EFFECT OF MANURES AND MULCHES ON THE GROWTH AND YIELD OF ONION

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CERTIFICATE

This is to certify that the thesis entitled, ***"Effect of Manures And Mulching on the Growth And Yield of Onion"*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in HORTICULTURE,*** *embodies the result of a piece of bona fide research work carried out by* ***Mousumi Akter,*** *Registration No.* ***11-04346*** *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 and style of this thesis have been approved and recommended for submission.

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ABSTRACT

An experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2016 to March 2017. The experiment consisted of two factors: Factor A: manure viz. factor A: T_0 = Control (no manure), T_1= Cowdung (9 t/ha), T_2= Cowdung + Poultry manure (5 t/ha+3 t/ha), T_3= Cowdung + Poultry manure + Vermicompost (3 t/ha+2 t/ha+2 t/ha) and factor B: mulch material viz. M_0 = No mulch, M_1 = Black polythene mulch, M_2 = Water hyacinth mulch. The two factor experiment was laid out in a Randomized Complete Blocked Design with three replications. Among the manure treatment, T_3 treatment performed best in case of vegetative characteristics (plant height, number of leaf, leaf length, neck diameter, root length) and also in reproductive characteristics like bulb diameter (4.14 cm), single bulb weight (40.33 g) and yield per hectare (10.08 t) and minimum in T_0 treatment (control). In case of mulching, vegetative characteristics like plant height, leaf length was found best in M_2 treatment and other vegetative and reproductive characteristics like bulb diameter (3.98 cm), single bulb weight (37.56 g) and yield per hectare (9.39 t) performed best in M_1 treatment while the minimum in M_0 treatment. In combined effect, the highest yield (10.67 t/ha) was obtained from T_3M_1 treatment combination with highest benefit cost ratio (2.31) and lowest yield (7.75 t/ha) in T_0M_0 treatment combination. So, mixture of cowdung, poultry manure and vermicompost with black polythene mulch combinedly performed best for the growth and yield of onion.

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ABBREVIATIONS AND ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
@	at the rate of
Adv.	Advanced
Agric.	Agricultural
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
CV	Coefficient of Variation
cv.	Cultivar
df	Degrees of Freedom
LSD	Least Significant Difference
DAT	Days After Transplanting
et al.	and others
etc.	etcetera
MOP	Muriate of Potash
ns	Non Significant
Res.	Research
RH	Relative humidity
Sci.	Science ’s

CHAPTER I

INTRODUCTION

Onion (*Allium cepa* L.) belongs to the family Alliaceae, is an important spice crop of Bangladesh. Central Asia is the primary center of its origin and the Mediterranean is the secondary center for large type of onion (McCullum, 1976). The top most producer of onion in world is China, India, USA, Japan and Spain (FAO,1993). Among the spices grown in Bangladesh, onion ranks first in respect of production and also in area.

As spice, onion bulb is used which is composed of carbohydrates (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g) and several vitamins like vitamin A (0.012 mg), vitamin C (11 mg), thiamine (0.08 mg), riboflavin (0.01 mg) and niacin (0.2 mg) and also some minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg) and potassium (157 mg) (Suresh, 2007).

Among the spices grown in Bangladesh, onion ranks first in respect of production and second in respect of acreage (BBS, 2016). It is groom in almost all the districts of Bangladesh, but it is commercially cultivated in the greater districts of Faridpur, Rajshahi, Dhaka, Mymensingh, Comilla, Jessore, Rangpur and Pabna (Anonymous, 1998). Onion production in Bangladesh during the year of 2013-2014 was 13,87,000 metric tons from 3,73,000 acre of land with an average yield of 3,718 kg/acre which is much lower than the other onion producing countries in the world (BBS,2016). As a result Bangladesh has to import onion from other countries to meet that demand. Improper cultural management practices, lack of enough soil moisture and lack of improved varieties are attributed to this lower yield.

To enhance onion production, improved and modern agronomic practices should be applied properly (Islam *et al*., 2007). In our country, the soils of most regions have less than 1.5% organic matter, some soils even have less than 1% organic matter (BARC, 2005). Organic manure contains natural elements that can support crop production and enhance the chemical and physical properties of soil. The use of chemical fertilizer in crop production is causing health hazards and creating problems to environment including the pollution of air, water and soil. When chemical fertilizers uses continuously then affects badly the soil texture and structure thus decreasing the soil organic matter and hampering the soil microbial activity due to toxicity. Organic matter inprove soil structure as well as increase its water holding capacity and supports soil microbial activity, which available nutrients through its decomposition and may serve as source of mineral nutrients (El-Koumey and Abu-Agwa,1993). Addition of organic waste into soil, resulted in increasing concentration of micronutrients in top soil because organic waste contains higher concentration of essential nutrients than most soils (Campbell *et al.*,1988). Manure like cowdung , poultry manure, vermicompost is becoming popular and they are also available locally due to establishment of livestock farming and poultry farming. Cowdung contains much higher amount of essential nutrients such as 0.5-1.5% N_2, 0.4-0.8% P and 0.5-1.9% K, poultry manure contains 1.6-4.5% N, 1%-3.0% P and 0.5%-1.3% K and vermicompost contains 1.5-2.0% N, 0.9-1.6% P and 1.5-2.4% K. Which can help growth and development of plants. Research on these aspects is so much important to find out the appropriate combination of manures.

Mulching is an effective cultural practice to ensure crop production especially in dry season. It also helps in better utilization of all the nutrients in the soil.

Mulching also stimulates microbial activity in soil through improvement of soil agro-physical properties (Goebal, l972). Conservation of soil moisture may help in preventing the loss of water through evaporation permitting maximum utilization of moisture by plants. Use of various mulches are black polythene, transparent polythene, water hyacinth, rice straw reported to conserve soil moisture efficiently (Aldefer,1996). Mulching is also reported to minimize the use of N-fertilizer and safe labor cost. Mulching increased marketable and total yield but higher yield were obtained with black polythene mulch than with white and nonwoven black polythene (Patil and Bansod, 1972). In Nigeria onions were mulched with polythene film to optimize water use during the dry season and total bulb yield of onion was 80 % higher than no mulched treatment (Adetunji, 1994).

But the study on the impact of different manure and mulching of onion has not been done adequately. Therefore, the present experiment has been done with the following objectives:

- To select the effective manure for maximum growth and yield of onion.
- To find out the effective mulching material for profitable onion production.
- To evaluate the yield and yield contributing characters of onion affected by different organic manures and mulching.

CHAPTER II

REVIEW OF LITERATURE

Some research works regarding mulching and manures were done in home and aboard. But a little work has been done on this crop with the combine effect of mulching and manure on the growth and yield of onion. However, available information portioning to this study was reviewed in the following sub headings.

2.1 Manure application

Adeyeye *et. al*. (2017) conducted an experiment at Nigeria to compare the effect of poultry manure, cow dung, organic manure, NPK (15:15:15) and Urea on the growth and yield of Onion. The results revealed that all the treatments significantly ($P<0.05$) improved the growth and yield parameters of onion. Poultry manure produced significantly higher number of leaves (50.60), shoot weight (20.96 g) and bulb weight (50.60 g). Bulb height was significantly higher in poultry, organic manure and NPK applications. The onion bulb yield is in order of poultry > organic manure > cow dung > NPK > Urea > control. It is concluded that poultry manure application is better for the production of onion.

An experiment was carried out by Mia *et al.* (2007) to investigate the effect of poultry manure along with inorganic N-fertilizer on the nutrient uptake, growth and yield of onion. The onion (*Allium cepa* L.) cv. "Taherpuri" was grown under six treatments viz. recommended dose of inorganic N (115 kg ha^{-1}, 100% N), 75% of inorganic N + 5 t ha^{-1} poultry manure, 50% inorganic N + 10 t ha^{-1} poultry manure, 25% inorganic N + 15 t ha^{-1} poultry manure, 15 t ha^{-1} poultry manure and absolute control (without poultry manure and inorganic N). Plant height, total dry matter, single bulb weight, yield and nutrients uptake at different growth stages of onion varied significantly due to application of poultry manure and inorganic N fertilizer. Among the treatments, the highest yield (10.1t ha^{-1}) and yield attributes of onion were recorded under the application of 50% inorganic N with 10 t ha^{-1} of poultry manure, which was 14% higher compared to 100% inorganic-N fertilizer. The higher nutrient uptake viz. N, P and K was noted in plot where poultry manure was applied at 10 t ha^{-1} along with 50% inorganic-N. It is concluded that application of 10 t ha^{-1} poultry manure was enough to reduce 50% inorganic-N in onion cultivation.

A field experiment was conducted by Magdi *et al.* (2009) to evaluate yield performance of onion cv. (Giza 6) fertilized with animal or poultry manures. The results obtained showed that the yield and quality of onion were significantly influenced by fertilizer types. The highest yield of onion bulbs (7.26 and 8.82 ton/feddan for 2004/2005 and 2005/2006, respectively) was obtained by the application of chicken manure in both season compared to

animal manure and mineral fertilizers in 2004/2005 (7.04, 7.74, respectively) and in 2005/2006 (5.55, 7.17 ton/feddan, respectively). Additionally, the application of poultry manure increased dry matter, weight of individual bulb and bulb diameter of onion.

Ayed Abdelrazzag (2002) conducted an experiment on the effect of poultry and sheep manure at rates of 20, 40 and 80 t ha^{-1}, as well as inorganic fertilizers at rate of 400 kg N ha^{-1}, 200 kg P_2O_5 ha^{-1}, 100 kg K_2O ha^{-1} on yields, nutrient content, leaf area and dry weight of onion yield. The results revealed that there was no significant difference in yield of onion bulbs due to poultry manure in both years, but in general the yield increased significantly with sheep manure and inorganic fertilizer. In general the yield of onion years, but in general the yield increased significantly with sheep manure and inorganic fertilizer. In general the yield of onion bulbs was higher in the second year compared with the first year. There was a significant difference in leaf area on onion only between sheep manure at level of 20 and 40 t ha^{-1} of chicken manure only in first year.

Pimpini *et al.* (1992) witnessed that poultry manure and mineral fertilizer combinations (equivalent to 140 kg N + 140 kg P_2O_5 + 100 kg K_2O /ha and 210 kg N + 210 kg P_2O_5 + 150 kg K_2O /ha), were compared with a non-fertilized control and with the control (RDF). All the fertilizer treatments produced the larger-size onion bulbs.

Sutharnathy and Seran (2011) conducted an experiment to evaluate the growth and yield response of red onion (*Allium ascalonicum* L.) grown with sandy soil, cattle manure, coir dust and paddy husk ash. The results indicated that potting materials have significant ($p<0.0l$) effect on the growth, yield and nutrient contents of red onion grown in different potting media. Maximum number of leaves per plant, maximum bulb diameter, high number of bulbs per plant, high weight (50.15 g) of bulbs per plant and also high P (74 g) and K (1080 g) contents of 100 g bulbs harvested were recorded in sandy soil: cattle manure: paddy husk ash at ratio of 6:2: l. It was also noted that the weight of bulbs per plant increased more than two fold in sandy soil: cattle manure: paddy husk ash at ratio of 6:2: l over control (medium l). Usage of paddy husk ash as a potting material in medium preparation would improve the growth and yield performances of red onion grown in pot culture technique.

Seran *et al.* (2010) conducted an experiment to find out the suitable ratio of inorganic fertilizer and compost, which could give an economic yield of onion (cv. Jaffna Local). This experiment was designed in a Randomized Complete Block Design with four replicates. Treatments were recommended dosage of inorganic fertilizers as a control (T_l), ¾ fold of the control treatment + compost (2 t ha^{-1}) (T_2), ½ fold of the control treatment + compost (4 t ha^{-1}) (T_3), ¼ fold of the control treatment + compost (6 t ha^{-1}) (T_4) and the compost alone (8 t ha^{-1}) (T_5). Relatively higher yield (5.03 t ha^{-1}) was obtained from the plants treated with inorganic fertilizers alone (T_1), whereas compost alone (T_5) produced the lowest yield (3.43 t ha^{-1}). It was also noted that there were no significant

(P>0.05) differences in the yields between T_1 and T_2 as well as T_1 and T_3. From this study, it could be stated that half fold of the inorganic fertilizer and at the rate of 4 t ha^{-1} (T_3) could give profitable yield (4.75 t ha^{-1}) and this combination could possibly reduce the cost of production in the cultivation of onion.

Two field experiments were carried out by Shaheen *et al.* (2007) to study the effect of two organic manures, i.e. poultry and cattle at rates of 60 and 120 N units/fed. and with or without bio-fertilizer on the productivity of onion plants in both Bani Sweef and Minia Governorate, and the following are the important obtained results: Using microbein as bio-fertilizer resulted in an increase in plant growth criteria's. Moreover, caused a slow enhancement effect on total bulbs yield and its components. Also, using microbein caused an increase in N, P, K, Fe, Mn, Zn, Cu, Pb, NO3 and NH4 . Mixing poultry manure with bio-fertilizer gained the highest values of plant growth characteristics as well as total bulbs yield, marketable and culls bulbs. Also, poultry manure with microbein caused slow increase in mineral contents of onion bulb tissues. The vigour onion plant growth was associated with that plants which received microbein as bio-fertilizer and applied by cattle manure at the higher rate, i.e. 120 N unit /fed. But, the highest yield of total bulbs in both experiments were obtained with that plants applied by poultry manure at 120 N unit /fed. with microbien.

Gupta *et al.* (2009) conducted a field experiment to study the effect of organic manure and inorganic fertilizers on growth, yield and quality of kharif onion cv. Agri found 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×l.8 m. 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.

Warade *et al.* (2006) 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.

A field experiment was conducted by Alemu-Degwale (2016) to study the effect of vermicompost on growth, yield and quality of garlic (*Allium sativum* L.). The treatment consisted of three levels of vermicompost (0, 2.5 and 5 t ha^{-1}). The results revealed that increasing rate of vermicompost significantly ($P < 0.05$) affected days to emergence. The effect of vermicompost also significantly ($P < 0.05$) influenced days to maturity, leaf number, leaf area index, mean clove weight, mean bulb weight, fresh biomass yield, total bulb yield, dry matter percent and total soluble solid. The highest bulb dry matter percent (51.05) and total bulb yield (7.78 t ha^{-1}) was recorded at 5 t vermicompost ha^{-1}. Increasing level of vermicompost also significantly (P <

0.05) affected marketable and unmarketable bulb yield, and mean clove number. The highest marketable and the lowest unmarketable yield was obtained at 5 t ha^{-1}vermicompost. Marketable yield of garlic was increased by 9.96% and unmarketable bulb yield was decreased by 12.83% at an application rate of 5 t vermicompost ha^{-1}over the control. Total soluble solid was also increased from 5.13 to 5.69^{o} Brix by applying 5 t vermicompost ha^{-1} over the control. Harvest index was also significantly ($P < 0.05$) affected by the increased application of vermicompost. The maximum harvest index 68.36% was also recorded at application of 5 t vermicompost ha^{-1}. It can, thus be concluded that, application of 5 t ha^{-1}vermicompost led to the maximum growth, yield and quality of the garlic crop.

Juan *et al.* (2006) determine vermicompost effect on bulbification dynamics in terms of garlic (*Allium sativum* L.) bulb dry weight and sucrose metabolism and evaluate the impact of vermicompost on garlic bulb yield and quality. The treatments were soil (control) and soil : 1 vermicompost (by volume). The use of vermicompost as a substrate caused early bulbing (18 to 20 days) and lengthened bulb filling period. Bulb filling period corresponded to an increase in the total soluble carbohydrates and a later modification in nonstructural carbohydrate distribution patterns regarding fructan (scorodose) metabolism. The vermicompost treatment increased scorodose accumulation, which was directly related to the harvest index, resulting in greater yield and bulb quality. Bulb quality was not modified in terms of bulb pungency and soluble solids content by the use of vermicompost.

Surindra (2009) the impact of vermicomposted and composted farmyard manure (FYM) along with some combination of NPK fertilizers, on field crop of garlic (Allium stivum L.). A total of six experimental plots were prepared: T1 (recommended doze of NPK), T2 (vermicompost @ 15t/ha), T3 (20 t/ha vermicompost), T4 (15t/ha vermicompost + 50 % NPK), T5 (15t/ha farmyard manure), and T6 (farmyard manure 15t/ha + 100% recommended NPK) to test the plant production patterns, under field conditions. The maximum range of some plant parameters i.e. root length, shoot length, leaf length, fruit weight, number of cloves in garlic bulb and number of leaves per plant was in the T4 treatment plot. Also, the average bulb weight was approximately 26.4% greater in T4 than recommended NPK treatment plot (T1). The vermicomposted FYM showed a comparatively better result of plant production than composted manure. The plant growth results indicate the presence of some growth-promoting substances in worm-processed material (vermicompost). The vermicomposted FYM also contained a considerable amount of some essential plant micronutrients Cu (0.973 mg kg-1), Fe (8.68 mg kg-1), Mn (13.64 mg kg-1) and Zn (16.91 g kg-1) that might be responsible for better plant growth and productivity. This study suggests that vermicompost manures may be a potential source of plant nutrients for sustainable crop production.

Yahumri *et al.* (2015) observed that the response of growth and yield of onion lowland through organic fertilizers from industrial waste and livestock waste. Experiments using a randomized block design with a single factor, it was use of organic fertilizers of various kinds of agricultural waste that is solid (P_1),

composted of cow manure (P_2), quail manure (P_3) and control (P_0) which is repeated five times. The results showed that the organic fertilizer significantly affected the growth and yield of onion. Of a given type of organic fertilizer, cow manure compost produced the highest yield (44.63 cm) in height parameter plant age 45 days after planting, weight of wet biomass (124.03 g), gross dry weight (79.54 g) and number cloves per clump (24.27 cloves) while the net dry weight was not significantly different, but the provision of manure cow compost generates the highest net dry weight (72.08 g).

Barman *et al.* (2013) observed the combined effect of cowdung and potassium on the growth and yield of onion cv. BARI piaz-1 at Horticulture Farm, Bangladesh Agricultural University, Mymensingh. The experiment was laid out in a randomized complete block design with three replications. The two factors experiment had four levels of cowdung, viz., 0, 5, 10 and 20 tons ha^{-1} and four levels of potassium, viz. 0, 50, 150 and 250 kg K ha^{-1}. Doses of cowdung and potassium showed significant variation in respect of all the parameters studied. The combination of 10 tons cowdung and 250 kg K ha^{-1} gave the tallest plant (46.60 cm), the highest number of leaves $plant^{-1}$ (6.40), the highest length of bulb (3.27 cm), the highest diameter of bulb (4.83 cm), individual weight of bulb (51.23 g), dry matter content (12.66%) and yield of bulb ha^{-1} (12.83 tons); whereas the control treatment gave the shortest plant (38.15 cm), lowest number of leaves $plant^{-1}$ (5.68), diameter of bulb (3.41), individual weight of bulb (35.65g) and gave lowest bulb yield ha^{-1} (9.16 tons).

An investigation was done by Varu *et al.* (2007) with organic and inorganic fertilizers to observe the effects on the increasing growth and yield of onion. Onion was given the following fertilizers treatments: NPK (100 kg N. 50 kg P_2O_5, 50 kg K_2O/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 (22.70 t /ha) was obtained from the FYM + NPK + Dharatidhara treatment. These treatments also gave the highest bulb diameter, weight and volume.

An experiment was conducted by Yoldas *et al.* (2011) to find the influence of both organic and mineral fertilizer on the quality and yield of onion (*Allium cepa* L.) and also on the macro and micro element contents of onion bulb. Cattle manure was applied at 0, 20, 40 and 60 t/ha. Nitrogen : phosphorus: potassium was applied at the recommended dose of 120:100:150 with half of the recommended rate of NPK. In the first year, bulb width and number of storage leaf was influenced significantly.

Nasreen *et al.* (2009) were investigated on the response of garlic (var. BARI Garlic-2) to zinc, boron, and poultry manure application along with a blanket dose of 150 kg N, 50 kg P, 100 kg K, and 40 kg S/ha was evaluated through field trials in the Grey Terrace Soil under AEZ 25. Application of zinc, boron, and poultry manure had significantly increased plant height, number of leaves/plant, cloves/bulb, diameter, and weight of bulb and yield/ha in both years. The highest bulb yields of 6.10 t/ha in 2005-2006 and 6.23 t/ha in 2006-

2007 were obtained from the Zn_5B_1 kg/ha plus 5 t/ha poultry manure treatment and it was significantly higher than all other treatments. Next to it, the treatment Zn_5B_1 kg/ha plus 2.5 t/ha poultry manure gave the highest bulb yield (5.99 t/ha in 2005-2006 and 6.00 t/ha in 2006-2007).

2.2 **Mulch application**

Rahman *et al.* (2013) conducted an experiment to evaluate the influence of mulching (M) on the growth and yield of onion (*Allium cepa* L.) cv. Taherpuri. Treatments of the experiment were three types of mulching such as no mulch or control (M_0), rice straw (M_s) and water hyacinth (M_w). The results indicated that growth parameters such as plant height and number of leaves at different days after transplanting, dry weight of leaf, pseudostem and root were increased significantly with the application of mulching (M). Mulching of soil with straw (M_s) and water hyacinth (M_w) increased the length and diameter of bulb, fresh weight and dry weight of bulb and bulb yield. Interestingly, the bulb yield did not show significant differences between M_s and M_w. But mulching with water hyacinth numerically gave the highest yield (10.46 t /ha) than the mulching with rice straw (9.78 t /ha). Therefore, the use of water hyacinth as mulching material may be applied to grow onion.

Islam *et al.* (2010) observed that the effect of mulch (non-mulch and straw mulch) and different levels of nitrogen (0, 40, 80 and 120 kg ha^{-1}) and potassium (0, 37.5, 75 and 112.5 kg ha^{-1}) on the growth and yield of onion.

Plants grown with straw mulch gave higher bulb yield (10.89 t ha-1) which showed 13.79% increase over non-mulch. Nitrogen and mulch together produced significant variations. The Nitrogen at the highest level (120 kg ha^{-1}) along with straw mulch gave the highest yield (13.31 t ha^{-1}). Potassium together with mulch also exhibited significant variation on yield and yield components. Plants grown with the highest level of potassium (112.5 kg ha^{-1}) along with straw mulch gave the highest bulb yield (11.58 t ha^{-1}). Nitrogen and potassium as 120 kg N ha^{-1} × 75.0 kg K ha^{-1} gave the highest bulb yield (13.07 t ha^{-1}). Nitrogen and potassium at their maximum levels with straw mulch gave the highest bulb yield (14.67 t ha^{-1}).

Woldetsadik *et al.* (2003) condected an experiment with shallot (*Allium cepa* var. *ascalanicum* Baker) on heavy clay soil to evaluate growth and yield response to mulching and nitrogen fertilization under the sub humid tropical climate of eastern Ethiopia. The treatments included wheat straw, clear and black plastic mulches, and an unmulched control, each with nitrogen rates of 0, 75, or 150 kg-ha^{-1}. Straw and black plastic mulches increased soil moisture while clear plastic reduced it considerably. Weed control was best with black and clear plastics in the short season and with black plastic or straw mulch in the main season. Both plastic mulches elevated soil temperature, especially clear plastic, which also caused most leaf tip burn. Yield increased nearly three-fold with the black plastic mulch in the short season and by one fourth in the main season compared to the bare ground. The straw and clear plastic mulches increased yield during the short season, but slightly reduced yield in

the main season. The growth and yield of shallot were related to the weed control and soil moisture conservation efficiency of the mulches. Mulching did not alter the dry matter and the total soluble solids contents of the bulbs. Nitrogen fertilizer increased leaf numbers, plant height, mean bulb weight, bulb dry matter, and total soluble solids while reducing marketable bulb number, but did not significantly affect yield, leaf tip burn, or weed abundance.

Anisuzzaman *et al.* (2009) observed the effects of planting time and mulches on bulb growth and seed production of onion (*Allium cepa* L.) cv. Taherpuri. Planting time and mulches had significant influence on almost all parameters studied. Onion planted on 21 November had better agronomic traits contributing towards yield formation. Growth and seed production was accelerated by black polythene. Seed yield (460.81 kgha $^{-1}$) was highest in the plots planted on 21 Nov. Seed yield was 529.06 kgha $^{-1}$ where black polythene mulch was used.

Singh *et al.* (2017) observed the influence of different mulching on the growth and yield of onion. Treatments of the experiment were seven types of mulching such as control (Mo), Rice straw (M1), Water hyacinth (M2), Baggage straw (M3), Wheat straw (M4), Grass straw (M5) and Pipal leaf straw (M6). The results revealed that growth parameters viz. plant height, no. of leaves, bulb length, bulb diameter, bulb weight and bulb yield were increased significantly with adopting mulching. The maximum plant height, no. of leaves, bulb length, bulb diameter, bulb weight and bulb yield were recorded under Pipal leaf straw. Interestingly, the plant height, no. of leaves, bulb length, bulb diameter, bulb

weight and bulb yield did not show significantly differences between M6 and M3. So, mulching with Pipal leaf straw and water hyacinth numerically gave the highest yield 38.00 t/ha, 38.40 t/ha and 37.50 t/ha., 37.60 t/ha during both year of experimentation, respectively.

Vavrina and Roka (2000) observed in 4 years of research comparing production of short-day onions (*Allium cepa* L.) on plastic mulch versus bare ground in southern Florida, greater marketable yields were obtained when onions were grown on plastic mulch. Results showed that in a semitropical environment, white-on-black plastic mulch provided the greatest yield enhancement from increased weight and bulb size. Yield loss due to splitting, while apparent, was not sufficient to reduce the impact of mulch on the increase in individual bulb weight.

Haque *et al.* (2003) observed the effect of natural and synthetic mulches on yield of local and exotic cultivars. The results revealed that significant variation exist among the different mulches in respect of morphological characters, yield contributing characters and yield of garlic. Water hyacinth mulch produced the tallest plant with higher number of leaves and roots per plant, higher fresh and dry weight of bulb, length of bulb and highest yield per hectare. Bulb diameter and number of cloves per bulb were higher in black polythene mulch. The exotic cultivar performed better than the local cultivar in respect of plant height, number of leaves and roots per plant, fresh and dry weight of bulb and yield per hectare.

Ahmmed *et al.* (2017) evaluate the influence of organic amendment and mulch on the growth and yield of onion (*Allium cepa*) cv. Taherpuri. The experiment was laid out in randomized complete block design (RCBD) with four replications. Treatments were no organic amendment and no mulch or control (T_0), mulch (T_1), organic amendment (T_2) and organic amendment + mulch (T_3). Results indicated that leaves per plant, plant height, diameter of bulb, single bulb weight and bulb yield were increased significantly with the application of organic amendment and mulch. Yield contributing characters and yield was found in ascending order ($T_0<T_1<T_2<T_3$). The value of nitrogen, potassium and boron were increased without changing status where organic matter, phosphorous, sulpher and zinc amount reserved sharply.

Schonbeck (2015) stated that mulches contribute to weed management in organic crops by reducing weed seed germination, blocking weed growth, and favoring the crop by conserving soil moisture and sometimes by moderating soil temperature. Opaque synthetic mulches like black plastic provide an effective barrier to most weeds and are amenable to mechanized application, but they must be removed at the end of the season. Organic mulches like straw suppress annual weed seedlings, conserve moisture, and add organic matter as they break down, but they are more labor-intensive to apply.

An experiment was done by Hamma (2013) at the Teaching and Research Farm of the Institute for Agricultural Research, Ahmadu Bello University, Zaria. The experiment was laid out in a split plot design and was replicated three times; keeping planting dates of 15th October, 30th October, 14th November and 29th

November in the main plot and mulching types; white polythene, black polythene, water hyacinth and control in sub-plots. NPK 20-10-10 fertilizer at rates of 150, 100 and 50 kg ha^{-1} were applied to grow the crop in three splits. The first dose was applied a week before transplanting during land preparation, while the second and third doses were applied four and seven weeks after transplanting, respectively. It was observed that planting date of 15th October and white polythene mulch significantly produced higher treatment means than the rest of the treatments. On the other hand, planting date of 29th November and the control treatment under mulching types significantly produced lower treatment means among treatments throughout the period of observations.

Azed *et al.* (2015) stated the effects of mulching and some micronutrients (boron/B and zinc/Zn) on the growth and yield of onion. The trial with one onion cultivar (Taherpuri) involved two separate experiments using different micronutrient levels (3 levels of B: 0, 0.20, 0.40 $g \cdot m^{-2}$ and 4 levels of Zn: 0, 0.50, 0.80, 1.25 $g \cdot m^{-2}$) with plastic mulch without irrigation, and without mulch with irrigation. Results demonstrated that most of the yield and yield contributing parameters were significantly influenced by applying plastic mulch, and different doses of B and Zn. The plant height (35.55 cm) at 60 DAP (days after planting), number of leaves (5.53), fresh weight of leaves (12.13 g), dry weight of leaves (1.41 g), fresh weight of bulb (27.78 g), dry weight of bulb (2.54 g), pseudo-stem diameter (1.16 cm), diameter of bulb (4.04 cm), and bulb yield (14.86 $t \cdot ha^{-1}$) were found to be greater when grown in plastic mulching. Interaction between mulching and boron, mulching and zinc, boron

and zinc, and mulching and boron with zinc at different levels had significant effects on all growth and yield parameters with few exceptions. The combination of the highest doses of B at 4 kg·ha^{-1} and Zn at 12.50 kg·ha^{-1} with plastic mulching gave higher yield (18.71 t·ha^{-1}) of onion bulb and other parameters than those of yield without mulching (15.56 t·ha^{-1}). However, it can be concluded that most of the yield contributing characters and yield were significantly influenced by plastic mulching along with the interaction effect of different levels of B and Zn with it.

Inusah *et al.* (2013) observed the influence of mulching with different straw materials, on the yields and productivity of onions, variety 'White Creole'. The trial comprised three treatments: No Mulch (T_1), mulching with Andropogan grass straw (T_2) and mulching with rice straw (T_3) at three tones per hectare each. The soil of the experimental field was categorized as sandy loam, with pH 5.8. The results of the trial indicated that different types of organic based mulch such as grass and rice straw could contribute significantly to improved onion productivity and yields under tropical conditions. Onion bulb yield of T_2 (10.58 t-ha^{-1}) was significant ($P<0.05$) and over 60% higher than T_3 (6.63 t-ha^{-1}); and over 230% greater than T_1 plot yields (3.20 t-ha^{-1}). Analysis of the economic returns of the mulching technologies revealed a benefit-cost ratio of 2.31 and marginal rate of returns of 140 for T_2, suggesting that this technology is dominant over T_3 or T_1 technologies and is therefore recommendable to irrigated onion farmers.

Adetunji (1994) mentioned that optimization of water use and soil condition during dry season onion production in semiarid Nigeria, soil solarization with transparent polyethylene film was compared with organic mulches (groundnut shell, millet stover and sawdust) and a no-mulch control. With the exception of sawdust mulch, mulching significantly enhanced vegetative growth and bulb yields of onion. Solarization provides better soil coverage and therefore conserved more soil moisture and more than doubled the concentrations of NH_4^+- N and NO_3^- -N compared to other mulches and the control. Thus with soil solarization the total bulb yield of onion was 80% higher than with no mulching and 25% higher than the best organic mulch (groundnut shell).

CHAPTER III

MATERIALS AND METHODS

This chapter includes the information regarding methodology that was used in execution of the experiment. It contains a short description of location of the experimental site, climatic condition, materials used for the experiment, treatments of the experiment, data collection procedure and statistical analysis etc.

3.1 Location of the experimental plot

The experiment was conducted at the Central Farm of the Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2016 to March, 2017. The site is 90.2^0N and 23.5^0E Latitude and at an altitude of 8.2 m from the sea level.

3.2 Characteristics of soil

The soil of the experiment was non-calcareous, dark gray, medium high land. The soil texture was silty caly loam with a pH 5.8-6.7. Soil samples of the experimental plot were collected from a depth of 0 to 30 cm before conducting the experiment. Soil was analyzed in the Soil Resources Development Institute (SRDI) Farmgate Dhaka. The experimental site was a medium high land.

3.3 Climatic condition

The experimental area was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during Kharif season and scanty in the Rabi season

(October to March). There was no rainfall during the month of October, November, December and January. The average maximum temperature during the period of experiment was 26.82˚C and the average minimum temperature was 17.14˚C. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the period of the experiment were collected from Weather Station of Agargaon, Dhaka.

3.4 Agro-ecological Zone

The experimental field belongs to the agro-ecological region of the Modhupur Tract (AEZ-28). The landscape comprises level upland, closely or broadly dissected terraces associated with either shallow or broad, deep valleys.

3.5 Experimental materials

"Taherpuri" a cultivar of onion was used as experimental material.

3.6 Experimental treatments

Treatments were as follows:

Factor A: Manure

1) T_0 = Control (no manure)
2) T_1= Cowdung (9 t/ha)
3) T_2= Cowdung + Poultry manure (5 t/ha+3 t/ha)
4) T_3= Cowdung + Poultry manure + Vermicompost (3 t/ha+2 t/ha+2 t/ha)

Factor B: Mulch material

1) M_0 = No mulch

2) M_1 = Black polythene

3) M_2 = Water hyacinth

3.7 Experimental design and layout

The experimental treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental field was divided into 3 blocks with 12 unit plots of $1m^2$ (1m x 1m) size in each block. Thus the total number of unit plots were 3 x 12 = 36. The distance maintained between two unit plots was 0.5 m and that between blocks 1.0 m.

3.8 Crop husbandry

3.8.1 Raising of seedlings

For raising seedlings, the soil was ploughed and converted into 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 2.5m x lm size on 24 October 2016. After sowing, the seeds were covered with a thin layer of sandy 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. Seed germination started at 28 October, 2016. The healthy 30 days old seedlings were transplanted in the experimental field on 23 November 2016.

3.8.2 Land preparation

The land was preparation was started at 18 November 2016 by ploughing and cross ploughing followed by laddering. The corner of the land was spaded and visible large clods were broken into small pieces. Weeds and stubbles were removed from the field. The layout of the experiment was done in accordance with the design adopted. Finally, individual plots were prepared by using spade before organic manure application.

3.8.3 Manure treatments under investigation

There were four manure treatments. T_0= 0 (conrol), T_1= Cowdung (9 t/ha), T_2= Cowdung + poultry manure (5 t/ha+3 t/ha), T_3= Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha). Thus Cowdung in 9 plots @ rate: 2.2 kg/plot, Cowdung + Poultry Manure in 9 plots @ rate: 1.10kg + 1.10kg, Cowdung + Poultry Manure + vermicompost in 9 plots @ rate: 1.10 + 1.10 + 0.67 kg/ plot. The whole amount of manure was incorporated at the time of final land preparation. No chemical fertilizer was used in this experiment.

3.8.4 Transplanting and after care

Healthy 30 days old seedlings were transplanted on 23 November, 2016 in the afternoon and light irrigation was given around each seedling for their better establishment. Each unit plot accommodated 12 plants. A number of seedlings were planted in the border of the experimental plots for gap filling.

3.8.5 Mulching

Mulching was done on 22 November 2016 and hole was made with the help of blade and khurpi in case of black polythene. Also the water hyacinth was used after transplanting.

3.8.6 Gap filing

Dead, injured and weak seedlings were replaced by new healthy seedlings from the stock kept on the seed bed.

3.8.7 Intercultural operation

3.8.8 Weeding

Weeding was done three times in each plot to keep the plot clear.

3.8.9 Irrigation

Light irrigation was given just after transplanting of the seedlings. Other irrigations were applied on the plots as and when required depending upon the condition of soil moisture.

3.8.10 Pest and disease control

Few plants were damaged by cut worms after the seedling was transplanted in the experimental plots. Cut worms (*Agrotis ipsilon*) were controlled both mechanically and spraying Furadan @ 20 Kg per hectare. Some of the plants were infected by *Alternaria pori*. To prevent the spread of the disease Rovral @ 2g /liter of water was sprayed in the field.

3.8.11 Harvesting

The crop was harvested on 15 march 2017 when 75% of the tops in each plot had fallen over (Shalaby *et. al.* 1991). Generally the maturity symptom indicated by 75-80% of leaf senescence and drying out of the top. The tops of onion were removed by cutting off the pseudostem keeping 2.5cm with the bulb.

3.9 Methods of data collection

The data pertaining to the following characters were recorded from ten (10) plants randomly selected from each unit plot such a way that the border effect could be avoided. Data on plant height, leaf length and leaf no. were collected at 20, 40, 60 and 80 days after transplanting and also at harvest. All other parameters were recorded at harvest. Data on the above mentioned crop characters were as follows:

3.9.1 Plant height (cm)

The plant height was measured in centimeters from the base of plant to the terminal growth point of main stem on tagged plants at 15 days, interval starting from 15 days of planting up to 60 days to observe the plant height. The average height was computed and expressed in centimeter.

3.9.2 Number of leaves per plant

The number of leaves per plant was manually counted at 15, 30, 45 and 60 days after transplanting from randomly selected plants. The average of ten plants were computed and expressed in average number of leaves per plant.

3.9.3 Leaf length (cm)

A meter scale was used to measure the length of leaves. Leaf length of ten randomly selected plants was measured in centimeter. It was measured from the neck of the bulb to the top tip of the leaf. The average of ten plants leaves were computed and expressed in average length of leaves per plant.

3.9.4 Length of roots

Root length was measured with a centimeter scale from the base to the tip of the longest root at harvest and their average was taken as the root length in centimeter.

3.9.5 Diameter of bulb (cm)

Diameter of the harvested bulb was measured with a slide calipers at the middle portion of ten randomly selected plants from each plot and their average was calculated and expressed in cm.

3.9.6 Diameter of neck

Diameter of the harvested bulb neck was measured with a slide calipers at the tip portion of bulb from ten selected plants from each plot and their average was calculated and expressed in mm.

3.9.7 Percent dry matter content of bulb

A sample of 100 g of leaves was collected and dried under direct sunshine for 48 hours and then dried in an oven at 70 ^{0}C for 3 days. After oven drying, bulbs were weighed. The dry weight was recorded in gram (g) with an electric balance. The percentage of dry matter was calculated by the following formula:

$$\text{Percent dry matter} = \frac{\text{Weight of dry matter}}{\text{Fresh weight}} \text{ x } 100$$

3.9.8 Weight of single bulb (g)

Ten plants were randomly selected from each unit plot. The bulbs were weighted by a simple balance and the average was calculated and expressed in gram.

3.9.9 Yield per plot (g)

All the leaves along with pseudo stem were removed keeping only 2.5 cm neck. The weight of the bulb was taken by an electric balance in kilograms (kg) from each unit plot separately.

3.9.10 Yield per hectare

The yield of bulb per plot was converted into ton per hectare to get the yield of onion.

$$\text{Crop yield} = \frac{\text{Crop yield per plot (kg)} \times 10000}{\text{Area of plot in } m^2 \times 1000}$$

3.10 Statistical analysis

The collected data on various parameters under study were statistically analyzed using SPSS computer package programmed. The means for all the treatments were calculated and analysis of variance for all the characteristics were performed by the F- variance test (Gomez and Gomez, 1984). Significance of difference between means was evaluated by Least Significant Difference (LSD) at 5% level for the interpretation of results.

3.11 Economic analysis

Economic analysis was done in details following the procedure of Alam *et al.* (1989) which was given in Appendix VIII.

3.11.1 Analysis for total cost of production of onion

All the material and non-material input cost, interest on fixed capital of land and miscellaneous cost were considered for calculating the total cost of production. The interest was calculated @ 14% for six months per year and miscellaneous cost

as 5% of the total input cost. The value of one hectare of land was considered to be Tk. 4,00,000/- and the price of one kg onion treated with manure was considered to be 35/- to 40/- and without manure treatment 22/-.

3.11.2 Gross income

Gross income was calculated on the basis of sale of mature bulb. The price of bulb was assumed on basis of current market value of Kawran Bazar, Dhaka at the time of harvesting.

3.11.3 Net return

Net return was calculated by deducting the total production cost from gross income for each treatment combination.

3.11.4 Benefit cost ratio (BCR)

The economic indicator BCR was calculated by the following formula for each treatment combination.

$$\text{Benefit cost ratio} = \frac{\text{Gross income per hectare}}{\text{Total cost of production per}}$$

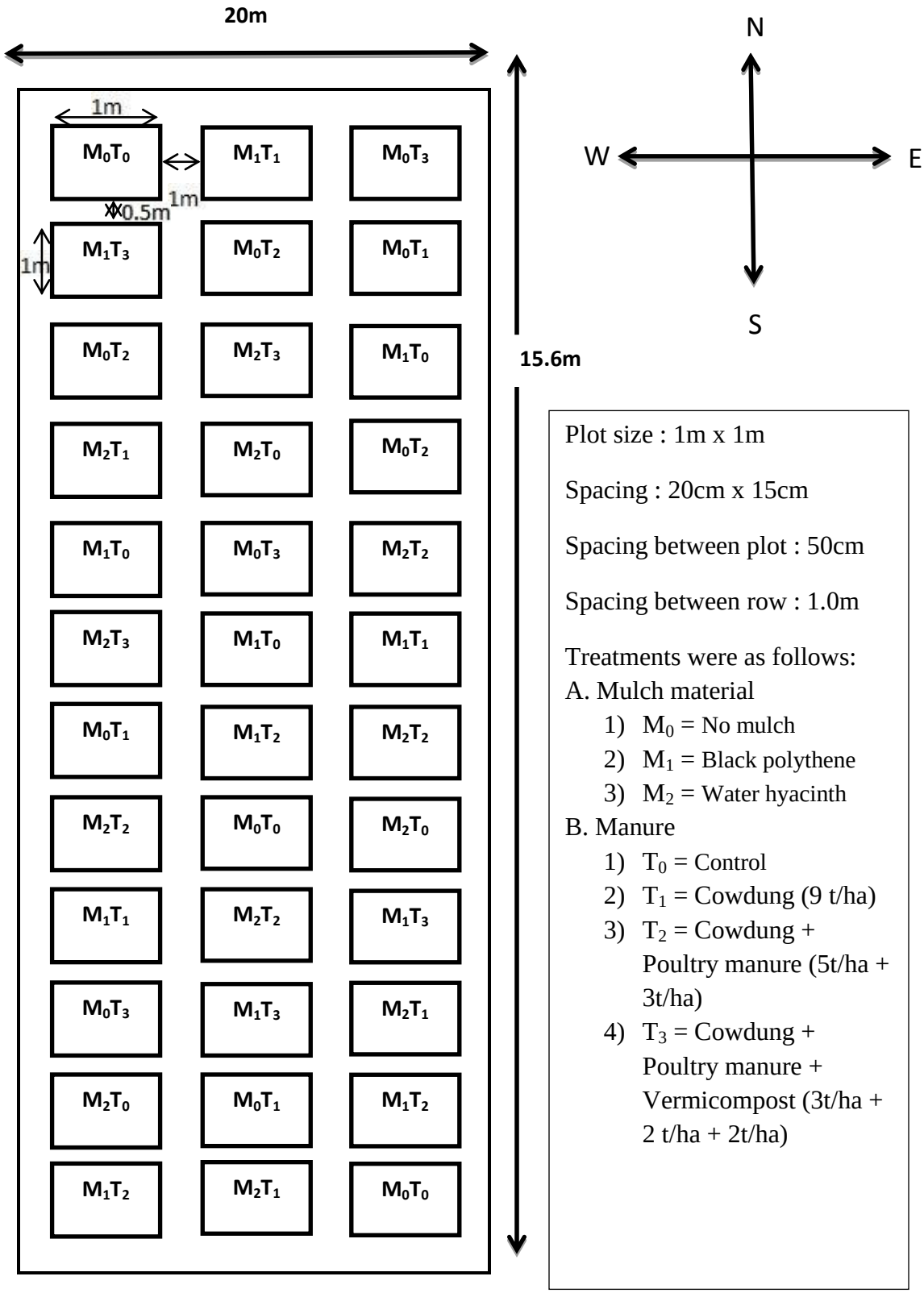

Figure 1: The layout of the field experiment

Plate 1. Raising of seedlings on seedbed

Plate 2. Uprooted seedlings before transplanting

Plate 3. Experimental plot

Plate 4. Mulching with black polythene

Plate 5. Mulching with water hyacinth

Plate 6. Measuring root length

Plate 7. Collecting harvesting data

CHAPTER IV

RESULTS AND DISCUSSION

The results of the effects of manure and mulching and their combined effects on the growth and yield of onion have been presented and discussed in this chapter. The analysis of variance (ANOVA) of data on different growth and yield parameters are presented in the Appendices II-VIII. The results of the study have been presented and discusses with the help of table and graphs and possible interpretations given under the following sub-headings.

4.1 Plant height (cm)

The result showed significant differences on plant height with the application of different organic manure combination at 15, 30, 45 and 60 day after transplanting (DAT) (Appendix III). At 15 DAT, the highest plant height (26.11 cm) was recorded from the treatment T_3 (Cowdung + Poultry manure + vermicompost) which is statistically similar with T_1, T_0, T_2 treatments (Figure 2). At 30 DAT, the longest plant height (40.57 cm) was recorded from the treatment T_3 and shortest plant height (35.58 cm) from the treatment T_0 (control). At 45 DAT, the longest plant height (51.44 cm) was recorded from the treatment T_3 while the shortest plant height (44.33cm) from T_0 treatment. At 60 DAT, the highest plant height (59.00 cm) was recorded from T_3 treatment while the shortest plant height (51.36cm) was observed from T_0 (control) treatment. The plant height increase with the progress of plant growth. This might be due to the fact that manures supplied adequate plant nutrients for better vegetative growth of the plants which

ultimately increased plant height. This finding is in agreement with the result of Vacchani and patel (1993) they reported that the height of plant increased with increasing levels of nutrients.

Many previous reports showed that mulching (M) conserves soil moisture as well as provides desirable soil temperature thus promotes the vegetative growth of plant including onion plant height (Stowell, 2000; Mahajan *et al*., 2007). Significance difference was observed due to mulching on the plant height at 15, 30, 45 and 60 DAT (Appendix III). At 15 DAT, the longest plant height (25.25 cm) was recorded from the treatment M_2 (black polythene) which is statistically similar with M_0, M_1 treatments (Figure 3). At 30 DAT, the longest plant height (37.92 cm) was recorded from the treatment M_2 while the shortest plant height (44.33cm) from M_0 (no mulch) treatment they were also statistically similar. At 45 DAT, the longest plant height (49.08 cm) was recorded from the treatment M_2 which was statistically similar with height (48.58) M_1 (water hyacinth) while the shortest plant height (44.33cm) from M_0 treatment. At 60 DAT, the longest plant height (56.75cm) was recorded from M_2 treatment while the shortest plant height (51.78 cm) from M_0 treatment. The effect of mulches might be accounted for conserving sufficient soil moisture providing water to plants at stages of growth and keeping the soil warm resulting increased height of plant. On the contrary, without mulch, plant suffered from water stress and could not accomplish potential vegetative growth. These results have the similarity with the previous reports of Suh *et al.* (1991) they reported that the increase in plant heights due to various mulches in onion. Synthetic mulch increased plant height over control (Hossain, 1996).

Combined effect of manure and mulching also showed significant difference on the plant height at 15, 30, 45 and 60 DAT. At 15 DAT, the longest plant height (26.10 cm) was recorded from the treatment T_3M_1 and the shortest plant height (21.00 cm) from the treatment T_2M_1 (table 1). At 30 DAT, the longest plant height (42.00 cm) was recorded from the treatment T_3M_1 while the shortest plant height (34.67cm) from T_0M_0 treatment. At 45 DAT, the longest plant height (55.33 cm) was recorded from the treatment T_3M_1 while the shortest plant height (41.69 cm) from T_0M_0 treatment. At 60 DAT, the longest plant height (62.67 cm) was recorded from T_3M_1 treatment combination while the shortest plant height (49.33 cm) from T_0M_0 treatment combination. In this study cowdung, poultry manure, vermicompost with black polythene mulch possibly maintained higher moisture content and more uniform temperature distribution in soil making more nutrient elements available for increasing plant growth.

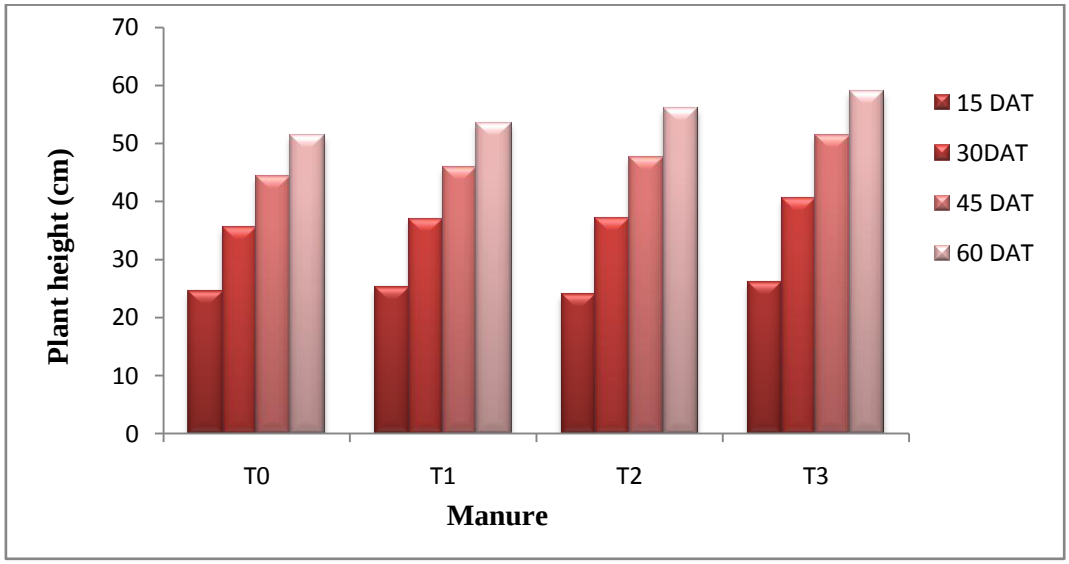

Figure 2. Effect of manure on plant height of onion at different days after transplanting (DAT)

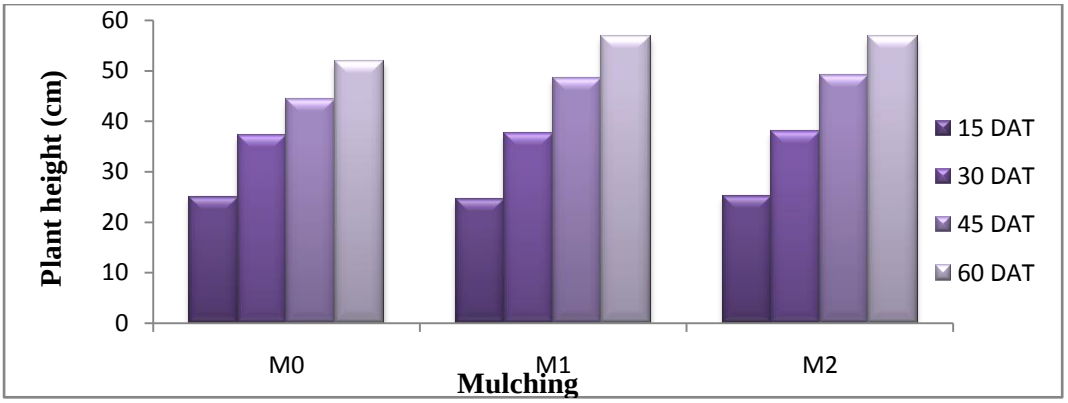

Figure 3. Effect of mulching on plant height of onion at different days after transplanting (DAT)

Table 1. Combined effect of manure and mulching on plant height of onion at different days after transplanting (DAT)

Treatments[x]	Plant Height at 15 DAT (cm)	Plant Height at 30 DAT (cm)	Plant Height at 45 DAT (cm)	Plant Height at 60 DAT (cm)
T_0M_0	23.33 ab	34.67 f	41.69 e	49.33 f
T_1M_0	24.67 ab	36.33 d-f	42.67 de	50.65 ef
T_2M_0	26.33 a	38.03 b-e	46.00 cd	52.67 e
T_3M_0	26.00 a	39.67 a-c	47.00 c	53.70 de
T_0M_1	26.67 a	36.69 c-f	45.70 cd	52.00 ef
T_1M_1	24.67 ab	35.33 ef	45.65 cd	53.65de
T_2M_1	21.00 b	36.20 ef	47.68 c	58.33 bc
T_3M_1	26.10 a	42.00 a	55.33 a	62.67 a
T_0M_2	23.67 ab	35.33 ef	45.67 cd	52.70 e
T_1M_2	26.33 a	39.43 a-d	49.33 bc	56.23 cd
T_2M_2	24.67 ab	37.00 b-f	49.33 bc	57.30 c
T_3M_2	26.33 a	40.00 ab	52.10 ab	60.67 ab
LSD $_{(0.05)}$	4.45	3.31	4.2	3.1
CV (%)	9.8	3.3	3.2	4.4

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[x]T_0- control, T_1- Cowdung (9 t/ha), T_2-Cowdung + poultry manure (5 t/ha+3 t/ha), T_3-Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha), M_0- No mulch, M_1- Black polythene), M_2-Water hyacinth

4.2 Number of leaves per plant

Significant variation was observed in the average no of leaves per plant due to the effect of manure at different growth stage like 15, 30, 45 and 60 DAT (Appendix IV). At 15 DAT, the highest leaves per plant (4.67) was recorded from the treatment T_3 (Cowdung + poultry manure+ vermicompost) and the lowest number of leaves (3.56) found from the treatment T_0 (control) which was statistically similar with T_1. At 30 DAT, the highest leaves per plant (6.00) was recorded from the treatment T_3 (Cowdung + poultry manure+ vermicompost) and the lowest number of leaves (5.33) found from the treatment T_1 (Figure 4). At 45 DAT the highest leaves per plant (9.11) was recorded from the treatment T_3 which was statistically similar with treatment T_2 (9.00) and the lowest number of leaves (7.89) found from the treatment T_0 (cowdung). At 60 DAT, the maximum leaves per plant (11.05) recorded from the treatment T_3 and the minimum number of leaves (8.90) found from the treatment T_0 was statistically similar with treatment T_1 (9.30). Soil organic matter is the key to soil fertility. It regulates the soil water and air supply. Organic manures improve texture, structure, humus, water holding capacity and microbial activity of soil. Therefore, combined application of cowdung, poultry manure and vermicompost might have influence on performance of the crop and ultimately produced more leaves per plant. Similar results also reported by Shaheen *et. al.* (2007) they found higher growth performance characteristics from poultry manure compared to cattle manure.

Significant difference was observed due to mulching on the number of leaves per plant on onion at 15, 30, 45 and 60 DAT (Appendix IV). At 15 DAT, the highest

number of leaves (4.17) was recorded from the treatment M_2 (Black polythene) which was statistically similar with M_1 (water hyacinth) and M_0 (no mulch) (figure 5). At 30, 45, 60 DAT, the maximum number of leaves per plant (respectively 5.75, 9.00, 10.08) was recorded from the treatment M_2 which was statistically similar with M_1 (water hyacinth) while the minimum number of leaves per plant (8.67) from M_0 treatment.

Combined effect of manure and mulching also showed significant difference on the number of leaves at 15, 30, 45 and 60 DAT (Table 2). At 15 DAT, the highest number of leaves per plant (5.00) was recorded from the treatment T_3M_1 and the lowest number of leaves per plant (3.33) from the treatment T_0M_1 which was statistically identical to T_1M_0. At 30 DAT, the highest number of leaves per plant (6.33) was recorded from the treatment T_3M_1 and the lowest number of leaves per plant (5.00) from the treatment T_0M_1. At 45 DAT, the highest number of leaves per plant (10.30) was recorded from the treatment T_3M_1 and the lowest number of leaves per plant (7.33) from the treatment T_0M_0. At 60 DAT, the maximum number of leaves per plant (12.67) was recorded from the treatment combination of T_3M_1 and the minimum number of leaves per plant (8.00) from T_0M_0 treatment combination.

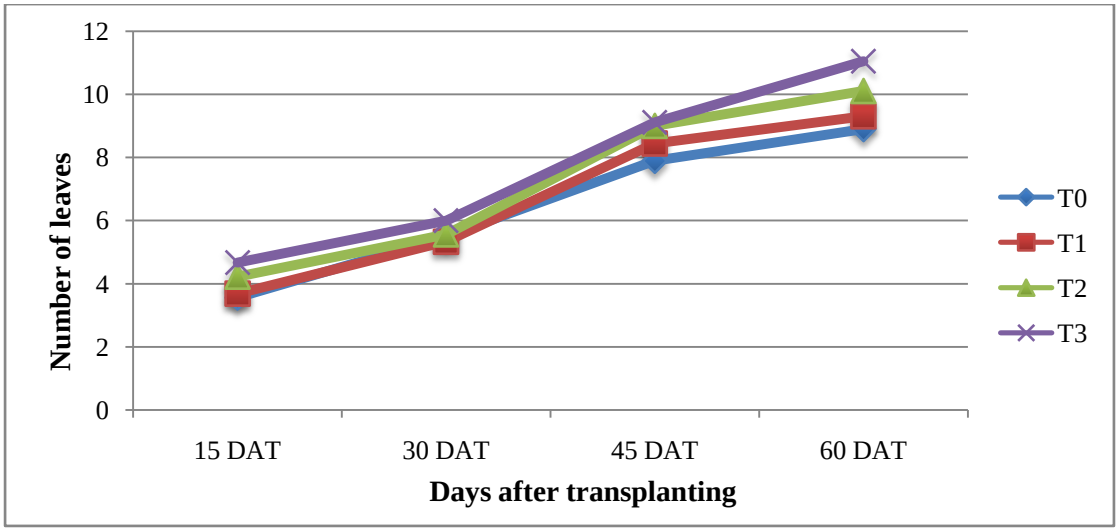

Figure 4. Effect of manure on number of leaves per plant at different days after transplanting (DAT)

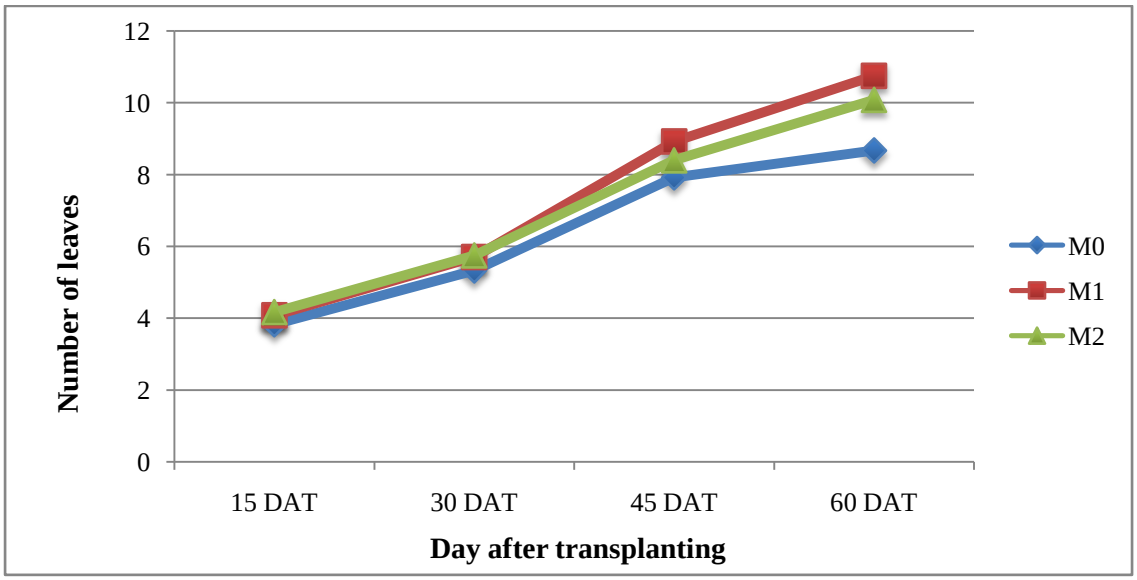

Figure 5. Effect of mulching on number of leaves per plant at different days after transplanting (DAT)

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0- control, T_1- Cowdung (9 t/ha), T_2-Cowdung + poultry manure (5 t/ha+3 t/ha), T_3- Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha), M_0- No mulch, M_1- Black polythene), M_2- Water hyacinth

Table 2. Combined effect of manure and mulching on number of leaves per plant at different days after transplanting (DAT)

Treatments[X]	Number of Leaf at 15 DAT	Number of Leaf at 30 DAT	Number of Leaf at 45 DAT	Number of Leaf at 60 DAT
T_0M_0	3.67 ab	5.33 ab	7.33 d	8.00 d
T_1M_0	3.33 b	5.00 b	8.00 b-d	8.67 cd
T_2M_0	4.00 ab	5.33 ab	8.33 b-d	9.05cd
T_3M_0	4.33 ab	5.67 ab	8.20 b-d	9.00 cd
T_0M_1	3.33 b	5.67 ab	7.67 cd	9.33 cd
T_1M_1	3.67 ab	5.33 ab	8.33 b-d	9.67 c
T_2M_1	4.33 ab	5.67 ab	9.36 ab	11.33 ab
T_3M_1	5.00 a	6.33 a	10.30 a	12.67 a
T_0M_2	3.67 ab	5.67 ab	8.65 b-d	9.30 cd
T_1M_2	4.00 ab	5.67 ab	9.00 a-c	9.67 c
T_2M_2	4.33 ab	5.67 ab	9.33 ab	10.00 bc
T_3M_2	4.67 ab	6.00 ab	9.00 a-c	11.33 ab
LSD $_{(0.05)}$	1.55	1.10	1.53	1.65
CV (%)	11.68	9.45	5.40	3.6

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[X] T_0- control, T_1- Cowdung (9 t/ha), T_2-Cowdung + poultry manure (5 t/ha+3 t/ha), T_3-Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha), M_0- No mulch, M_1- Black polythene), M_2-Water hyacinth

4.3 Leaf length (cm)

The length of leaf was varied significantly due to manure application at different growth stage like 15, 30, 45 and 60 DAT (Appendix V). At 15 DAT, the highest length of leaves (23.03 cm) was recorded from the treatment T_3 (Cowdung + poultry manure + vermicompost) which was statistically identical with T_1 , T_0, T_2. At 30 DAT, the highest length of leaves (37.86 cm) was recorded from the treatment T_3 (Table 3). At 45 DAT, the highest length of leaves (48.44 cm) was recorded from the treatment T_3 and the lowest length of leaves (41.22 cm) from the treatment T_0 (control). At 60 DAT, the highest length of leaves (55.50 cm) was recorded from T_3 treatment and the lowest length of leaves (47.83 cm) from T_0 treatment (control). This may be due to the fact that organic manure play role in chlorophyll formation and also influence cell division, meristemetic activity of tissue expansion of cell and formation of largest leaf. Shaheen *et. al.* (2007) stated that organic manure play a dominant role in the growth of onion.

Length of leaf was significantly influenced by manure treatments at different growth stage like 15, 30, 45 and 60 DAT (Appendix V). At 15, 30, 45 and 60 DAT, length of leaf was highest (respectively 23.47, 35.72, 46.00, 53.25 cm) in the treatment M_2 (water hyacinth) which was statistically identical to M_1 (black polythene) (Table 4). And at 60 DAT, lowest length (48.03cm) of leaf was found from the treatment M_0 (control).

Combined effect of manure and mulching also showed significant difference on the length of leaf at 15, 30, 45 and 60 DAT (Table 5). At 45 and 60 DAT, the highest length of leaf (respectively 52.30 cm and 59.15 cm) was found from the

treatment combination of T_3M_1 and lowest length of leaf (respectively 38.67 cm and 45.83 cm) found from T_0M_0 treatment.

Table 3. Effect of manure on length of leaf at different days after transplanting

Treatments[x]	Leaf length at 15 DAT (cm)	Leaf length at 30 DAT (cm)	Leaf length at 45 DAT (cm)	Leaf length at 60 DAT (cm)
T_0	22.98 a	33.51 b	41.22 c	47.83 d
T_1	22.99 a	34.30 b	42.89 bc	50.06 c
T_2	21.77 a	33.73 b	44.67 b	52.61 b
T_3	23.03 a	37.86 a	48.44 a	55.50 a
LSD $_{(0.05)}$	1.50	2.97	3.24	2.15
CV (%)	13.30	9.76	6.60	4.45

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[x] T_0- control, T_1- Cowdung (9 t/ha), T_2-Cowdung + poultry manure (5 t/ha+3 t/ha), T_3- Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha)

Table 4. Effect of mulching on length of leaf at different days after transplanting (DAT)

Treatments[X]	Leaf length at 15 DAT (cm)	Leaf length at 30 DAT (cm)	Leaf length at 45 DAT (cm)	Leaf length at 60 DAT (cm)
M_0	22.86 b	34.53 a	41.33 b	48.03 b
M_1	21.75 a	34.30 b	45.58 a	53.17 a
M_2	23.47 a	35.72 a	46.00 a	53.25 a
LSD $_{(0.05)}$	0.50	1.30	3.4	3.9
CV (%)	13.30	9.76	6.60	4.45

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[X] M_0- No mulch, M_1- Black polythene), M_2-Water hyacinth

Table 5. Combined effect of manure and mulching on length of leaf at different days after transplanting (DAT)

Treatments[x]	Leaf length at 15 DAT (cm)	Leaf length at 30 DAT (cm)	Leaf length at 45 DAT (cm)	Leaf length at 60 DAT (cm)
T_0M_0	21.13 ab	31.93 fg	38.67 f	45.83 f
T_1M_0	22.47 ab	33.67 d-g	39.67 ef	47.17 ef
T_2M_0	24.13 a	35.60 b-e	43.00 c-e	49.20 e
T_3M_0	23.70 a	36.93 a-c	44.00 cd	50.25 de
T_0M_1	24.37 a	33.90 c-g	42.67 c-e	48.50 ef
T_1M_1	22.47 ab	32.63 e-g	42.67 c-e	50.20 de
T_2M_1	18.80 b	31.30 g	44.67 cd	54.83 bc
T_3M_1	21.37 ab	39.37 a	52.30 a	59.17 a
T_0M_2	23.43 a	34.70 b-f	42.33 ef	49.15 e
T_1M_2	24.03 a	36.60 a-d	46.30 bc	52.80 cd
T_2M_2	22.37 ab	34.30 b-g	46.23 bc	53.83 c
T_3M_2	24.03 a	37.27 ab	49.00 ab	57.17 ab
LSD $_{(0.05)}$	3.8	3.15	3.98	3.10
CV (%)	13.30	9.76	6.60	4.45

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[x] T_0- control, T_1- Cowdung (9 t/ha), T_2-Cowdung + poultry manure (5 t/ha+3 t/ha), T_3- Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha), M_0- No mulch, M_1- Black polythene), M_2-Water hyacinth

4.4 Diameter of bulb (cm)

The variation in diameter of bulb due to manure treatments was statistically significant (Appendix VI). The maximum bulb diameter (4.14 cm) was found from the T_3 (Cowdung + Poultry manure + vermicompost) treatment and the minimum bulb diameter (3.67 cm) was recorded from the control T_0 (control) treatment followed by T_2 (3.83 cm) and T_1 (3.81 cm) which were statistically similar with T_0 (Table 6). This may be due to production of maximum number of leaves as well as

highest leaf length by manure which accumulated more carbohydrates in bulb which was reported by the Nasreen *et. al.* (2009).

Mulching conserve soil moisture and regulate soil temperature thus induce rapid growth of onion plant and proper development of onion bulb resulting in higher bulb diameter (Jamil *et al*., 2005) (Appendix VI). In this study showed that mulching had significant effect on diameter of onion bulb (Table 7). The highest bulb diameter (3.98 cm) was recorded with treatment of M_1 (black polythene mulch). Whereas the lowest bulb diameter (3.72 cm) was obtained from control (M_0) plots. Sumi *et al*. (1986) reported that mulch produced higher bulb diameter compare to unmulch condition. In case of garlic, Beten *et al.* (1995) and Mia (1996) also reported similar results of higher bulb diameter with mulch.

Combined effect of manure and mulching also showed significant difference on the diameter of onion bulb (Table 8). The highest bulb diameter (4.40 cm) was recorded with treatment T_3M_1 whereas the lowest bulb diameter (3.53 cm) was obtained from treatment T_0M_0.

4.5 Diameter of neck (mm)

Significant variation was observed in diameter of neck among the manure treatments (Appendix VI). At harvesting, the maximum neck diameter (10.67 mm) was obtained from T_3 (Cowdung + Poultry manure + vermicompost) treatment, whereas the minimum neck diameter (7.17 mm) was recorded from control T_0 (control) treatment (Table 6). These results indicate that optimum levels of manure supplied plant nutrients and provide better growing conditions, which helped for

getting proper vegetative growth as well as maximum neck diameter of onion. Rizk (1997) found that all vegetative growth parameters and yields of bulbs increased with increasing the nutrient rate.

Neck diameter was significantly influenced by mulching treatments (Appendix VI). The maximum neck diameter (9.83 mm) was obtained from M_1 (black polythene mulch) treatment, whereas the minimum neck diameter (8.06 mm) was recorded from M_0 (no mulch) treatment followed by M_2 (8.65 mm) which was statistically similar with M_0 (Table 7).

The diameter of neck was significantly influenced by the combinations of manure and mulching (Table 8). At harvest, maximum diameter of neck (12.33 mm) was obtained from the T_3M_1 treatment and minimum diameter of neck (6.83 mm) found from the treatment T_0M_0.

4.6 Root length (cm)

Root length was significantly influenced by the effect of manure treatments (Appendix VI). The longest root length (11.23 cm) was found from the treatment T_3 (cowdung + poultry manure + vermicompost) whereas the shortest root length (6.69 cm) was found from treatment T_0 (control) (Table 6).

The variation in root length due to mulch treatments was statistically significant (Table 7). The longest root length (10.03 cm) was found from the treatment M_2 (water hyacinth) followed by treatment M_1 (black polythene) (9.28 cm) which was

statistically similar with M_2. And the shortest was found from the M_0 (7.24 cm) treatment.

Combined effect of manure and mulch showed significant difference in case of root length (Appendix VI). The longest root length (13.58 cm) was found from the treatment T_3M_1. And the shortest root length (5.90 cm) was found from the treatment T_0M_1 followed by the treatment M_0T_0 (6.17 cm) which was statistically identical to T_0M_1treatment (Table 8).

Table 6. **Effect of manure on the diameter of bulb, diameter of neck, root length and percent of dry matter content of bulb**

Treatments[x]	Bulb diameter (cm)	Neck diameter (mm)	Root length (cm)	Percent of dry matter content (%)
T_0	3.67 b	7.17 c	6.69 c	11.04 c
T_1	3.82 b	8.42 b	8.24 b	12.54 b
T_2	3.83 b	9.13 b	9.24 b	13.49 b
T_3	4.14 a	10.67 a	11.23 a	15.67 a
LSD $_{(0.05)}$	0.26	1.4	1.2	2.10
CV (%)	12.75	7.3	6.4	6.3

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[x]T_0- control, T_1- Cowdung (9 t/ha), T_2-Cowdung + poultry manure (5 t/ha+3 t/ha), T_3- Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha)

Table 7. Effect of mulching on the diameter of bulb, diameter of neck, root length and percent of dry matter content of bulb

Treatments[x]	Bulb diameter (cm)	Neck diameter (mm)	Root length (cm)	Percent of dry matter content (%)
M_0	3.72 b	8.06 b	7.24 b	11.42 b
M_1	3.98 a	9.83 a	9.28 a	14.40 a
M_2	3.91 ab	8.65 b	10.03 a	13.75 a
LSD $_{(0.05)}$	0.12	0.94	1.1	0.96
CV (%)	12.75	7.3	6.4	6.3

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[x]M_0- No mulch, M_1- Black polythene), M_2-Water hyacinth

Table 8. Combined effect of mulching on the diameter of bulb, diameter of neck, root length and percent of dry matter content of bulb

Treatments[x]	Bulb diameter (cm)	Neck diameter (mm)	Root length (cm)	Percent of dry matter content (%)
T_0M_0	3.53 c	6.83 d	6.17 e	9.25 f
T_1M_0	3.70 bc	8.00 bcd	7.33 de	10.59 ef
T_2M_0	3.77 bc	8.07 bcd	7.67 c-e	12.36 c-e
T_3M_0	3.90 bc	9.33 bc	7.80 c-e	13.42 cd
T_0M_1	3.73 bc	7.25 cd	5.90 e	11.63 de
T_1M_1	3.83 bc	9.20 bc	7.50 c-e	13.60 b-d
T_2M_1	3.93 a-c	10.23 ab	10.13 bc	14.55 bc
T_3M_1	4.40 a	12.33 a	13.58 a	17.83 a
T_0M_2	3.70 bc	7.33 cd	8.00 c-e	12.25 de
T_1M_2	3.97 abc	7.97 cd	9.90 b-d	13.43 cd
T_2M_2	3.80 bc	9.00 b-d	9.92 b-d	13.55 cd
T_3M_2	4.13 ab	10.30 ab	12.32 ab	15.77 ab
LSD $_{(0.05)}$	0.51	2.38	2.65	2.23
CV (%)	12.75	7.3	6.4	6.3

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[x]T_0- control, T_1- Cowdung (9 t/ha), T_2-Cowdung + poultry manure (5 t/ha+3 t/ha), T_3-Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha), M_0- No mulch, M_1-

4.7 Percent dry matter content of bulb (%)

Percent dry matter content of bulb significantly influenced by the manure treatments (Table 6). The highest dry matter content (15.67%) was found from T_3 (cowdung + poultry manure + vermicompost) treatment and the lowest dry matter content (11.04%) was recorded from T_0 (control) treatment.

Mulch conserved adequate soil moisture which increases chlorophyll content of plant (El-oksh *et al*., 1993). Rate of photosynthesis increased with the increase level of chlorophyll content. For this reason higher amount of dry matter was accumulated in onion bulb. Mulching had significant effect on dry matter content of bulb (Appendix VI). The highest dry matter content (14.40%) was found from the treatment M_1 (black polythene mulch) followed by the treatment M_2 (13.75%) (water hyacinth) which was statistically similar with M_1 (Table 7). And lowest dry matter content (11.42%) was recorded from the M_0 (no mulch) treatment. Uddin (1997) observed the same result that black polythene mulch gave the highest day matter content of bulb compared with water hyacinth and straw mulch.

Percent dry matter content of bulb was greatly influenced by the combination of manure and mulching treatments (Appendix VI). The highest dry matter content (17.83%) was found from the T_3M_1 treatment whereas lowest dry matter content (9.25%) was found from the treatment T_0M_0 (Table 8). It can be noted that the available soil nutrients supported proper vegetative growth by producing bulb with more protoplasm in the cells in comparison to less available nutrient in onion. On

the other hand, when nutrient availability become reduce in the soil, decreased plant growth which causes less percent dry matter content in the onion bulb.

4.8 Weight of single bulb (g)

From the present research work, it was observed that there was significant variation among the treatments in respect of fresh weight of bulb due to different manures application (Appendix VII). The maximum bulb weight (39.78 g) was obtained from T_3 (Cowdung + Poultry manure + vermicompost) whereas lowest bulb weight (30.33 g) was obtained from the T_0 (control) (Table 9). From the above result, it was noted that combindly used of organic manure increased nutrient availability to plants and much bulb formation was occurred. The available soil nutrients supported proper vegetative growth by producing succulent bulb with more protoplasm in the cells in comparison to less available nutrients in onion. Barman *et al.* (2013), Yahumri *et al.* (2015), Adeyeye *et. al*. (2017) also said that the organic manure application increase the bulb weight and yield of onion.

Mulching had significant effect on the single bulb weight (Appendix VIII). The highest weight of single bulb (37.58 g) was found from the treatment M_1 (black mulch) followed by the water hyacinth treatment M_2 (36.50 g) which was statistically similar with M_1 treatment (Table 10). In case of black polythene mulch, plants get sufficient moisture and higher temperature. Probably that is why maximum bulb weight per plant was occurred in case of black polythene mulch. The mulching favors the reduction of evaporation leading to higher soil moisture content, a reduction in weed growth and the decomposition of added mulches

might have also contributed to increase the supply of nutrients and moisture for overall increase in crop yields (Gupta, 1985; Gupta and Gupta, 1986; Vander Zaag *et al.*,1986).

Weight of single bulb was greatly influenced by the combination of manure and mulching treatments (Appendix VII). The highest single bulb weight (42.67 g) was found from the treatment combination T_3M_1 whereas the lowest single bulb weight (26.67 g) found from the T_0M_0 treatment (Table 11). Thompson and Kelly (1988) reported that the rate of release nitrogen from the manure depends on the soil temperature. The higher the temperature, the faster the release of nutrients, provided sufficient water and air to occur proper decomposition. In this study organic manure along with black polythene mulch possibly maintained a higher moisture content and a more uniform temperature distribution in soil and resulted more release of nitrogen from manure which ultimately reflected higher bulb weight.

4.9 Yield per plot (kg)

Yield per plot was found to be significantly influenced by different manure treatments (Appendix VII). The highest yield per plot (0.997 kg) was obtained from the T_3 (Cowdung + Poultry manure + vermicompost) whereas the lowest yield per (0.761 kg) T_0 (control) (Table 9). In the present study a balanced combination of cowdung, poultry manure and vermicompost resulted maximum bulb yield of onion. It might be due to the fact that manures kept the soil cool, conserved more moisture in the soil, helps in the soil loosening and maintain

friable for better bulb growth. On the other hand, when manures availability become reduced in the soil, decreased soil fertility and soil become compact and interrupted bulb formation and development and ultimately less bulb yield. These results have the similarity with the previous reports of Yoldas *et al.* (2011), Yahumri *et al.* (2015) who were said that the organic manure provide proper nutrient to increase the yield of onion.

Yield per plot was significantly influenced by the effect of mulching treatments (Appendix VII). The highest yield per plot (0.940 kg) was obtained from the treatment M_1 (Black polythene) followed by the yield (0.916 kg) of treatment M_2 (water hyacinth) (Table 10). These results were agreed with the findings of Adetunji (1994), Hossain (1996) and Mia (2006) they reported that mulching gave higher bulb yield compare to unmulched condition.

Yield per plot was significantly influenced by the combination of manure and mulching treatments (Table 11). The highest yield per plot (1.07 kg) was obtained from the T_3M_1 treatment combination whereas the lowest yield per plot (0.67 kg) was obtained from the T_0M_0 treatment. Organic matter as a source of humus, promotes beneficial organisms, on decomposition produces carbon dioxide which may be of direct value in increasing the CO_2 content of air and indirect value in making availability if some of the mineral elements in soil. Besides, black polythene mulch plot maintained higher moisture content and a uniform temperature distribution in the soil. In this study combination of cowdung, poultry manure and vermicompost with black polythene mulch produced maximal bulb yield in onion.

4.10 Yield per hectare (t)

Yield per hectare was significantly varied due to the effect of manure treatments (Appendix VII). The highest yield (9.94 t) was obtained from the treatment T_3 (Cowdung + Poultry manure + vermicompost) whereas the lowest yield (7.58 t) was obtained from the treatment T_0 (control) (Table 9). These results were agreed with the findings of Barman *et al.* (2013), Yahumri *et al.* (2015) who were that organic manure application increase the yield of onion.

Yield per hectare was significantly influenced by the effect of mulching treatments (Appendix VII). The highest yield (9.39 t) was found from the M_1 (black polythene) treatment followed by the yield (9.12 t) from M_2 (water hyacinth) which was statistically similar with M_1. The lowest yield (7.71 t) was found from the M_0 (no mulch) treatment (Table 10). These results were agreed with the previous findings. Polythene mulch increases soil temperature and moisture. These synthetic mulches reduce weed problems and certain insect pests and also stimulate higher crop yields by more efficient utilization of soil nutrients (Rhu *et al*., 1990; Kashi, *et al*., 2004). Mulching with plant residues and synthetic materials is a well-established technique for increasing the profitability of many horticultural crops (Duranti and Cuocolo, 1989; Gimenez *et al.*, 2002).

Yield per hectare was significantly influenced by the combined effect of manure and mulching treatments (Appendix VII). The highest yield (10.67 t) was found from the T_3M_1 treatment whereas the lowest yield (6.67 t) was found from the T_0M_0 treatment (Table 11).

Table 9. Effect of manure on the single bulb weight, yield per plot and yield per hectare

Treatments[x]	Single bulb weight (g)	Yield per plot (kg)	Yield per ha (ton)
T_0	30.33 c	0.761 c	7.58 c
T_1	33.22 bc	0.833 bc	8.27 bc
T_2	36.67 ab	0.917 ab	9.16 ab
T_3	39.78 a	0.997 a	9.94 a
LSD $_{(0.05)}$	4.34	0.099	0.97
CV (%)	8.49	8.62	8.24

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[x]T_0- control, T_1- Cowdung (9 t/ha), T_2-Cowdung + poultry manure (5 t/ha+3 t/ha), T_3- Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha)

Table 10. Effect of manure on the single bulb weight, yield per plot and yield per hectare

Treatments[x]	Single bulb weight (g)	Yield per plot (kg)	Yield per ha (ton)
M_0	30.92 b	0.775 b	7.71 b
M_1	37.58 a	0.940 a	9.39 a
M_2	36.50 a	0.916 a	9.12 a
LSD $_{(0.05)}$	2.51	0.078	0.75
CV (%)	8.49	8.62	8.24

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[x]M_0- No mulch, M_1- Black polythene), M_2-Water hyacinth

Table 11. Combined effect of manure and mulch on the single bulb weight, yield per plot and yield per hectare

Treatments[x]	Single bulb weight (g)	Yield per plot (kg)	Yield per ha (t)
T_0M_0	26.67 f	0.67 e	6.67 e
T_1M_0	29.00 de	0.73 de	7.25 de
T_2M_0	32.33 b-e	0.81 b-e	8.08 b-e
T_3M_0	37.30 b-d	0.89 a-d	8.91 a-d
T_0M_1	33.00 b-e	0.83 b-e	8.25 b-e
T_1M_1	35.67 a-d	0.89 a-d	8.92 a-d
T_2M_1	39.00 a-c	0.98 a-c	9.75 a-c
T_3M_1	42.67 a	1.07 a	10.67 a
T_0M_2	31.33 c-e	0.78 c-e	7.83 c-e
T_1M_2	35.00 a-e	0.88 a-e	8.75 a-e
T_2M_2	38.67 a-c	0.97 a-c	9.67 a-c
T_3M_2	41.00 ab	1.03 ab	10.25 ab
LSD $_{(0.05)}$	8.82	0.224	2.19
CV (%)	8.49	8.62	8.44

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[x] T_0- control, T_1- Cowdung (9 t/ha), T_2-Cowdung + poultry manure (5 t/ha+3 t/ha), T_3-Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha), M_0- No mulch, M_1- Black polythene), M_2-Water hyacinth

4.11 Economic analysis

Input costs for land preparation, manure, mulching, irrigation and manpower required for all the operations from seed sowing to harvesting of onion were recorded as per experimental plot and converted into cost per hectare. Price of onion was considered as per market rate. The economic analysis presented under the following headings-

4.11.1 Gross return

The combination of different manure and mulching showed different value in terms of gross return under the trial (Table 12) (Appendix VIII). The highest gross return (Tk. 426,800) was obtained from the treatment combination T_3M_1 (Cowdung + Poultry manure + vermicompost with black polythene mulch). The lowest gross return (Tk. 146,740) was obtained from treatment T_0M_0.

4.11.2 Net return

In case of net return, different manure and mulching showed different levels of net return under the present trial (Table 12). The highest net return (Tk. 242,000) was found from T_3M_1 treatment and the lowest (Tk. 62,740) net return was obtained in T_0M_0 treatment.

4.11.3 Benefit cost ratio

The highest benefit cost ratio (2.31) was noted from the treatment combination of T_3M_1 and the lowest benefit cost ratio (1.74) was obtained from T_0M_0 treatment (Table 12). From economic point of view, it is apparent from the above results that

T_3M_1 treatment (Cowdung + Poultry manure + vermicompost with black polythene mulch) was more profitable treatment combination than rest of the combinations.

Table 12. Cost and return of onion cultivation as influenced by manure and mulching

Treatments combinations[x]	Total cost of production (Tk)	Yield (ton/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio
$\mathbf{T_0M_0}$	84,000	6.67	146,740	62,740	1.74
$\mathbf{T_1M_0}$	114,240	7.25	217,500	103,260	1.90
$\mathbf{T_2M_0}$	117,600	8.08	242,400	124,800	2.06
$\mathbf{T_3M_0}$	172,480	8.91	356,400	183,920	2.06
$\mathbf{T_0M_1}$	96,320	8.25	181,500	85,180	1.88
$\mathbf{T_1M_1}$	126,560	8.92	267,600	141,040	2.11
$\mathbf{T_2M_1}$	129,920	9.75	292,500	162,580	2.25
$\mathbf{T_3M_1}$	184,800	10.67	426,800	242,000	2.31
$\mathbf{T_0M_2}$	91,840	7.83	172,260	80,420	1.87
$\mathbf{T_1M_2}$	122,080	8.75	262,500	140,420	2.15
$\mathbf{T_2M_2}$	125,440	9.67	280,430	154,990	2.24
$\mathbf{T_3M_2}$	180,320	10.25	410000	229,680	2.27

[x] T_0- control, T_1- Cowdung (9 t/ha), T_2-Cowdung + poultry manure (5 t/ha+3 t/ha), T_3-Cowdung + Poultry manure + vermicompost (3 t/ha+2 t/ha+2 t/ha), M_0- No mulch, M_1- Black polythene), M_2-Water hyacinth

Total cost of production was done in details according to the procedure of Krishitattik Fasaler Utpadan O Unnayan (in Bangla), 1989 by Alam *et al.*

Sale of manure treated onion @ Tk. 40,000/t

Sale of non-treated onion @ Tk. 22,000/t

CHAPTER V

SUMMARY AND CONCLUSIONS

5.1 Summary

A field experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October, 2016 to March, 2017 to find out the effect of manure and mulch on the growth and yield of onion. The experiment consisted of two factors: Factor A: Four levels of manure viz. T_0 = Control (0), T_1= Cowdung (9 t/ha), T_2= Cowdung + Poultry manure (5 t/ha+3 t/ha), T_3= Cowdung + Poultry manure + Vermicompost (3 t/ha+2 t/ha+2 t/ha) and Factor B: Three levels of mulch viz. M_0 = No mulch, M_1 = Black polythene, M_2 = Water hyacinth. There were 12 treatment combinations and experiment was setup in randomized complete block design (RCBD) with three replications.

Collected data were statistically analyzed for the evaluation of treatments for the detection of the best treatment of manure, mulch and the best amalgamation. Summary of the results and conclusion have been described in this chapter.

In case of manure treatment, the highest plant height (59.00 cm) and lowest plant height (51.36 cm) was obtained at 60 DAT from T_3 and T_0 treatments, respectively. On the other hand, observing the mulch treated plants, highest plant height (56.75 cm) and lowest plant height (51.78 cm) was observed at 60 DAT from M_2 and M_0 treatments respectively. In case of combined effect highest plant height (62.67 cm) and the lowest plant height (49.33 cm) was obtained from T_3M_1 and T_0M_0 treatment, respectively.

Maximum leaf number T_3 (11.05) and minimum leaf number T_0 (8.90), T_1 (9.30) was obtained at 60 DAT from manure treatment. On the other hand, observing the mulch treated plants, M_2 (10.08), M_1 (10.75) and minimum leaf number M_0 (8.67) was observed at 60 DAT. In case of combined effect, maximum leaf number (12.67) and the minimum leaf number (8.00) was obtained from T_3M_1 and T_0M_0 treatment, respectively.

In case of manure treatment the highest leaf length (55.50 cm) and lowest leaf length (47.83 cm) was obtained at 60 DAT from T_3 and T_0 treatments, respectively. On the other hand, observing the mulch treated plants, highest leaf length (53.25 cm), (53.17 cm) and lowest plant height (51.78 cm) was observed at 60 DAT from M_2, M_1 and M_0 treatments, respectively. In case of combined effect, highest leaf length (59.15 cm) and the lowest leaf length (45.83 cm) was obtained from T_3M_1 and T_0M_0 treatment, respectively.

In manure treated plants, the maximum bulb diameter (4.14 cm) was found from the T_3 treatment and the minimum bulb diameter were recorded from the T_0 (3.67 cm), T_2 (3.83 cm) and T_1 (3.81 cm) treatments. Whereas in mulch treated plants, the highest bulb diameter (3.98 cm) was recorded with treatment M_1 and lowest bulb diameter (3.72 cm) was obtained from M_0 (control) treatment. In case of combined effect, the highest bulb diameter (4.40 cm) was recorded with treatment T_3M_1 whereas the lowest bulb diameter (3.53 cm) was obtain from treatment T_0M_0.

In case of manure treatment, the maximum neck diameter (10.67 mm) was obtained from T_3 treatment and minimum neck diameter (7.17 mm) was recorded from control T_0 treatment. The maximum neck diameter (9.83 mm) was obtained from M_1 treatment and the minimum neck diameter was recorded from M_0 (8.06 mm) and M_2 (8.65 mm) treatment from mulch application. In amalgamation,

maximum diameter of neck (12.33 mm) showed from the T_3M_1 treatment and minimum from the T_0M_0 (6.83 mm) treatment.

Regarding manure treatment, the longest root length was found from the treatment T_3 (11.23 cm) and the shortest was found from T_0 (6.69 cm) treatment. In mulch application, the longest root length were found from the treatment M_2 (10.03 cm) and M_1 (9.28 cm) and the shortest from the M_0 (7.24 cm) treatment.in combined effects, the longest root length (13.58 cm) was found from the treatment T_3M_1. And the shortest root length were found from the treatment T_0M_1 (5.90 cm) and M_0T_0 (6.17 cm).

In case of manure, the highest dry matter content was found from T_3 (15.67%) treatment and the lowest from T_0 (11.04%) treatment. Regarding mulch, the highest dry matter content was found from the M_1 (14.40%), M_2 (13.75%) treatment and lowest from the M_0 (11.42%) treatment. In amalgamation, the highest dry matter content was found from the T_3M_1 (17.83%) treatment and lowest showed from the treatment T_0M_0 (9.25%).

In case of manure, the highest single bulb weight (40.33 gm), yield per plot (1008.33 gm) and yield per hectare (10.08 t) were obtained from T_3 treatment. And lowest single bulb weight (31.77 gm), yield per plot (794.44 gm) and yield per hectare (7.94 t) were obtained from T_0 treatment. Regarding mulching, the highest single bulb weight (36.50 gm), yield per plot (912.50 gm) and yield per hectare (9.12 t) were obtained from M_2 treatment. And lowest single bulb weight (33.58 gm), yield per plot (839.58 gm) and yield per hectare (8.39 t) were obtained from M_0 treatment In case of combined effect, the highest single bulb weight (42.67 gm), yield per plot (1066.67 gm) and yield per hectare (10.67 t) were obtained

from T_3M_1 treatment. And lowest single bulb weight (31.00 gm), yield per plot (755.00 gm) and yield per hectare (7.75 t) were obtained from T_0M_0 treatment.

5.2 Conclusions

Based on the findings of the experiment, it may be concluded that for efficient production of onion and maintenance of soil productivity, it is judicial to use cowdung, poultry manure and vermicompost combindly with black mulch as an alternative shortage of irrigation. The result reveled that combined application of cowdung, poultry manure and vermicompost was found best for higher yield of onion. The recent study also revealed that the successful onion production is possible by using mulches. Use of black polythene mulch may be suggested for this purpose. Therefore, the treatment combination of manure (cowdung+ poultry manure+ vermicompost) with black polythene mulch may be used where precipitation is scanty and irrigation is costly. Otherwise, the use of water hyacinth mulching with the manure combination is also profitable where it's found plenty in amount. Since the present study was conducted in only one agro-ecological zone, further investigations are needed to be carried out in other AEZ of Bangladesh.

CHAPTER VI

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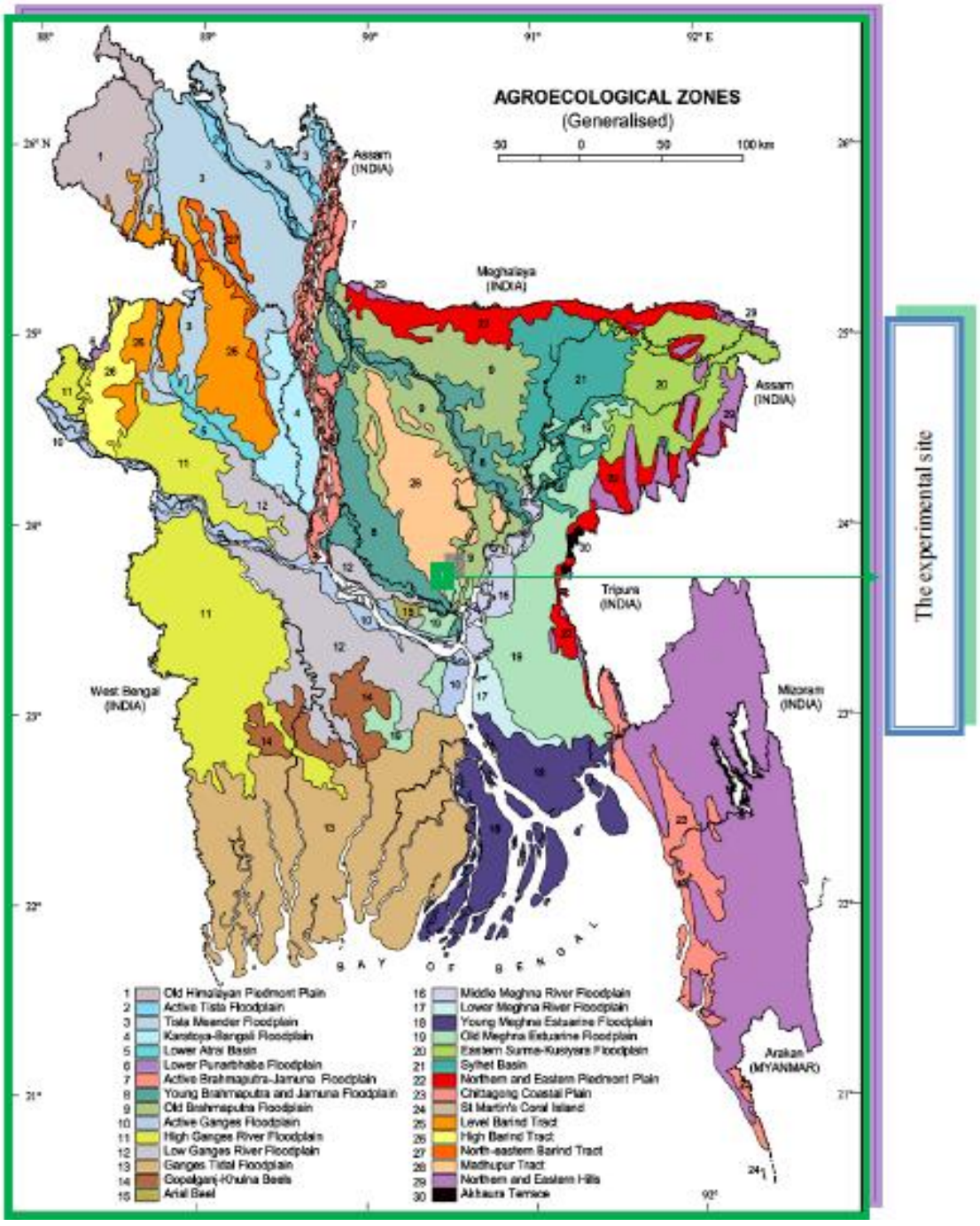
CHAPTER VII

APPENDICES

Appendix I. Map showing the experimental site



Appendix II. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological characteristics

Morphological features	Characteristics
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General soil type	Shallow redbrown terrace soil
Land type	Medium high land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Mechanical analysis

Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix-III. Analysis of variance of data on plant height at different days after transplanting of onion

Source of variation	Degrees of freedom (df)	Mean square of plant height at			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	1.69	3.36	4.78	15.08**
Factor A (Manure)	3	3.59*	37.87**	86.32**	98.30**
Factor B (Mulch)	2	9.36*	6.03*	80.03**	105.08**
Interaction (A X B)	6	10.29*	10.44**	9.77*	7.602**
Error	22	5.33	2.72	3.83	1.51
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-IV. Analysis of variance of data on number of leaves plant^{-1} at different days after transplanting of onion

Source of variation	Degrees of freedom (df)	Mean square of number of leaves plant^{-1} at			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	0.53	0.86	1.36	0.58
Factor A (Manure)	3	2.39**	0.70*	2.85**	7.74**
Factor B (Mulch)	2	0.36*	0.69*	4.36**	13.58**
Interaction (A X B)	6	0.18*	0.06*	0.99*	1.21*
Error	22	0.49	0.32	0.57	0.64
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-V. Analysis of variance of data on length of leaf at different days after transplanting of onion

Source of variation	Degrees of freedom (df)	Mean square of length of leaves plant^{-1} at			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	1.28	2.56	4.78	15.08
Factor A (Manure)	3	3.43*	37.13**	86.32**	98.30**
Factor B (Mulch)	2	9.09*	6.92*	80.02**	105.08**
Interaction (A X B)	6	10.05*	10.56**	9.77*	7.60**
Error	22	5.16	2.70	3.84	1.51
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VI. Analysis of variance of data on diameter of bulb, diameter of neck, root length and percent of dry matter content of bulb of onion

Source of variation	Degrees of freedom (df)	Mean square of			
		Diameter of bulb (cm)	Diameter of neck (cm)	Root length (cm)	Dry matter content of bulb (%)
Replication	2	0.006	1.550	3.842	0.001
Factor A (Manure)	3	0.430**	19.206**	32.606**	33.787**
Factor B (Mulch)	2	0.373**	9.812**	25.027**	27.348**
Interaction (A X B)	6	0.027*	1.076*	6.135**	1.424*
Error	22	0.049	1.491	1.721	1.606
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VII. Analysis of variance of data on weight of single bulb, yield plot^{-1}and yield ha^{-1} of onion

Source of variation	Degrees of freedom (df)	Mean square of		
		Weight of single bulb (g)	Yield plot^{-1} (g)	Yield ha^{-1} (t)
Replication	2	2.86	12945	0.178
Factor A (Manure)	3	113.14**	145582*	7.071**
Factor B (Mulch)	2	59.53**	24540**	3.721**
Interaction (A X B)	6	4.97*	20692*	0.311*
Error	22	11.65	27718	0.728

** : Significant at 1% level of probability; * : Significant at 5% level of probability

Appendix VIII. Per hectare production cost of onion as influenced manure and mulching

A. Input cost

Treatments combination	Labour cost	Ploughng cost	Seed cost	Insectcide cost	Irrigation cost	Organic Manure + Mulch cost	Sub Total (A)
T_0M_0	24,000	15,000	5,000	4,000	2,000	0	50,000
T_1M_0	24,000	15,000	5,000	4,000	2,000	27,000	77,000
T_2M_0	24,000	15,000	5,000	4,000	2,000	30,000	80,000
T_3M_0	24,000	15,000	5,000	4,000	2,000	79,000	1,29,000
T_0M_1	26,000	15,000	5,000	3,000	1,000	12,000	61,000
T_1M_1	26,000	15,000	5,000	3,000	1,000	39,000	88,000
T_2M_1	26,000	15,000	5,000	3,000	1,000	42,000	91,000
T_3M_1	26,000	15,000	5,000	3,000	1,000	91,000	1,40,000
T_0M_2	26,000	15,000	5,000	3,000	1,000	8,000	57,000
T_1M_2	26,000	15,000	5,000	3,000	1,000	35,000	84,000
T_2M_2	26,000	15,000	5,000	3,000	1,000	38,000	87,000
T_3M_2	26,000	15,000	5,000	3,000	1,000	87,000	1,36,000

B. Overhead cost

Treatment Combination	Cost of lease of land months for 6 months (14% of value of land Tk. 4,00,000/ year)	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 months (Tk. 14.0% of cost/year)	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
T_0M_0	28,000	2,500	3,500	34,000	84,000
T_1M_0	28,000	3,850	5,390	37,240	114,240
T_2M_0	28,000	4,000	5,600	37,600	117,600
T_3M_0	28,000	6,450	9,030	43,480	172,480
T_0M_1	28,000	3,050	4,270	35,320	96,320
T_1M_1	28,000	4,400	6,160	38,560	126,560
T_2M_1	28,000	4,550	6,370	38,920	129,920
T_3M_1	28,000	7,000	9,800	44,800	184,800
T_0M_2	28,000	2,850	3,990	34,840	91,840
T_1M_2	28,000	4,200	5,880	38,080	122,080
T_2M_2	28,000	4,350	6,090	38,440	125,440
T_3M_2	28,000	6,800	9,520	44,320	180,320