.64 cm) and lowest number of leaves (6.7) were found in the treatment of control. The plants receiving 50% Farmyard manure + 50% Recommended fertilizer dose produced the highest yield (9.38 t/ha) while the lowest was found in the treatment of control (2.83 t/ha) and the highest benefit cost ratio of garlic (6.01) was obtained when applied 50% Farmyard manure + 50% Recommended fertilizer doses.



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ABBREBIATION

%	:	Percentage
/	:	Per
@	:	At the rate of
Abstr.	:	Abstract
AEZ	:	Agro-Ecological Zone
Agric.	:	Agriculture
Agril.	:	Agricultural
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BCR	:	Benefit Cost Ratio
Biol.	:	Biology
CD	:	Cowdung
TDC	:	Tricoderma compost
FYM	:	Farmyard manure
VC	:	Vermicompost
RFD	:	Recommended fertilizers dose
Cm	:	Centimeter
cv.	:	Cultivar
DAP	:	Days Afer Planting
Dev.	:	Development
Expt.	:	Experiment
FAO	:	Food and Agriculture Organization
g	:	Gram
Hort.	:	Horticulture
hrs.	:	Hours
J	:	Journal
Kg	:	Kilogram
LSD	:	Least Significant Difference
CD	:	Cowdung
MP	:	Muriate of Potash
TSP	:	Triple Superphosphate
OM	:	Organic Matter
PPM	:	Parts per million
RCBD	:	Randomized Complete Block Design
Res.	:	Research
Sci.	:	Science
t/ha	:	Ton per hectare
UK	:	United Kingdom
UNDP	:	United Nations Development Program
Viz.	:	Namely

Chapter I

Introduction

Garlic (*Allium sativum* L.) is an aromatic herbaceous annual spice and one of the most important bulb crop belonging to the family Alliaceae (Kurian, 1995). It is the second most widely used *Allium* after onion (Bose and Som, 1990) with the characteristics of pungent smell. This spice according to Vvedensky (1946) originated in Central Asia, especially Mediterranean region (Thompson and Kelly, 1957) from where it was extended to North-Eastwards to the Pamir-Ali and Tien when regions of China. The major garlic producing countries of the world are China, South Korea, Spain, India, USA, Egypt, Thailand and Turkey (FAO, 2004).

Garlic is generally planted with the onset of winter (Rashid, 1983). In Bangladesh the area and production of garlic during 2002-03 were 21,052 hectares and 73,000 metric tons, respectively and the average yield was 3.47 t/ha (BBS, 2004). The yield is very low as compared to other garlic growing countries. There are many ways of increasing the yield, among which use of high yielding cultivars, proper planting time etc.

Garlic has been recognized all over the world as a valuable spice for cooking different dishes. Besides, it is also used in preparing chutneys, pickles, curry powders, curried vegetables, tomato ketchup etc. in different Asian and Middle-East countries. It also acts as a popular remedy for various ailments and physiological disorders. According to the Unani and Ayurvedic medicines in the treatments of disease like chronic infection of the stomach and intestine, dysentery, typhoid, cholera and diseases of lungs, garlic is successfully used (Chopra *et al.*, 1958). In recent oil and powder are prepared from it for adding flavor to the curries (Purthi, 1976).

Augusti (1977) reported that aqueous extract of garlic contains allicin, which is sulphur containing component, has a hypocholesterolaemic action, and reduces the cholesterol concentration in human blood.

In Bangladesh about 209000 tons of garlic was produced from approximately 104000 hectares of land in 2010-2011 (BBS, 2011). The requirement of garlic in Bangladesh is about 85,000 metric tons (Rahim, 1992). The crop is extensively cultivated during the winter season of Bangladesh. Delay planting greatly reduces yield due to the high temperature shortly after the planting and during the vegetative growth among the Asian countries. Bangladesh has the lowest garlic yield (Haque *et al.*, 1997) and the yield is gradually decreasing probably due to viral infection (Rahim *et al.*, 1984). Garlic ranks second in world production among the *Allium* after onion Purselove (1975).

Use of appropriate inorganic fertilizers plays a significant role in the growth and yield of garlic. Inorganic fertilizer supplies sufficient nutrients for growth and development of plant. Among the major macro nutrients NPK are used largely by the plants for better physio-morphological and biological development. Application of nitrogenous fertilizer causes vigorous vegetative growth and linear increase in yield. But increased use of inorganic fertilizer in crop production causes health hazards, create problem to the environment including the pollution of air, water, soil etc. The continuous use of chemical fertilizer is badly affecting the texture and structure of soil, decreasing the soil organic matter and hampering soil microbial activity due to toxicity. Use of organic manures is essential for proper growth and development of garlic. In addition to being a good source of plant nutrients, organic manure improves texture, structure, humus, aeration, water holding capacity and microbial activity of soil and thus helps to increase and conserve the soil productivity. The response of crops to the applied organic manure is slow but the residual effect of these fertilizers last for long periods. In general, the organic matter content of Bangladesh soil is below 1% in about 60% cultivable land which is very low as compared

to an ideal minimum value of 5%. Now it is well agreed that depleted soil fertility is a major constraint for higher crop production. Maintenance of soil fertility is a prerequisite for long term sustainable agriculture and it is certain that organic manure (Cowdung, Vermicompost, Trichoderma compost, Farmyard manure) can play a vital role in the sustenance of soil fertility and crop production. The manures in the tropics is more important than the temperate region, due to excessive weathering and leaching, the tropical soil becomes seriously impoverished in plant nutrients and proper manuring can only play a vital role in crop improvement. Organic manure contains all plant nutrients in a relatively small amount. On the other hand, inorganic fertilizer contains large amount of specific plant nutrient in readily available form. Therefore, inorganic fertilizer in combination with organic manure may lead to better performance of the crops. Considering above facts, the present study was undertaken with the following objectives:

To investigate the effects of different organic and inorganic fertilizers on the performance of garlic.



Chapter II

Review of the Literature

Garlic is an important spice crop in Bangladesh for its culinary and medicinal uses. The production of garlic bulb is greatly influenced by organic and inorganic fertilizers. They play an important role on growth and yield of garlic. To ensure better yield proper management of organic and inorganic fertilizers need to be assured. The present study has been under taken to investigate the performance of organic and inorganic fertilizers on the growth and yield of garlic. Available research findings in home and abroad related to the present study have been reviewed here.

2.1 Effect of organic manures on growth and yield of garlic

Organic matter influences the physical, chemical and biological properties of soil. Organic matter content of a particular soil is an indicator of its productivity.

Asiegbu *et al.* (1984) carried out an experiment in Nigeria on onion with farmyard manure and reported that bulb diameter and the percentage of grade I bulbs were increased with increasing FYM application. They also found that onion yields were maximum with 20 t FYM/ha.

Bhattarai and Subedi (1996) conducted experiments in three places of Nepal (Mallajh, Lower Salija and Hemja). They observed that at Hemja the marketable bulb yield with FYM alone was significantly higher than the FYM + NPK fertilizers whereas at lower Salija and Mallajh it was higher with F YM + NPK application. Though the results were not consistent across the sites, it seems likely that onion production can be successfully done purely under organic manuring practices.

Bevacqua and Mellano (1994) observed that onion seedlings transplanted to compost treated plots established more vigorously than those in the control plots. They also found that compost treatments increased yields (FW) of onions compared to controls.

Another experiment was conducted by Bull *et al.* (1998) in Brazil on garlic. They reported that organic fertilizer can substitute for phosphate fertilization in the recommended dosage for spring garlic.

Cho *et al.* (1994) conducted an experiment to assess the effect of organic matters and lime materials on quality improvement of tissue cultured garlic. For this purpose, they used organic matter (rice straw, compost or fermented poultry manure) and/or lime and the growth and yield

were investigated. They found that organic manure improved yield but the lime application had no effect on yield.

Gudi *et al.* (1988) in a trial conducted in Indonesia, observed that application of manure increased fresh yield of garlic. They applied stable manure to garlic at 0 to 10 t/ha and found that 10 t/ha stable manure gave the highest yield (12.2 kg/4.5 m²) compared to control (5.2 kg/4.5 m²).

Khalaf and Taha (1988) carried out two field experiments in Egypt to evaluate the effect of organic manure 0 and 20 kg/feddan (1 feddan = 0.24 ha) and sulphur (0, 250 and 500 kg/feddan) on the growth, plant mineral contents, yield, bulb quality and volatile oil content of garlic. The treatments were applied during land preparation. They reported that both organic matter and S were beneficial for plant growth, total yield and quality.

Limat *et al.* (1984) conducted 2-years trial with the cv. Amaranle of garlic. The plants were grown on soil into which the followings were incorporated: green manure (*Crotalaria spectabilis*), FYM (30 t/ha), processed industrial waste (30 t/ha) or vermiculite (6 t/ha). Profitability was the greatest with bulbs grown using processed industrial waste followed by FYM.

An experiment on fertilization was carried by Pereira *et al.*, (1987) in Brazil with garlic. Plants were grown without any fertilization, with NPK or with compost at 10, 20, 30, 40 or 50 t/ha. The highest yield (7067 kg/ha) was obtained with 20 t compost /ha.

Wani *et al.* (1998) conducted an experiment on garlic in sterile soil and revealed that *Glomus mosseae* used the insoluble P. sources (Pressmud, rock phosphate and bone meal) for enhancing growth and yield. Inoculation with *G. mosseae* significantly increased plants height, number of leaves per plant and weight, size and yield of bulbs.

2.2 Effect of inorganic fertilizers on growth and yield of garlic

Fertilizers are indispensable for the production system of modern agriculture. Among the factors that affect crop production, fertilizer is the single most important one that plays a crucial role in yield increase. Provides other factors. Inorganic fertilizer today holds the key to the success of the crop production system in Bangladesh Agriculture, being responsible for about 50 percent of the total production (BARC, 1997).

Agrawal *et al.* (1981) conducted an experiment at the Vegetable Research Farm, Kanpur, India during 3 consecutive seasons of 1968-69 to 1970-71 with three trials on onion cv. Kalianpur Red Round. The plant received N, P₂O₅ and/or K₂O at 80-160; 40-80 kg/ha. The highest yield was obtained from plots receiving 160:40:40 or 80:40:80 kg/ha. The application of nitrogen alone at 80 kg/ha gave satisfactory yield (2.02 t/ha) and was the most economic dose.

Asandhi, (1989) in Indonesia, low land and high land garlic crops are traditionally fertilized with N: P₂O₅:K₂O at the rate of 250:90:150 kg/ha. Since the garlic crop is grown after 2 preceding rice crops, which were heavily fertilized. To determine whether omitting P and K and reducing the N rate to 120 kg/ha was possible. The results showed that P and K fertilization was needed and that decreasing the N rates reduced plant growth and garlic yield. The best method of N fertilization was the application of 80 kg N/ha at 15, 30 and 45 days after planting

Amado and Teixeira (1991) studied in a fallow area with or without N and all the treatments received 120 kg P₂O₅/ha and 66 kg K₂O/ha. Combined application of NPK gave the highest dry matter and bulb yield of onion. They also reported to the amount of dry matter of the cover crop residues.

Abbas *et al.* (1994) conducted an experiment in Indonesia with a local garlic cultivar where N was applied at 0, 50, 100 or 150 kg/ha as urea and 0, 30, 60 or 90 kg K₂O/ha as Murate of potash. Garlic yield was found to be highest with 100 kg N/ha and 90 kg K₂O/ha. However, there was no significant interaction between N and K in this respect.

Borabash and Kochina (1987) worked in Ukrain on mineral fertilization with garlic productivity. They reported that mineral fertilization increased the assimilating leaf area, photosynthetic productivity and yield of garlic. The yields of underground bulbs and of underground bulbs + aerial bulbils at 90:90:90 kg/ha N: P₂O₅; K₂O treatments were 6.48 and 7.50 t/ha, respectively and returns were highest in this treatments although the 90:90: 150 kg/ha treatment gave the highest yield.

Das *et al.* (1985) conducted an experiment at the Bidhan Chandra Kisi Viswavidyalaya, Cooch Behar, India on the effect of fertilization of N:P₂O₅ and/or K₂O at 0-120:0-60 and 0-120 kg/ha. The average yield was highest (6.32 t/ha) with NPK at 60:60: 120 kg/ha.

An experiment was conducted by Das and Mohamy (2001) to evaluate the effect of plant density (8×8, 10×8, 10×10 and 15×10 cm) and N: P: K rates (50:50:50, 75:75:75, 100:100:100 and 125:125:125 kg/ha) on the yield of garlic cv. Madrasi. Among the spacing treatments, 8×8

(at 900 plants/plot) produced the highest yield (165.28 q/ha), followed by 10x8 cm among the fertilizer treatments, N: P: K at 100:100:100 kg/ha produced the highest bulb yield (153.78 q/ha), followed by 125:125:125 kg/ha. Combination of 10x89 spacing and 100:100:100 kg N: P: K/ha resulted in the maximum yield of 170.27 q/ha.

Eid *et al.* (1991) in Egypt found that growth parameters and its components were generally increased with increased K application rate up to 100 kg K₂O/feddan and with micronutrient mixture (Cu, Zn and Fe).

Gupta and Gaffar (1980) conducted an experiment to study the effect of different row spacing under different combinations of nitrogen, phosphorus and potassium on the growth and yield of onion. Application of NPK exerted a significant effect on the yield and yield contributing characters of onion. Economic yield was obtained from NPK application 46:36:36 kg/ha.

Guandi and Asandhi (1986) studied the effect of fertilization on garlic cv. Lumba Hijau planted at 20x40 m² plots and fertilized with 0, 80, 160 or 240 kg N/ha as urea or (NH₄)₂SO₄ + 120 K₂O/ha as KCl or K₂SO₄ + 120 kg P₂O₅/ha as triple super phosphate. They observed that higher rates of N produced greater plant heights and greater stem diameter.

Hedge (1988) conducted an experiment with cv. Pusa Red and found that application of N fertilizer increased the bulb yield, but not quality. It was also showed that the dry matter production of bulb was increased due to uptake of more, N, P, K, Ca and Mg nutrients.

Hilman and Noordiyata (1988) conducted an experiment in a rice field at Ciwidey, Indonesia, to study equilibrium N, P and K fertilization on garlic yield. The results showed that the equilibrium N, P and K fertilization at several levels did not significantly affect bulb diameter, bulb length, number of cloves per bulb, or fresh bulb weight. However, the treatments indicated a significant effect on bulb dry weight.

Harun-or Rashid (1998) conducted an experiment at the Bangladesh Agricultural University, Mymensingh on the effects of NPKS on the growth and yield of onion at different plant spacing. He reported that the maximum bulb weight (40.50g) and bulb yield (20.75 t/ha) were found from the combination of 125-150-150-30 kg N, P₂O₅, K₂O, t/ha, and the minimum bulb yield (16.75 t/ha) was recorded from the control treatment (no NPKS). He reported that application of NPKS increased the plant height, leaf number, and length of bulb, bulb diameter, bulb weight as well as the bulb yield. He recommended 100-150-200-30 kg N, P₂O₅, K₂O, t/ha

for the cultivation of BARI Peaj-1 at BAU farm conditions. But Islam (1998) found that nitrogen at 120 kg/ha produced the maximum bulb weight and bulb yield (25.5 t/ha).

Islam and Haque (1977) in Bangladesh studied the effect of NPK on an indigenous cultivar of onion, and observed that the combined dose of nitrogen at 60 kg, phosphorus at 35 kg and potash at 35 kg per hectare produced the highest yield.

The effect of fertilization was investigated by Kusomo and Widiajanto (1973). The normal fertilizer rate of 240 kg N, 60 kg P_2O_5 and 200 kg K_2O /ha (control) was compared with 5 other fertilizer treatments. The best of these five was a compound fertilizer, Rustica Blue, supplemented with urea to give 232 kg N 120 kg P_2O_5 and 170 kg K_2O /ha, its effects, however, differed little from those of the control.

Katwale and Saraf (1994) stated that the largest bulb yield was obtained from the application of NPK at the rate of 125:60:100 kg/ha, respectively in onion. They also reported that the rate gave the highest economic return.

Lazo *et al.* (1969) in their trial on the use of NPK fertilizers in onion at the rate of 50, 100, 150 kg per hectare observed that nitrogen used alone or in combination with phosphorus and potash responded well.

Minard (1978) conducted an experiment in New Zealand with garlic cloves of two sizes (1.0-1.9 and 2.0-2.9g) fertilized with N at 0 or 210 kg/ha, P at 263-1250 kg/ha, K at 0 or 750 kg/ha and lime (as ground lime stone) at 5 or 15 t/ha. The highest yield was obtained from larger bulb size, receiving N and K at high and low rates, respectively Lazzari *et al.* (1978) found that the application of higher nitrogen fertilizer improved the yield and quality of garlic grown in a loam soil in Argentina.

Madan and Sandhu (1985) noticed that good plant growth and maximum bulb yield and dry matter contents were obtained with N: P_2O_5 : K_2O at 12:60:60 kg/ha in onion.

Nelson (1983) conducted an experiment on garlic fertilization trial. May planted garlic on silt loam soil was supplied with combination of (1) N at 100, 150 or 200 kg/ha as a basal dressing 100 days after planting (2) 25 or 325 kg/ha and (3) 25 or 175 + 150 kg K/ha. Both yield and bulb size were improved by increasing the basal N rate, increased N side dressing improved bulb size and when combined with the higher P rate it also raised the yield. The different K rates had no effect on yield or bulb size.

Naik and Hosamani (2003) conducted an experiment to study the effect of different levels of N, P and K on growth and yield of garlic under rainfall condition of Dharwad, Karnataka, India. There were twenty-four treatment combinations of fertilizers comprising four levels of N (0, 50, 100 and 150 kg/ha), three levels of P (0, 40 and 80 kg/ha) and two levels of K (0 and 60 kg/ha). They reported that among the fertilizer combinations, 100:40:60 kg NPK/ha was found to be the optimum for increasing plant height, number of leaves per plant, Number of bulbs per plot, number of cloves per bulb and bulb yield per hectare.

Pal and Pandey (1986) conducted an experiment in India to investigate the effect of different levels of fertilizers. Plant growth was significantly increased by the application of 150 kg N, 250 kg P and 75 kg K/ha. Bulb yield was significantly increased by 150 kg N, 250 kg P and 75 kg K/ha (9.49 t/ha compared with 3.39 t/ha in control receiving no NPK).

Pimpin (1970) reported the results of a study conducted with garlic cv. *Blanca piacintin* where 0, 80 and 160 kg/ha each of N, P₂O₅ and K₂O were applied in factorial combinations. N and K improved the number and weight of bulbs, but P had negative effects on these parameters.

Pandey *et al.* (1991) studied with four levels of nitrogen (0, 50, 100 and 150 kg/ha), three levels of phosphorus (0, 40 or 80 kg/ha) and two levels of potash (0 and 50 kg/ha) to determine the yield and quality of kharif onion. They found that the maximum yield and net return were achieved with N: P: K at 150:40:50 kg/ha.

Purewal and Daragan, (1961) conducted an experiment on fertilization with garlic in India. The application of nitrogen increased the weight of individual bulb significantly over control. Highest response was obtained on the weight of individual bulb with 112.27 kg/ha nitrogen. Phosphorus and potash did not give any response.

Pande and Mundra (1971) conducted an experiment on response of onion to varying levels of N, P and K in Madhya Pradesh, India and reported that the height of plant, number of leaves, length of bulbs, diameter of the bulbs, fresh and dry weight of top growth and yield of garlic bulbs per hectare were significantly increased by the application of N.

Rahman *et al.* (1976) studied the effect of NPK on the local onion cv. Faridpur Bhatti in Bangladesh. They found that a combined dose of nitrogen at 56 kg/ha, phosphorus at 67 kg/ha and potash at 67 kg/ha produced the best results in order to get the highest yield. Higher level of nitrogen application (112 kg/ha) resulted in decreased yield but increased levels of potassium (135 kg /ha) increased the size and yield of bulbs.

Rizk (1997) conducted an experiment to investigate the effects of plant density and NPK fertilizers on the productivity of onion. He noted that increasing the NPK rate increased all the vegetative growth parameters measured and increased the yield of bulbs.

Rahman and Faruque (1975) studied the effect of NPK on onion cv. White Creole and found that an application of N: P: K, 90:45:45 kg/ha resulted in the highest yield.

Singh (1987) in his trial with onion cv. Pusha Red at different levels and combination of NPK fertilizers observed a significant response from N but not from K. The highest yield (26.04 t/ha) was obtained with N and P₂O₅ at 112.5 and 196.9 kg/ha, respectively.

Soto (1988) carried out an experiment with critical levels for P, K and S and response to N. The rates were 100 kg/ha each of N, P₂O₅ and K₂O and 50 kg S/ha. Nitrogen was applied at 0, 50, 100 and 150 kg/ha. He mentioned that 50 kg t/ha gave the best yield response.

Setty *et al.* (1989) studied the effects of nitrogen, phosphorus and potash on the growth and yield of garlic at Dharwad, India during 1989. Application at three levels each of N (0, 100 and 200 kg/ha), P₂O₅ (0, 50 and 100 kg/ha) and K₂O (0, 50 and 100 kg/ha) were made. Application of N at 200 kg/ha produced significant increases in plant height, number of leaves, neck thickness, bulb size, number of cloves/bulb and yield. Application of P at 100 kg/ha increased the number of leaves, bulb size and number of cloves/bulb. Application of K at 100 kg/ha produced significantly larger bulbs.

Singh *et al.* (1994) carried out an experiment in Uttar Pradesh, India to investigate the effects of N (as urea at 0, 100 or 200 kg N/ha) on the growth of garlic cv. Amaranle. Plants also received 50 kg P₂O₅/ha and 50 kg K₂O/ha. They observed that vegetative growth and yield (62.07 q/ha) were maximum for plants receiving N at the rate of 100 kg/ha.

Sarvananan and Nambisan (1994) conducted an experiment at Kodiakanal, Madras, India on garlic. Garlic crop was given 0, 50, 100 or 150 kg N; 0, 25, 50 or 75 kg P and 0, 25, 50 or 75 kg K/ha in various combinations. Mean bulb yield was the highest (9.75 t/ha) with 100 kg N + 75 kg P + 50 kg K/ha. BARI (1974) stated that a dose of 66:88:88 kg N, P₂O₅ and K₂O per hectare gave the highest yield of onion.

Results over 2 years trial conducted by Saimbhi *et al.* (1987) indicated that applying of NPK at the highest rate gave the greatest bulb size, maximum yield (33.89 t/ha) and best quality of dehydrated onions. The highest NPK combination was 100 kg N, P₂O₅ and 60 kg K₂O per hectare.



Sardar *et al.* (1999) conducted an experiment to study the effects of applying N (0, 50, 100 or 150 kg/ha), P (0, 40 or 80 kg/ha) and K (0 or 60 kg/ha) on garlic cv. Kanpur Local. They reported that bulb yields were increased as the rate of each element applied increased. A fertilizer rate of 100 kg N + 80 kg P + 60 kg K/ha was recommended for garlic production.

Vachhani and Patel (1993) conducted an experiment on the effects of nitrogen (50, 100 or 150 kg N/ha), phosphorus (25, 50 or 75 kg P₂O₅/ha) and potash (50, 100 or 150 K₂O/ha) levels on the growth and yield of onion. They reported that plant height, number of leaves/plant, bulb weight and yield were highest with 150 kg N/ha. Increasing phosphorus application increased the number of leaves per plant and weight, size and yield of bulbs. Application of K increased only the number of leaves per plant.

Wang *et al.* (1992) worked in China with garlic and found that the optimum N, P and K requirements for higher yield of garlic were 260, 60 and 369 ppm respectively. They also observed that garlic yield was increased significantly as N, P and K supply was increased.

2.3 Combined effects of organic and inorganic fertilizers on growth and yield of garlic

Organic fertilizer improves the physical, chemical and biological condition of soil. Fertilizers play a very important role in utilizing the soils for an efficient crop production. A number of works investigated the combined effect of organic and inorganic fertilizers.

An experiment was conducted by Abbey (2000) using the treatments: 3 t/ha poultry manure, 340 kg NPK (15-15-15)/ha and 1.5 t/ha poultry manure plus 100 kg NPK (15-15-15)/ha. A combination of poultry manure and NPK fertilizer gave the highest yield of 12.4 t/ha.

Beresniewicz and Nowosiecki (1986) reported that application of 200 kg N, 200 kg P₂O₅, 200 kg K₂O, 20 kg Mg, 5 kg Mn, 5 kg Zn, 10 kg Cu and 1.5 kg Mo/ha gave the highest yields. Yields were further increased when organic fertilizer (lignite or peat) at 100 M³/ha and Ca at 2 t/ha were applied at the same time.

Bogatirenko (1975) reported that annual application of FYM in UK at 40 t/ha + N, P₂O₅ and K₂O at 120:60:120 kg/ha gave garlic yields in 1971 (good year), 1972 and (poor year) of 132, 76 and 65 centners/ha, respectively with control yields of 90, 54 and 46 centners/ha.

Devjatova (1969) stated that autumn application of 30 tons of peaty compost/ha plus NP or NK or NPK at 90 kg/ha of each nutrient increased yield of garlic crop. (Koltunov, 1984) showed

that application of FYM at 40 t/ha + N: P: K at 1:1:2 (N, P_2O_5 and K_2O at 60:60:120 kg/ha) gave the best yield of garlic suitable for long term storage.

Gupta *et al.* (1999) conducted a field experiment to study the effect of organic manure and inorganic fertilizers on growth, yield and quality of kharif onion cv. Agrifound Dark Red. The organic manures evaluated were sunflower cake @ 19 q/ha, poultry manure @ 57 q/ha and FYM @ 143 q/ha and 72 q/ha. The inorganic fertilizers evaluated were urea @ 252 kg/ha, CAN 444 kg/ha and ammonium sulphate @ 565 kg/ha. The control plot was maintained without any organic/inorganic fertilizer. The bed size was 3.6 x 1.8m. They reported that FYM @ 72.0 q/ha along with ammonium sulphate @ 565 kg/ha were effective in increasing the growth, yield and quality contributing characters such as bulb colour.

An investigation was done by Goto and Kimoto (1992) to observe the effect of different organic fertilizers on onion cultivar Pira Ouro. Onion was given the following fertilizer treatments: (1) castor bean cake, (2) poultry manure (3) sewage sludge or (4) FYM, and in each case P + K or N + P + K was added. There was also an N + P + K variant and P + K as the control. N was used at 80 kg/ha. P_2O_5 at 180 kg/ha and K_2O at 120 kg/ha. The quantities for (1), (2), (3) and (4) were 1600, 4000, 4000 and 16000 kg/ha, respectively. N was applied in 3 split doses. The highest commercial yields were obtained with treatments (1) + P + K and (4) + N + P + K (12.1 t/ha in each case).

Kropisz (1992) carried out an experiment using composted pine bark (CPB) + vegetable matter, compost sawdust (CS) + vegetable matter (added to CPB and CS at 10, 20 or 30% by volume) and FYM were applied at 25 t/ha in 3-year field trials with cabbage, onion and carrot. All the organic fertilizers were applied in the first year only. NPK fertilizers were applied annually and there were plots where NPK alone was applied. Organic fertilizers in all cases improved cropping, with the highest average yields being obtained on plots receiving FYM + NPK. (Rashid, 1983) recommended 10 tons of cowdung, 175 kg of Urea, 125 kg of TSP and 150 kg of MP per hectare for successful onion cultivation in Bangladesh.

Khalil *et al.* (2002) conducted an experiment to study the effects of farm yard (FYM; 40, 50, and 60 m³/feddan) manures on onion cv. Shandaweel I. N (100 kg/feddan as urea) was also applied at 45 and 60 days after transplanting, whereas P (30 kg/feddan as calcium superphosphate) was applied as a basal dressing. K (24 kg/feddan as potassium sulfate) was incorporated before transplanting. The tallest plants were obtained with 25 and 30m³ chicken manure/feddan (1 feddan = 0.24 ha). Chicken manure and inorganic fertilizers were more

effective than F YM in increasing leaf number per plant. The highest average bulb weight, marketable bulb yield were recorded for 25m³ chicken manure/feddan. Chicken manures resulted in the highest total bulb yield.

Mallanagouda *et al.* (1995) conducted an experiment to investigate the effects of NPK and farmyard manure on the growth and yield of onions. The recommended rate of NPK was applied alone or in combination with FYM. FYM was applied alone or in combination with half the recommended dose of NPK. The highest yield of onion (4698.38 kg/ha) was obtained from plots treated with the recommended rate of NPK + FYM.

In a field trial in Indian was carried out by Selvaraj *et al.* (1993) on a local garlic cultivar planted at a spacing of 15x7.5 cm. and found that the mean uptake of N, P, K and Mg at harvest (calculated from plant nutrient content) was 251.2, 19.03, 298.0 and 2.64 kg/ha. Respectively. They obtained the highest yield (22.0 t/ha) with the application of N, K (K20) and MgSO₄; at 75, 75 and 50 kg/ha, respectively (in addition to 25 t FYM and 90 kg P₂O₅/ha).

Seno *et al.* (1996) studied the effect of four doses of P₂O₅ (control, 150, 300 and 450 kg/ha) and four doses of chicken manure (control, 4, 8 and 12 t/ha) on the culture of garlic. The phosphorus, compost and additional nutrients (20 kg N, 90 kg K₂O, 2.2 kg B and 4 kg Zn per ha) were applied. Two foliar applications of nutrients were made with 1% urea at 40 and 60 days after planting. The phosphorus induced linear decrease for the plant length at 30 days and for the production of medium sized bulbs therefore increased the average weight of bulbs. The chicken manure induced a linear increase in the average weight of bulbs.

An investigation was done by Varu *et al.* (1997) with organic and inorganic fertilizers to observe the effects on the growth and yield of onion. Onion was given the following fertilizer treatments: NPK (100 kg N, 50 kg P₂O₅, 50 kg K₂O/ha), Farmyard manure (FYM at 50 t/ha), a concentrated organic manure (Dharatidhara at 4 t/ha); FYM (25 t/ha) + Dharatidhara (2 t/ha); FYM (25 t/ha) + NPK (full rate), FYM (95 t/ha) + NPK (half rate) + Dharatidhara (2 t/ha) and no fertilizer. The highest bulb yield (32.70 t/ha) was obtained from the FYM + NPK + Dharatidhara treatment. This treatment also gave the highest bulb diameter, weight and volume.

Vinay *et al.* (1995) conducted an experiment to find out the response of onion to N, P, Zn and FYM. They reported that the highest bulb yield (50.6 g plot) was obtained from plants fertilized with F YM (10 t/ha) + 40 kg N /ha + 60 kg P/ha.

Warade *et al.* (1996) worked with different sources of nutrients on yield of onion bulbs at Rahuri, India. The highest bulb yield (27.7 t/ha) was obtained from 40 t FYM/ha + NPK (100, 50 and 50 kg/ha, respectively) followed by 40 t FYM/ha + NPK (75, 50 and 50 kg/ha, respectively) + biofertilizer inoculation. These 2 treatments increased yields by 64.4 and 64.0%, respectively, compared with controls which received no fertilizers.

Yadav and Yadav (2001) conducted an experiment to determine the effect of NICAST (OM) in comparison to the recommended dose of manure and fertilizers in onion cv. R0-1. The experiment consisted of 10 treatments of manure and fertilizers. The rates of manure and fertilizers were, FYM (30 t/ha), NPK (100: 50: 100 kg/ha), NICAST (250 kg/ha), NICAST (500 kg/ha), NICAST (750 kg/ha), Vermicompost (15 t/ha) respectively. They reported that out of 10 treatments FYM + NPK gave the highest significant bulb yield (370.37 q/ha).

Zhang *et al.* (1998) conducted an experiment in China on NPK absorption in garlic. The ratio of NPK absorbed by garlic was 1:0.3:0.71. The peak of N and K absorption was at the inflation stage of squamosal bulbs and the peak of P absorption was during sprout elongation. The recommended optimum application of NPK was 160-350 kg, 120-155 kg and 133.4 kg/ha in Henan Province. They reported that combination of organic fertilizers with NPK fertilizers increased the yield by 78.4-118.4%.

It is revealed from the above review of literature that, different organic and inorganic fertilizers had significant effect on growth and yield of garlic as reported by different authors. But this work on effect of growth and yield of garlic under different doses of organic and inorganic fertilizer is meager in Bangladesh. So, the present study was undertaken.

Chapter III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in conducting the experiment.

3.1 Experimental site

The present research work was carried out to study the performance of organic and inorganic fertilizers on the growth and yield of garlic. The experiment was conducted at the Professor Purnendu Gain Field laboratory, Agrotechnology Discipline, Khulna University, Khulna during the period from November, 2013 to April, 2014 in an attempt to evaluate the effect of different organic and inorganic fertilizers and their combination on growth and yield of garlic (local variety).

3.2 Climate

The experimental area was under the sub-tropical climate which is characterized by heavy rainfall, high humidity, high temperature and relatively long day during the period from April to September and scanty or a little rainfall during the rest period of the year (Nov-April). The total rainfall of the locality was 261 mm during the growing period of garlic. Details of the meteorological data were in respect of temperature, rainfall, relative humidity, sunshine and soil temperature during the experimental period are shown in (Appendix I).

3.3 Soil

The soil of the experimental area was clay loam to sandy loam in texture belonging to the Ganges Tidal Floodplain Tract under the AEZ number 13 UNDP (1998). The selected plot was a medium high land. Soil samples of the experimental plots were collected at a depth of 0-30 cm before conducting the experiment and were analyzed in SRDI Laboratory, Daulatpur, Khulna, Bangladesh. Details of the characteristics of soil samples are shown in (Appendix II).

In addition the morphological characteristics of the soil of the experimental plot as indicated by FAO (1988) are given below:

Morphological characteristics

AEZ	:	Ganges Tidal Floodplain (13)
General Soil	:	Non-calcareous dark grey
Parent materials	:	Ganges River Bom Deposits

3.4 Planting materials

In this research work, a local cultivar (Deshi) of garlic was used as planting material. Bulbs were collected from local market in Gollamari, Khulna of Bangladesh. The cloves of uniform size were selected for planting and weight of clove was 0.95- 0.115 gram.

3.5 Land preparation

The selected experimental plot was first opened by a power tiller in the month of November, 2013, one month before planting. 4-5 times ploughing and cross ploughing with power tiller followed by laddering were done until the desired tilth was achieved for planting the cloves.



Plate 1. Showing land preparation by power tiller

The corners of the plots were trimmed by spade. The clods were broken into friable soil and the surface of the soil was leveled. During land preparation weeds and stubbles of the previous crops were collected and removed from the field. Irrigation and drainage channels were prepared around the plots.

3.6 Treatments of the experiment

The present experiment consisted of ten treatments of organic and inorganic fertilizers. The ten treatments are given below:

T₀ = Control (Without manures and fertilizers)

T₁ = Vermicompost (VC)

T₂ = Trichoderma compost (TDC)

T₃ = Cowdung (CD)

T₄ = Farmyard manure (FYM)

T₅ = Recommended fertilizer dose of NPK (N 99.82, P 53.40, K 166.50) kg/ha , CD 5 ton/ha)

T₆ = 50% Trichoderma + 50% Recommended fertilizer

T₇ = 50% Vermicompost + 50% Recommended fertilizer

T₈ = 50% Cowdung + 50% Recommended fertilizer

T₉ = 50% Farm yard manure + 50% Recommended fertilizer

3.7 Application of manures and fertilizers

The doses of manures and fertilizer were applied to the plots as per following ways as recommended. The following doses of inorganic fertilizers were applied to the plots for bulb production (Rahim *et al.*, 1984).

Table 1. Used doses of manures and fertilizers

Manure and fertilizer treatments	Doses/ha	Doses/ plot (2m×1m)
T1 = Vermicompost (VC)	8 ton/ha	2kg
T2 = Trychoderma compost (TDC)	10 ton/ha	2kg
T3 = Cowdung (CD)	20 ton/ha	5kg
T4 = Farmyard manure (FYM)	20 ton/ha	5kg
T5 = Recommended fertilizer dose of NPK and cowdung	N 99.82 kg/ha, P 53.40 kg/ha, K 166.50 kg/ha and Cowdung 5 ton/ha	Urea 45g, TSP 53.4g, MoP 70g, Zypsum 22g and Cowdung 1.08 kg
T6 = 50% TDC + 50% Recommended fertilizer	4 ton/ha TDC + N 49.91 kg/ha, P 26.7 kg/ha, K 83.25 kg/ha and cowdung 2.5 ton/ha	1kg TDC + Urea 22.5g, TSP 27.5g, Mop 35g, Zypsum 11g, and cowdung 0.54g
T7 = 50% VC + 50% Recommended fertilizer	4 ton/ha VC + N 49.91 kg/ha, P 26.7 kg/ha, K 83.25 kg/ha and cowdung 2.5 ton/ha	1kg VC + Urea 22.5g, TSP 27.5g, Mop 35g, Zypsum 11g, and cowdung 0.54g
T8 = 50% CD + 50% Recommended fertilizer	10 ton/ha TDC + N 49.91 kg/ha, P 26.7 kg/ha, K 83.25 kg/ha and cowdung 2.5 ton/ha	2.5kg CD + Urea 22.5g, TSP 27.5g, Mop 35g, Zypsum 11g, and cowdung 0.54g
T9 = 50% FYM + 50% Recommended fertilizer	10 ton/ha TDC + N 49.91 kg/ha, P 26.7 kg/ha, K 83.25 kg/ha and cowdung 2.5 ton/ha	2.5kg FYM + Urea 22.5g, TSP 27.5g, Mop 35g, Zypsum 11g, and cowdung 0.54g

The entire quantity of well decomposed cowdung, vermicompost, trichoderma, farm yard manure were applied to the unit plots as per treatment and the whole amount of Triple Super Phosphate (TSP). 1/2 of MoP and 1/3 of urea were applied to the soil during final land preparation of 5 days before planting. The rest of MoP and half of urea were applied as top dressing at 25 DAP and rest of urea was applied at 50 DAP.



3.8 Design of the experiment

The single factor experiment was conducted in randomized complete block design (RCBD) with three replications.



Plate 2. Showing the design of experimental plot

3.9 Layout of the experiment

The whole experimental plot was divided into three blocks and each of which was then divided into 10 unit plots. The ten treatments were then distributed randomly among the unit plots of each block so as to all treatments were placed once in each block. The size of each unit plot was 2 m×1 m. The space between the blocks and plots were 75 cm and 50 cm respectively.

3.10 Planting method of clove

The cloves for planting were selected from large bulbs of garlic. The cloves were separated from bulbs immediately before planting. Planting was done by placing cloves at a depth of 5 cm below the soil surface with the help of a pointed stick. The cloves were inserted vertically with the root side down making sure that there was a root-soil contact. One hundred eighty

(180) cloves were planted in each unit plot maintaining spacing of 10 cm × 10 cm. Cloves were also planted around the experimental plot area to check border effect. The planting was done on 08 December, 2013.

3.11 Intercultural operations

After planting the cloves, the experimental area was kept under careful observation and the following intercultural operations were done.

3.11.1 Gap filling

The unsprouted cloves were replaced by healthy seedling taken from border plants planted at the same time within two weeks after planting. The damaged plants were also replaced by healthy border plants.

3.11.2 Weeding

Weeding was done manually regularly to keep the plots free from weeds and to pulverize the soil.



Plate 3. Picture showing before weeding (left side) and after weeding (right side).

3.11.3 Irrigation

Frequency of watering depended upon the moisture status of the soil. Irrigation was given by watering can as and when needed. Irrigation's were provided in each plot uniformly.



Plate 4. Showing garlic field after irrigation.

3.11.4 Plant protection

After complete emergence of the crop, Rovral at the rate of 25 g in 10 liters of water was applied at an interval of 15 days up to one month before harvesting to control purple leaf blotch disease of garlic.

3.12 Harvesting

The crop was harvested on 15 April, 2014, after attaining maturity, showing the sign of drying out of most of the leaves and softening of the neck of the bulb.

3.13 Collection of data

Ten plants were selected randomly from each unit plot for the collection of data. Data were collected periodically at 20, 30, 40, 50, 60, 70, 80, 90 and 100 days after planting in respect of following parameters.

3.13.1 Plant height

Plant height was measured from ten selected plants in centimeter (cm) from the ground level to the tip of the longest leaf of the sample plants at 20, 30, 40, 50, 60, 70, 80, 90 and 100 days after planting (DAP). The mean was also calculated.

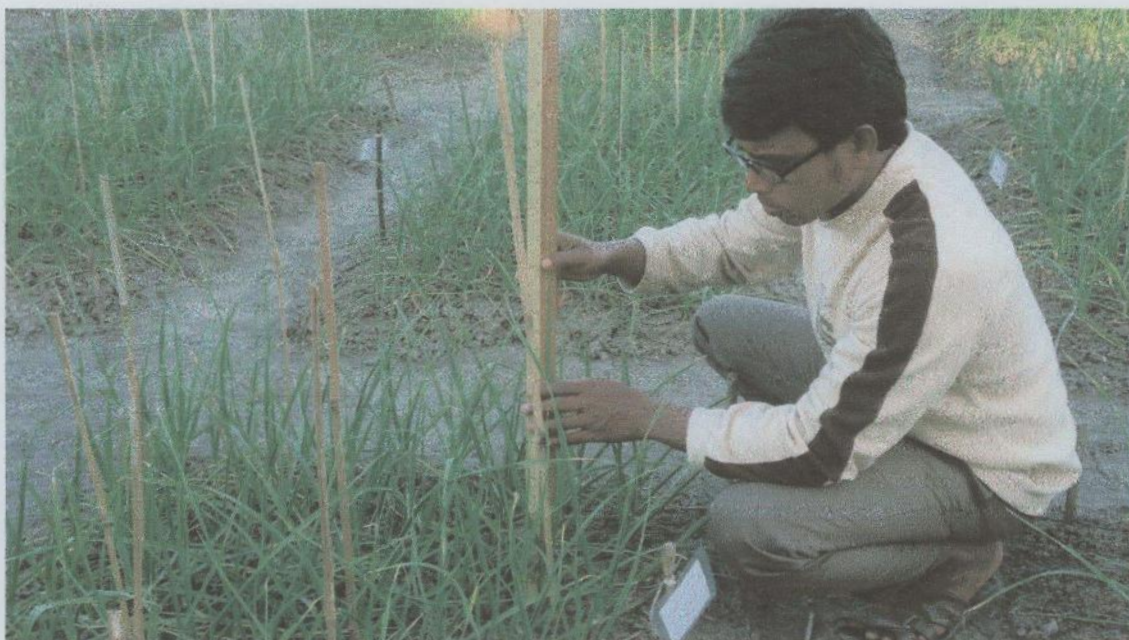


Plate 5. Showing the measurement of plant height.

3.13.2 Number of leaves per plant

The number of leaves of 10 selected sample plants were counted at 20, 30, 40, 50, 60, 70, 80, and 90 days after planting and their average was calculated.

3.13.3 Length of leaf per plant

Length of leaf was measured from ten sample plants in centimeter (cm) from the ground level to the tip of the longest leaf of the sample plants at 20, 30, 40, 50, 60, 70, 80, and 90 days after planting (DAP). The mean was also calculated.

3.13.4 Breadth of leaf per plant

Breadth of leaf was measured from 10 plants in centimeter (mm) from the ground level to the tip of the longest leaf of the sample plants at 20, 30, 40, 50, 60, 70, 80, and 90 days after planting (DAP). The mean was also calculated.

3.13.5 Fresh shoot weight per plant

After harvest, shoot of 10 selected plants from each plot were collected and weight of leaves were taken by an electric balance in gram (g) and their mean was calculated.

3.13.6 Dry shoot weight per plant

After harvest, shoot of 10 selected plants from each plot were separated from the bulb with a sharp knife then weighed and dried inside the electric oven in the Molecular Horticulture laboratory for 72 hours at 70°C till constant weight was recorded. After drying, the shoot samples were weighed and mean weight was calculated in gram (g).



Plate 6. Showing the measurement of dry shoot weight by using micro balance

3.13.7 Fresh root weight per plant

After harvesting, the roots were separated from the bulbs with a sharp knife. Then fresh weight of roots of 10 sample plants were taken and their mean was calculated in gram (g).

3.13.8 Dry root weight per plant

The fresh root sample was dried into oven for 72 hours at 70°C at Molecular Horticulture laboratory. After drying, the weight was recorded. It was calculated in gram (g).

3.13.9 Fresh weight of bulb

After harvest, the root and top portion were removed keeping only 2.5cm pseudostem with the bulb, the bulb weight of 10 selected plants were taken and their mean was calculated.

3.13.10 Dry weight of bulb

After cutting and sun drying for two days the bulb samples were dried for 72 hours at 70°C in an oven. After oven drying, the weight of the bulb sample was recorded and calculated in gram (g).

3.13.11 Diameter of bulb

The diameter at the middle part of the bulb was taken from ten randomly selected plants after harvest with a slide calipers and their mean was recorded in cm.

3.13.12 Number of cloves per bulb

The number of cloves of 10 bulbs from the selected plant of each plot were counted and their mean was calculated.



Plate 7. Showing the picture of number of cloves per bulb

3.13.13 Yield of bulb per plot

Bulb yield per plot was recorded by harvesting all the bulbs in each plot and taking their weight after cutting roots and pseudostem keeping only 2.5 cm with the bulb. Yield per plot was expressed in kilogram (kg).



Plate 8. Showing the measurement of yield of bulb per plot by using electronic balance.

3.13.14 Yield of bulb per hectare

Yield of bulb per plot was converted into yield per hectare and was expressed in tons.

3.14 Statistical analysis

Data were recorded from the sample plants during the course of experiment. Recorded data were analyzed statistically with the help of computer package program MSTAT-C and the mean differences were adjusted with Duncan's New Multiple Range Test at 5 % and 1 % level of probability (Gomez and Gomez, 1984).

Chapter IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the performance of different organic and inorganic fertilizers on the growth and yield of garlic in Batiaghata of Bangladesh. The data have been presented in table 1-7 and figures 1 and a summary of the analysis of variance in respect of all the parameters have been shown in appendix I-IV. The results of each parameter have been discussed under the following headings.

4.1 Effects of organic and inorganic fertilizers on growth and yield of garlic

4.1.1 Plant height

The different types of organic manures and inorganic fertilizers significantly influenced the plant height of garlic at different stages of growth i.e. 20, 30, 40, 50, 60, 70, 80 and 90 days after planting (Appendix III). Among the treatments, it was observed that plant height was increased gradually with the advancement of time. Plant height showed increasing trend up to 90 DAP for each treatment. At 90 DAP, the longest plant (65.58 cm) was recorded from the treatment of 50% FYM + 50% RF (T9) followed by (59.87 cm) Vermicompost (T1) and the shortest plant (43.64cm) was found from the control treatment (Table. 2). The plant height reached to its maximum at 90 DAP in all the treatments.

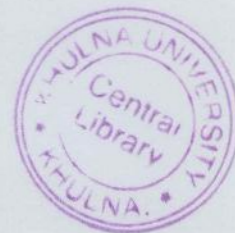
The maximum plant height obtained from 50% FYM + 50% RF was due to the fact that inorganic fertilizers released nutrients quickly and organic fertilizer supplied adequate plant nutrients and improve soil physical properties by organic matter which might have encouraged more vegetative growth and development.

Table. 2 Effect of organic and inorganic fertilizer on the plant height of garlic

Code	Treatments	Days after planting (DAP)									
		20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP	90 DAP		
T ₀	Control	15.2	20.87 d	25.63 b	30.47 cd	34.17 c	39.57 d	40.97 c	43.64 c		
T ₁	Vermicompost (VC)	17.467	26.53 abc	29.97 a	35.13 abc	43.2 ab	50.17 abc	55.1 ab	59.87 ab		
T ₂	Trichoderma compost (TDC)	18.7	27.3 abc	31.37 a	37.27 ab	42.9 ab	49.4 abc	51.52 ab	54.29 abc		
T ₃	Cowdung (CD)	17.333	27 abc	30.1 a	34.67 abcd	41.9 abc	48.67 abc	51.58 ab	54.18 abc		
T ₄	Farmyard manure (FYM)	17.167	25.7 abcd	28.9 ab	33.47 abcd	39.7 abc	46.7 abcd	47.88 bc	51.87 bc		
T ₅	Recommended fertilizer (RF)	16.567	25.2 abcd	28.47 ab	31.6 bcd	37.83 abc	44.3 bcd	47.25 bc	49.67 bc		
T ₆	50% TDC + 50% RF	17.867	28.17 ab	32 a	36.67 ab	45.4 ab	51.03 ab	54.03 ab	57.78 ab		
T ₇	50% VC + 50% RF	15.333	22.77 bcd	25.83 b	29.87 cd	38.87 abc	44.56 bcd	47.19 bc	49.37 bc		
T ₈	50% CD + 50% RF	15.4	21.8 cd	25.87 b	29.33 d	36.6 bc	42.23 cd	46.52 bc	54.78 abc		
T ₉	50% FYM + 50% RF	18.533	28.97 a	30.4 a	37.4 a	45.83 a	54.01 a	58.99 a	65.58 a		
CV (%)		9.33	8.65	7.63	9.07	8.49	6.87	8.17	9.77		
Significance		NS	**	*	*	**	**	**	**		

Here, ** = Level of significance 1%, * = 5% level of significance. NS= Non significance

Here, T₀ = Control (Without manures and fertilizers), T₁ = Vermicompost (VC), T₂ = Trichoderma compost (TDC), T₃ = Cowdung (CD), T₄ = Farmyard manure (FYM), T₅ = Recommended fertilizer dose, T₆ = 50% Trichoderma + 50% Recommended fertilizer, T₇ = 50% Vermicompost + 50% Recommended fertilizer, T₈ = 50% Cowdung + 50% Recommended fertilizer, T₉ = 50% Farmyard manure + 50% Recommended fertilizer.



4.1.2 Number of leaves per plant

The variations in total number of leaves per plant under different organic and inorganic fertilizer treatments were found statistically significant at 20, 30, 40, 50, 60, 70, 80 and 90 DAP except at 20 DAP (Appendix III). The maximum number of leaves (8.33) was recorded from the treatment of 50% FYM + 50% RF (T₉) together followed by vermicompost (8.13) and the minimum was observed (6.7) in the treatment of control (Table. 3). Number of leaves per plant are maximum at 90 DAP in all the treatments.

At all DAP, maximum number of leaves per plant was produced with organic fertilizer 50% FYM + inorganic fertilizer 50% RF (T₉). The higher number of leaves production per plant may be accounted for higher vegetative growth due to optimum vegetative growth and optimum nutrient supply. But the minimum number of leaves was counted from the control treatment at each DAP. The result was in conformity with the results of Singh *et al.* (1994) who obtained a higher leaf number/plant from organic + inorganic fertilizers in onion.

Table. 3 Effect of organic and inorganic fertilizer on the number of leaves of garlic

Code	Treatments	Days After Planting									
		20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP	90 DAP		
T ₀	Control	2.967	4.6 cd	5.26 bc	5.767	6 c	6.033 d	5.933 b	6.7 d		
T ₁	Vermicompost (VC)	3.2	4.86 abcd	5.6 abc	6.167	6.8 ab	7.2 ab	7.36 a	8.13 ab		
T ₂	Trichoderma compost (TDC)	3.16	4.83 abcd	5.63 abc	6	6.43 b	6.63 c	7.13 a	7.53 c		
T ₃	Cowdung (CD)	3.3	5 abc	5.76 a	6.2	6.53 b	6.6 c	7.23 a	7.56 c		
T ₄	Farmyard manure (FYM)	3	4.9 abcd	5.5 abc	6.06	6.6 ab	6.56 c	6.96 a	7.53 c		
T ₅	Recommended fertilizer (RF)	3.33	4.7 bcd	5.66 ab	6.2	6.53 b	6.53 cd	7.03 a	7.66 bc		
T ₆	50% TDC + 50% RF	3.26	5.13 ab	5.76 a	6.2	6.6 ab	6.5 cd	7.63 a	7.73 bc		
T ₇	50% VC + 50% RF	2.86	4.567 cd	5.233 c	6	6.53 b	6.9 bc	7.13 a	7.7 bc		
T ₈	50% CD + 50% RF	2.83	4.4 d	5.27 bc	5.9	6.67 ab	6.6 c	6.96 a	7.6 c		
T ₉	50% FYM + 50% RF	3.26	5.33 a	5.8 a	6.5	7.03 a	7.53 a	7.63 a	8.33 a		
CV (%)		9.20	5.61	3.96	4.52	2.90	3.23	3.86	2.67		
Significance		NS	*	*	NS	**	**	**	**		

Here, ** = Level of significance 1%, * = 5% level of significance, NS = Non significance.

Here, T₀ = Control (Without manures and fertilizers), T₁ = Vermicompost (VC), T₂ = Trichoderma compost (TDC), T₃ = Cowdung (CD), T₄ = Farmyard manure (FYM), T₅ = RF dose of NPK, T₆ = 50% Trichoderma + 50% Recommended fertilizer, T₇ = 50% Vermicompost + 50% Recommended fertilizer, T₈ = 50% Cowdung + 50% Recommended fertilizer, T₉ = 50% Farmyard manure + 50% Recommended fertilizer.

4.1.3 Length of leaves

There were significant variations among the different types of organic and inorganic fertilizers in respect of the length of bulb (Appendix III). The highest length of leaf (40.55cm) was produced by the organic fertilizer of Vermicompost (T₁) and (39.40cm) the combination of organic and inorganic fertilizer 50% FYM + 50% RF (T₉), (Table. 4) followed by (T₆) organic fertilizer 50% TDC + 50% RF (37.96 cm) while the minimum length of leaf (30.42 cm) was obtained from the Control.

Table. 4 Effect of organic and inorganic fertilizer on length of leaf of garlic at different days after sprout

Treatments	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP	90 DAP
Control	13.13	15.76	21.41	23.90	26.20	28.27bc	29.86b	30.42d
Vermicompost (VC)	12.72	15.79	20.72	25.20	30.10	34.38ab	38.32a	40.55a
Trichoderma compost (TDC)	13.75	16.86	21.65	26.25	30.49	33.01abc	35.03ab	35.42abcd
Cowdung (CD)	12.18	15.25	20.47	23.95	27.67	30.56abc	32.29ab	33.17bcd
Farmyard manure (FYM)	12.25	14.73	19.73	22.99	26.88	29.05bc	31.10ab	31.81cd
Recommended fertilizer (RF)	11.29	13.55	18.37	21.58	25.52	28.55bc	30.62ab	31.56cd
50% TDC + 50% RF	12.85	16.04	21.48	25.98	31.92	35.73a	37.50ab	37.96abc
50% VC + 50% RF	11.60	14.67	17.97	21.02	24.52	27.13c	29.28b	30.06d
50% CD + 50% RF	11.09	14.57	18.35	20.55	24.91	27.81c	29.86b	30.44d
50% FYM + 50% RF	12.36	15.39	20.36	24.94	28.72	33.02abc	36.93ab	39.40ab
CV (%)	10.13	8.84	11.25	12.99	11.20	10.86	9.66	8.69
Significance	NS	NS	NS	NS	NS	*	**	**

Here, ** = Level of significance 1%, * = 5% level of significance, NS= Non significance.

Here, T₀ = Control (Without manures and fertilizers), T₁ = Vermicompost (VC), T₂ = Trichoderma compost (TDC), T₃ = Cowdung (CD), T₄ = Farmyard manure (FYM), T₅ = RF dose of NPK, T₆ = 50% Trichoderma + 50% Recommended fertilizer, T₇ = 50% Vermicompost + 50% Recommended fertilizer, T₈ = 50% Cowdung + 50% Recommended fertilizer, T₉ = 50% Farmyard manure + 50% Recommended fertilizer.

4.1.4 Breath of leaves

There were significant variations among the different types of organic and inorganic fertilizers in respect of the breath of leaves (Appendix III). The highest breath of leaves (1.31 cm) was produced by the combination of organic fertilizer 50% FYM + 50% RF (T₉), (Table. 5) followed by (T₆) organic fertilizer 50% TDC + 50% RF (1.21 cm) while the minimum breath of leaves (1.03 cm) was obtained from the Control.

Table. 5 Effect of organic and inorganic fertilizer on breadth of leaves of garlic at different days after sprout

Treatments	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP	90 DAP
Control	3.46b	3.84 c	4.55c	5.57c	6.896c	8.17b	9.20d	10.32c
Vermicompost (VC)	3.82b	4.77ab	5.80ab	7.03ab	8.29ab	9.51b	10.81bc	11.87b
Trichoderma compost (TDC)	3.61b	4.16bc	5.11bc	5.96bc	7.50bc	9.20b	10.68bc	11.74b
Cowdung (CD)	3.66b	4.29bc	5.17bc	6.29bc	7.54bc	8.86b	10.29bcd	11.38bc
Farmyard manure (FYM)	3.97ab	4.59abc	5.32bc	6.30bc	7.57bc	8.81b	10.66bc	11.61b
Recommended fertilizer (RF)	4.01ab	4.45abc	5.25bc	6.56bc	7.96abc	9.47b	11.05bc	11.97b
50% TDC + 50% RF	4.01ab	4.69t6abc	5.63bc	6.53bc	8.15abc	9.30b	11.38ab	12.13b
50% VC + 50% RF	4.03ab	4.56abc	5.28bc	5.75bc	6.97c	8.48b	9.10bcd	11.30bc
50% CD + 50% RF	3.68b	4.23bc	5.25bc	6.14bc	7.30bc	8.50b	9.85cd	11.03bc
50% FYM + 50% RF	4.51a	5.23a	6.25a	7.67a	9.13a	10.91a	12.36a	13.96a
CV (%)	7.84	7.76	7.99	8.90	8.59	6.00	5.17	3.86
Significance	*	**	*	*	*	**	**	**

Here, ** = Level of significance 1%, * = 5% level of significance

Here, T₀ = Control (Without manures and fertilizers), T₁ = Vermicompost (VC), T₂ = Trichoderma compost (TDC), T₃ = Cowdung (CD), T₄ = Farmyard manure (FYM), T₅ = RF dose of NPK, T₆ = 50% Trichoderma + 50% Recommended fertilizer, T₇ = 50% Vermicompost + 50% Recommended fertilizer, T₈ = 50% Cowdung + 50% Recommended fertilizer, T₉ = 50% Farmyard manure + 50% Recommended fertilizer.

4.1.5 Fresh shoot weight

A significant variation was observed on the fresh weight of shoot per plant due to different organic and inorganic fertilizers (Table 6 and Appendix III). The maximum fresh shoot weight per plant (10.96 g) was recorded from the treatment of organic fertilizer 50% FYM + inorganic fertilizer (50% RF) (T₉) followed by (T₁) vermicompost (10.17 g) while the minimum was recorded from the treatment of control (3.48g). The highest plant height along with the maximum number of leaves per plant in 50% FYM + 50% RF (T₉) contributed to give the highest weight of leaves due to better nutrient supply at the growing stage of the plant.

4.1.6 Individual weight of bulb

Individual weight of bulb varied significantly among different organic and inorganic fertilizers (Table 6 and Appendix III). The maximum weight of bulb (16.90g) was obtained from the treatment 50% FYM + 50% RF (T₉) followed by (13.89g) Vermicompost (T₁). The minimum bulb weight (8.97g) was observed when the plants were raised under the control (Table 6). The maximum bulb weight obtained from the treatment 50% FYM + 50% RF (T₉) was probably due to the fact that combination of organic and inorganic fertilizers provided good soil condition for growth and supplied sufficient plant nutrients, while inorganic fertilizers supplied readily available adequate nutrients that helped in the production of large sized bulb of maximum weight. Varu *et al.* (1997) also obtained the highest individual bulb weight from organic + inorganic fertilizers.

4.1.7 Fresh weight of roots

The fresh weight of roots per plant was significantly differed with different organic and chemical fertilizers (Table 6 and Appendix III). The maximum fresh weight of roots per plant (1.61g) was observed in 50% FYM + 50% RF (T₉) followed by organic fertilizers

Vermicompost (T₁). The minimum fresh weight of roots per plant (0.49g) was observed in the control treatment (Table 6).

4.1.8 Dry weight of shoot

Different organic and inorganic fertilizers showed significant variation in respect of dry weight of shoot plant (Table 6). The maximum dry weight of shoot per plant (3.86g) was obtained from organic fertilizer 50 % FYM + 50% RF (T₉) which was followed (3.40g) by organic fertilizer Vermicompost (T₁). The minimum (1.16g) dry weight shoot per plant was recorded from the control (Appendix III). Higher dry weight shoot per plant was obtained due to availability of more nutrients in the soil in all stages of plant resulting higher vegetative growth.

4.1.9 Dry weight of roots

The dry weight of roots also varied significantly with the application of different organic and inorganic fertilizers (Table 6 and Appendix III). The maximum dry weight of roots (0.528) was recorded in the treatment (T₉) 50% FYM + 50% RF followed by organic fertilizer (T₁) Vermicompost (0.393g). The minimum dry weight of roots was found (0.146g) from the control treatment (Table 6).

4.1.10 Length of bulb

There were significant variations among the different types of organic and inorganic fertilizers in respect of the length of bulb (Appendix III). The longest bulb (4.13cm) was produced by the combination of 50% FYM + 50% RF (T₉), (Table 6) followed by (T₆) 50% TDC + 50% RF (3.59cm) while the minimum length of bulb (2.9cm) was obtained from the control treatment.

4.1.11 Diameter of bulb

Bulb diameter was significantly influenced by the different organic and inorganic fertilizers (Table 6 and Appendix III). The maximum diameter of bulb (3.49cm) was found in the plants

having both the combination of 50% FYM + 50% RF (T₉) followed by organic fertilizer (T₁) Vermicompost (3.20 cm). This might be due to the fact that organic manure 50 % VC + 50% RF kept the soil loose and both manure and fertilizers supplied adequate plant nutrients for better vegetative growth of garlic plants and ultimately increased bulb diameter.

4.1.12 Number of cloves per bulb

The clove number per bulb differed significantly among different treatments of organic and inorganic fertilizers (Table 6 and Appendix III). It was observed that the maximum number of cloves (20.23) per bulb was obtained from the combination of 50% FYM + 50% RF (T₉) followed by (18.70) organic fertilizer whereas the minimum (12.63) number of cloves per bulb was produced by the control treatment.

4.1.13 Yield of bulb per plot

Different types of organic and inorganic fertilizers were found to be influenced significantly on the yield per plot (Table 6 and Appendix III). 50% FYM + 50% RF (T₉) gave the maximum yield per plot (1.86 kg), followed by Vermicompost (T₁) 1.54 kg and Trichoderma compost (T₂) 1.36 kg. The minimum yield per plot (0.69 kg) was obtained from the control treatment. 50% FYM + 50% RF gave the highest yield and it was probably due to the fact that combination of organic and inorganic fertilizers improved physical condition of the soil for better growth as well as supplied sufficient plant nutrients in all stages of plant growth. This result is in agreement with the findings of Mallanagouda *et al.* (1995), Kropisz (1992), Vinay *et al.* (1995).

4.1.14 Yield of bulb per hectare

The yields of garlic under different types of organic and inorganic fertilizers were found to be significantly different when converted into yields per hectare (Table 6 and Appendix III). The maximum yield (9.38 t/ha) was recorded from the treatment of organic fertilizer 50% FYM + 50% RF (T₉) followed by Organic fertilizer (T₁) Vermicompost (8.71 t/ha) and the minimum

(2.83 t/ha) was observed from the Control treatment (Fig. 1). The plants received more nutrients when raised with the combination of organic and inorganic fertilizers. Bogatirenko (1975) and Koltunov (1984) found the highest yield of garlic when grown with the combination of organic and inorganic fertilizers.

Table. 6 Effect of organic and inorganic fertilizer on growth and yield of garlic

Code	Treatments	Fresh shoot wt/plant (g)	Individual Wt of Bulb (g)	Fresh Root wt/plant (g)	Dry Shoot wt/plant (g)	Dry Root wt/plant (g)	Length of Bulb cm	Diameter of Bulb cm	No. of cloves/Bulb	Yield (kg/plot)
T ₀	Control	3.486 d	8.97 d	0.49 e	1.16 g	0.147 d	2.9.6c	2.69 c	12.63 d	0.70c
T ₁	Vermicompost (VC)	10.17 a	13.89 b	1.27 b	3.40 b	0.3937 b	3.51b	3.20 ab	18.70 ab	1.54ab
T ₂	Trichoderma compost (TDC)	5.67 c	13.43 b	0.75 cde	2.24 e	0.28 c	3.69ab	3.25 ab	16.13 c	1.37abc
T ₃	Cowdung (CD)	8.45 b	12.18 bc	1.25 b	3.15 bc	0.42 b	3.52b	3.12 abc	17.07 bc	1.14abc
T ₄	Farmyard manure (FYM)	7.11b	11.29 bcd	0.87 cd	2.69 d	0.28 c	3.16 bc	2.86 bc	14.90 cd	1.20abc
T ₅	Recommended fertilizer (RF)	7.65 b	12.64 bc	1.32 b	2.90 cd	0.44 b	3.39 bc	3.02 abc	14.53 cd	0.98bc
T ₆	50% TDC + 50% RF	8.48 b	13.75 b	0.98 c	3.19 bc	0.29 c	3.59 b	3.25 ab	15.27 c	1.55ab
T ₇	50% VC + 50% RF	7.68 b	11.12 bcd	0.86 cd	2.83 d	0.27 c	3.19 bc	3.04 abc	15.87 c	0.82bc
T ₈	50% CD + 50% RF	4.47 cd	9.75 cd	0.67 de	1.63 f	0.21 cd	3.16 bc	3.12 abc	15.40 c	0.96bc
T ₉	50% FYM + 50% RF	10.96 a	16.90 a	1.61 a	3.86 a	0.59 a	4.13 a	3.49 a	20.23 a	1.87a
CV (%)		8.57	9.61	11.22	4.52	6.61	6.18	6.12	6.60	24.59
Significance		**	**	**	**	**	**	**	**	*

Here, T₀ = Control (Without manures and fertilizers), T₁ = Vermicompost (VC), T₂ = Trichoderma compost (TDC), T₃ = Cowdung (CD), T₄ = Farmyard manure (FYM), T₅ = RF dose of NPK, T₆ = 50% Trichoderma + 50% Recommended fertilizer, T₇ = 50% Vermicompost + 50% Recommended fertilizer, T₈ = 50% Cowdung + 50% Recommended fertilizer, T₉ = 50% Farmyard manure + 50% Recommended fertilizer.

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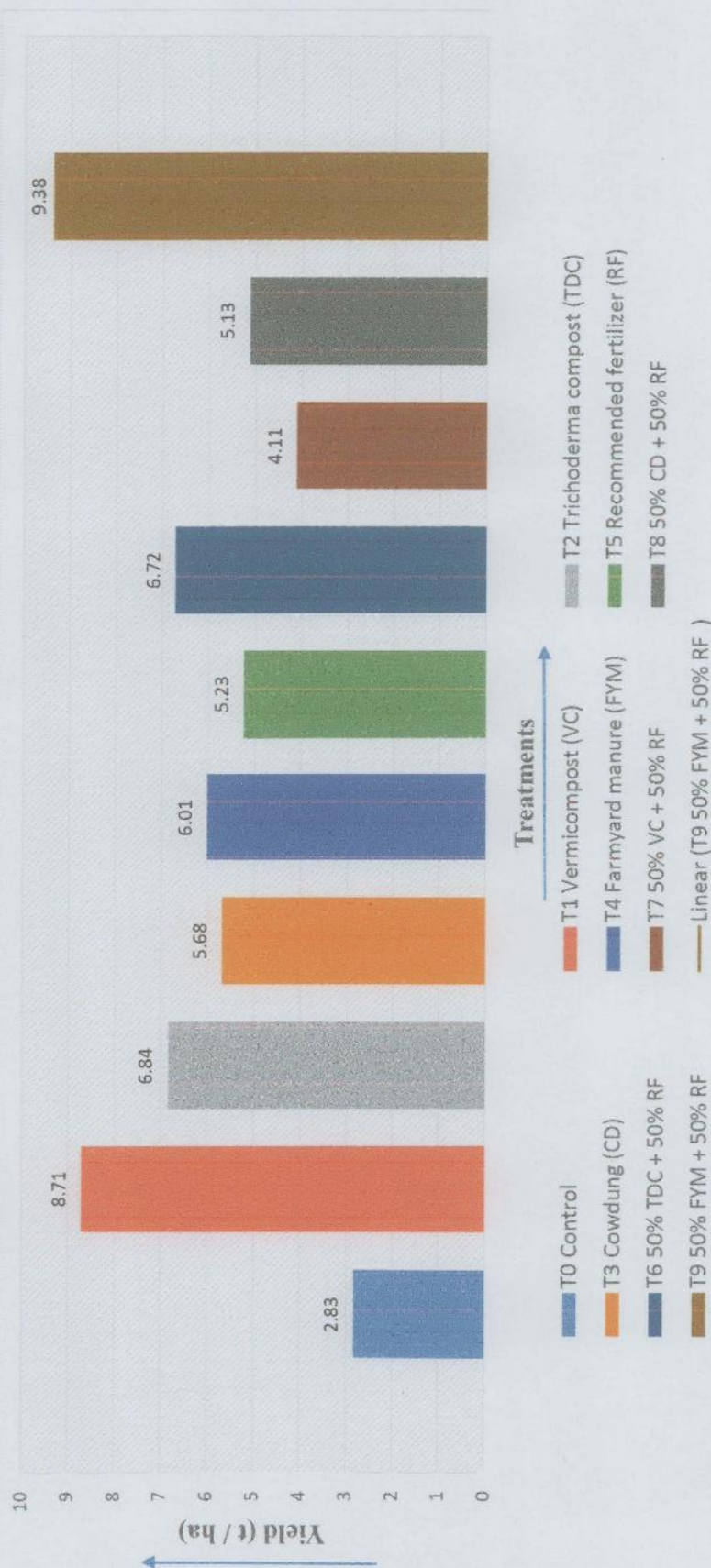


Fig. 1 Effect of organic and inorganic fertilizer on yield of garlic (t/ha)

4.2 Economic analysis

Cost and return analysis in details was done according to the procedure of Alam *et al.*, (1989). The details of economic analysis have been shown in (Table 7 and Appendix IV). Material, non-material and overhead costs including harvesting of bulbs were recorded for all treatments on unit plot basis and converted to per hectare. The total cost of production ranged between Tk. 392,415 to 135100 among the treatments (Appendix IV). The variation was due to cost of variable organic and inorganic fertilizers. It was found that the highest cost of production (Tk. 392415) was observed in Trichoderma compost (T₂). While it was the lowest of Tk. 135,100 in the treatment of recommended dose of fertilizer (T₅). The gross return from different treatments ranged between Tk. 844,200 to 254,700 per hectare. Gross returns were the total income through sale of garlic (bulbs) @ Tk. 90,000 per ton. It was found from the economic analysis that the combination of 50% FYM + 50% RF (T₉) gave the highest net return of Tk. 703,788 followed by Vermicompost (Tk. 504,865), while the lowest was in control (Tk. 116,365). Considering the benefit cost ratio (BCR) the treatment of 50% FYM + 50% RF (T₉) showed higher BCR (6.01) value than the other treatments. The lowest BCR (1.84) value was found in control. There was a wide gap between the lowest and the highest BCR. However, the cost and return analysis was based on the crop yield as well as factors such as cost of inputs and market price of harvested material, which may vary from year to year. Therefore, the cost and return analysis from a crop grown in a particular year may not represent exactly, the same with crop grown in another year. The experiment revealed that 50% FYM + 50% RF (T₉) treatment was found to be conducive to higher economic return from garlic under the soil and climatic conditions of Batiaghata, Khulna.

Table. 7 Cost and return analysis of garlic production due to different organic and inorganic fertilizers treatments under study

Treatments	Marketable yield (t/ha)	Total cost of production (Tk/kg)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio (BCR)
T ₀	2.83	138335	254700	116,365	1.84
T ₁	8.71	279035	783,900	504,865	2.80
T ₂	6.84	392415	615,600	223,185	1.57
T ₃	5.68	181366	511,200	329,834	2.82
T ₄	6.01	181366	540,900	359,534	2.98
T ₅	5.24	135100	471,600	336,500	3.49
T ₆	6.72	245937	604,800	358,863	2.46
T ₇	4.11	187312	369,900	182,588	1.97
T ₈	5.13	140412	461,700	321,288	3.29
T ₉	9.38	140412	844,200	703,788	6.01

Sale of marketable garlic @ Tk. 90,000 Tk/t, Net return = Gross return - Total cost of production, Benefit cost ratio (BCR) = Gross return ÷ Total Cost of production

T₀ - Control (Without organic and inorganic fertilizer)

T₁ = Vermicompost @ 10 t ha⁻¹

T₂ = Trichoderma compost @ 10 t ha⁻¹

T₃ = Cowdung @ 20 t ha⁻¹

T₄ = Farmyard Manure @ 20 t ha⁻¹

T₅ = Recommended doses of NPK (Urea @ 217 kg ha⁻¹, TSP @ 267 kg ha⁻¹, MoP @ 333 kg ha⁻¹, Zipsum @ 110 kg ha⁻¹, Cowdung @ 20 ha⁻¹)

T₆ = 50 % Trichoderma compost + 50 % Recommended doses of fertilizer

T₇ = 50 % Vermicompost + 50 % Recommended doses of fertilizer

T₈ = 50 % Cowdung + 50 % Recommended doses of fertilizer, T₉ = 50 % Farmyard manure + 50 % Recommended doses of fertilizer

Chapter V

SUMMARY AND CONCLUSION

An experiment was conducted at the Professor Dr. Purnendu Gain Field laboratory, Agrotechnology Discipline, Khulna University, Khulna during the period from November, 2013 to April, 2014 to evaluate the performance of organic and inorganic fertilizers on the growth and yield of garlic. The experiment consisted of ten different types of organic and inorganic fertilizers treatments viz. Control, Vermicompost (VC), Trichoderma compost (TDC), Cowdung (CD), Farmyard manure (FYM), Recommended fertilizer dose of NPK, 50% Trichoderma + 50 % Recommended fertilizer, 50 % Vermicompost + 50 % Recommended fertilizer, 50 % Cowdung + 50 % Recommended fertilizer, 50 % Farmyard manure + 50 % Recommended fertilizer.

The experiment was laid out in randomized complete block design (RCBD) with three replications. The size of each unit plot was 2.0 m x 1.0 m and 180 plants were accommodated in each plot following a spacing of 10 cm x 10 cm. The space between the blocks and plots were 50 cm and 30 cm, respectively. The cloves were planted on 08 December, 2013. The plants were harvested on 14 April, 2014 when they reached maturity showing the sign of drying out of the leaves. From each unit plot 10 plants were randomly selected and tagged to record data on growth, yield contributing characters and yield.

From the result of the present experiment it was found that almost all the parameters studied were significantly influenced by different types of organic and inorganic fertilizers. Almost all the characters attained highest values when 50 % FYM + 50 % RF were applied. The control treatment gave the lowest values in all the characters. Almost all the parameters studied were significantly influenced by different types of organic and inorganic fertilizers.

The maximum plant height was obtained from the treatment of 50 % FYM + 50 % RF (65.58 cm) followed by Vermicompost (59.87 cm), while the minimum plant height was recorded from the control (43.64 cm). The result of the experiment revealed that the number of leaves per plant varied significantly by fertilizers except 20 DAP. Maximum number of leaves per plant was observed from 50 % FYM + 50 % RF (8.33) followed by Vermicompost (8.13) while the minimum (6.7) was recorded from the control.

Fresh shoot weights of plant, individual of bulbs weight and roots weight were found to be significantly influenced by different types of organic and inorganic fertilizers. The highest fresh weight of shoot (10.96 g), bulbs (16.90 g) and roots (1.61g) were recorded in 50 % FYM + 50 % RF followed by Vermicompost. Significant variation was observed on dry shoot weights of plants, individual weight of bulbs and roots. The maximum dry shoot weights of plants were observed in 50 % FYM + 50 % RF (3.86 g) and dry weights of individual bulb (16.90 g) and roots (0.52 g) were observed with the treatment of 50 % FYM + 50 % RF. The minimum dry bulb weight was obtained the treatment of control (8.96 g).

The maximum weight of individual bulbs was obtained from the treatment of 50 % FYM + 50 % RF (16.90 g) followed by Vermicompost (13.89 g) and the minimum was with the control (8.97 g).

Cloves per bulb varied significantly with different organic and inorganic fertilizer treatments. The highest number of cloves per bulb was obtained from 50% FYM + 50% RF treatment and the second highest was found in Vermicompost. The lowest number of cloves per bulb was recorded from control (12.63).

Significant variation was found in length of bulb. Length of bulb was found to be the highest (4.139 cm) with the 50 % FYM + 50% RF. The second highest (3.51cm) length of bulb was

found in Vermicompost. The lowest bulb diameter was found from the plants raised with the control (2.96 cm).

Significant variation was found in bulb diameter. Bulb diameter was found to be the highest (3.49cm) in 50 % FYM + 50 % RF. The second highest (3.20 cm) bulb diameter was found in Vermicompost. The lowest bulb diameter was found from the plants in with the control (2.69 cm).

The bulb yields per plot as well as per hectare showed significant variations by different types of organic and inorganic fertilizer treatments. The highest yield of bulb (9.38 t/ha) was found from the plot receiving 50 % FYM + 50 % RF followed by (8.71 t/ha) Vermicompost and the lowest yield (2.83 t/ha) was come from the control. The results obtained from the investigation showed that the maximum yield was obtained from 50 % FYM + 50 % RF.

But economic analysis showed that the treatment of 50% FYM + 50% RF (T₉) was profitable over all other treatment combinations giving the highest net return (Tk. 703,788) and BCR (6.01) value followed by Vermicompost (Tk. 504,865) and BCR (2.80), respectively. So, the use of 50% FYM + 50% RF or Vermicompost may be recommended for profitable garlic production.

The present study revealed that 50 % Farmyard manure + 50 % recommended dose of fertilizer increased growth and yield of garlic. Based on the findings of the experiment, it may be concluded that for profitable production of garlic and maintenance of soil health 50 % farmyard manure + 50 % recommended dose of fertilizer (T₉) may be used.

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APPENDICES

Appendix I. Monthly record of temperature, relative humidity, rainfall and sunshine during the period from October, 2013 to April, 2014

Year	Months	Air temperature (°C)		Monthly relative humidity (%)	Monthly total rainfall (mm)	Monthly average sunshine (hrs)
		Monthly average maximum	Monthly average minimum			
2013	October	31.6	24.4	85	260	4.425
	November	30.4	18.2	76	000	8.25
	December	27.0	15.0	79	000	5.975
2014	January	24.0	12.6	82	000	5.225
	February	27.7	15.2	75	24	7.35
	March	32.9	20.1	69	5	8.375
	April	37.7	25.1	65	000	8.758

Source: Md. Amirul Azad, Officer in charge, Assitant Metrologist, Regional Inspection Center, Bangladesh Metrological Department, Gollamari, Khulna, Bangladesh.

Appendix II: Chemical analysis of soil sample

Parameters	Soil pH		EC (ds/m)		Organic matter (%)		Potassium (mg/ 100 g soil)		Total Nitrogen (%)		Phosphorus (μ g/ g soil)		Sulphur (μ g/ g soil)		Zinc (μ g/ g soil)	
	After applic ation	After harvest	After applic ation	After harvest	After applicati on	After harvest	After applicati on	After harvest	After applicati on	After harvest	After applicati on	After harvest	After applicati on	After harvest	After applicati on	After harvest
T ₀	7.5	5.4	2.0	8.2	6.00	5.34	0.70	0.43	0.359	0.309	15.44	11.20	319.18	61.90	1.25	1.24
T ₁	6.4	5.7	4.8	7.7	6.83	3.65	0.63	0.61	0.396	0.211	49.24	25.05	281.53	260.30	2.04	1.37
T ₂	6.5	5.9	4.6	8.4	6.42	5.37	0.64	0.63	0.372	0.311	114.80	40.89	246.80	226.10	2.47	1.84
T ₃	5.8	5.6	6.0	8.7	6.27	3.37	0.64	0.64	0.363	0.195	25.41	20.83	305.00	302.20	1.94	1.57
T ₄	6.1	5.6	5.7	9.4	5.82	3.18	0.75	0.70	0.337	0.185	40.16	20.08	312.41	304.50	2.22	2.08
T ₅	5.7	5.3	6.0	7.7	6.80	6.57	1.02	0.88	0.395	0.381	70.07	34.32	508.40	353.70	1.41	1.30
T ₆	5.7	5.7	5.8	10.0	8.81	6.58	0.83	0.79	0.511	0.382	97.78	52.07	318.80	231.25	2.20	1.63
T ₇	5.1	4.8	6.8	9.5	7.63	7.20	0.88	0.81	0.442	0.418	71.83	48.91	319.22	295.90	2.18	1.42
T ₈	5.2	4.7	6.1	9.0	8.40	7.93	0.91	0.88	0.487	0.459	71.40	65.89	332.30	281.30	2.83	1.99
T ₉	5.5	5.4	5.8	9.0	7.24	6.61	0.88	0.85	0.419	0.383	45.28	35.44	288.41	281.32	2.36	2.00
Range (Min. to Max.)	5.1- 7.5	4.7-5.9	2.0- 6.8	7.7-10	5.82- 8.81	3.18- 7.93	0.63- 1.02	0.43-0.88	0.337- 0.511	0.185- 0.459	15.44- 114.8	11.2- 65.89	246.8- 508.4	61.9- 353.7	1.25- 2.83	1.24- 2.08
Average	5.95	5.41	5.36	8.76	7.022	5.58	0.788	0.722	0.4081	0.323	60.141	35.468	323.205	259.847	2.09	1.644
SD	5.47	4.95	4.99	8.03	6.47	5.22	0.73	0.67	0.38	0.30	57.50	33.77	300.15	243.40	1.94	1.52
CV (%)	13.01	7.87	26.79	9.55	15.45	32.3	18.6	21.82	15.14	32.32	54.1	49.94	23.2	32.39	24.23	20.61

Here, T₀ = Control (Without manures and fertilizers), T₁ = Vermicompost (VC), T₂ = Trichoderma compost (TDC), T₃ = Cowdung (CD), T₄ = Farmyard manure (FYM), T₅ = Recommended fertilizer dose, T₆ = 50% Trichoderma + 50% Recommended fertilizer, T₇ = 50% Vermicompost + 50% Recommended fertilizer, T₈ = 50% Cowdung + 50% Recommended fertilizer, T₉ = 50% Farmyard manure + 50% Recommended fertilizer.

Appendix-III. Analysis of variance of data on growth parameters and yield of garlic as influenced by different combination of organic and inorganic fertilizers

Source of variance	Degree of freedom	Mean sum square																	
		Plant height (cm) at									Number of leaves at								
		20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP	90 DAP	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP	90 DAP		
Replication	2	4.46	0.97	2.34	0.15	11.04	10.65	42.88	52.02	0.29	0.17	0.02	0.03	0.24	0.02	0.16	0.03		
Treatment	9	5.03 ^{ns}	22.80 ^{**}	16.66	28.92 [*]	44.34 ^{**}	58.39 ^{**}	80.73 ^{**}	111.78 ^{**}	0.11 ^{ns}	0.24 [*]	0.15 [*]	0.12 ^{**}	0.21 ^{**}	0.51 ^{**}	0.69 ^{**}	0.55 ^{**}		
Error	18	2.50	4.84	4.84	9.28	11.89	10.46	16.77	27.94	0.08	0.07	0.05	0.08	0.04	0.05	0.08	0.04		

Here, ** Significant at 1% level of probability

* Significant at 5% level of probability

NS = non-significant.

Appendix-III. Continued

Source of variance	Degree of freedom	Mean sum square																	
		Length of leaves (cm) at									Breath of leaves (mm) at								
		20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP	90 DAP	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP	90 DAP		
Replication	2	0.76	5.15	3.18	7.13	15.98	23.28	16.12	15.04	133	0.90	1.72	2.60	1.84	1.06	0.26	0.01		
Treatment	9	2.09 [*]	2.59 [*]	5.77 [*]	12.55 [*]	19.33 [*]	27.94 [*]	37.10 ^{**}	47.36 ^{**}	0.27 [*]	0.45 ^{**}	0.62 [*]	1.15 [*]	1.36 [*]	1.80 ^{**}	2.32 ^{**}	2.66 ^{**}		
Error	18	1.56	1.82	5.09	9.42	9.63	11.15	10.21	8.77	0.09	0.12	0.18	0.32	0.44	0.30	0.30	0.21		

Here, ** Significant at 1% level of probability

* Significant at 5% level of probability



Appendix-III. Continued

Source of variance	Degree of freedom	Mean sum square							
		Fresh shoot wt (g)	Individual wt of bulb (g)	Fresh root wt (g)	Dry shoot wt (g)	Dry root wt (g)	Length of bulb (cm)	Diameter of bulb (cm)	No. of cloves per bulb
Replication	2	25.96	15.93	7.85	4.69	5.00	0.03	0.06	0.02
Treatment	9	34.08**	15.27**	15.71**	13.98**	16.56**	2.02**	0.36**	0.04**
Error	18	4.50	3.63	1.42	1.12	0.40	0.02	0.02	0.05

Here, ** Significant at 1% level of probability

* Significant at 5% level of probability

Appendix-III. Continued

Source of variance	Degree of freedom	Mean sum square	
		Yield per plot	Yield ton per ha
Replication	2	0.28	6.93
Treatment	9	0.41**	10.13**
Error	18	0.09	2.23

Here, ** Significant at 1% level of probability

* Significant at 5% level of probability

Appendix-III. Continued

Source of variance	Degree of freedom	Mean sum square					
		Sprout at					
		5 DAP	8 DAP	11 DAP	14 DAP	17 DAP	20 DAP
Replication	2	3854.43	1155.03	16.23	13.73	2.13	2.50
Treatment	9	1308.82*	737.19*	104.03*	11.74*	2.15*	2.70*
Error	18	853.29	234.59	49.23	7.33	1.84	1.83

Here, ** Significant at 1% level of probability

* Significant at 5% level of probability

Appendix IV: Cost and return analysis of garlic production due to different organic and inorganic fertilizers treatments under study

Treatments	Marketable yield (t/ha)	Total cost of production (Tk/kg)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio (BCR)
T ₀	2.83	138335	254700	1,16,365	1.84
T ₁	8.71	279035	7,83,900	5,04,865	2.80
T ₂	6.84	392415	6,15,600	223,185	1.57
T ₃	5.68	181366	5,11,200	329,834	2.82
T ₄	6.01	181366	5,40,900	359,534	2.98
T ₅	5.24	135100	4,71,600	336,500	3.49
T ₆	6.72	245937	6,04,800	358,863	2.46
T ₇	4.11	187312	3,69,900	182,588	1.97
T ₈	5.13	140412	4,61,700	321,288	3.29
T ₉	9.38	140412	8,44,200	703,788	6.01

Sale of marketable garlic @ Tk. 90,000 Tk/t

Net return = Gross return - Total cost of production

Benefit cost ratio (BCR) = Gross return ÷ Total Cost of production

T₀ = Control (Without organic and inorganic fertilizer)T₁ = Vermicompost @ 10 t ha⁻¹T₂ = Trichoderma compost @ 10 t ha⁻¹T₃ = Cowdung @ 20 t ha⁻¹T₄ = Farmyard Manure @ 20 t ha⁻¹T₅ = Recommended doses of NPK (Urea @ 217 kg ha⁻¹, TSP @ 267 kg ha⁻¹, MoP @ 333 kg ha⁻¹, Zipsum @ 110 kg ha⁻¹, Cowdung @ 20 ha⁻¹)T₆ = 50 % Trichoderma compost + 50 % Recommended doses of fertilizerT₇ = 50 % Vermicompost + 50 % Recommended doses of fertilizerT₈ = 50 % Cowdung + 50 % Recommended doses of fertilizer, T₉ = 50 % Farmyard manure + 50 % Recommended doses of fertilizer