FEASIBILITY OF REPLACING CHEMICAL FERTILIZER BY ORGANIC FERTILIZER IN MAIZE PRODUCTION

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CERTIFICATE

*This is to certify that the thesis entitled, "**FEASIBILITY OF REPLACING CHEMICAL FERTILIZER BY ORGANIC FERTILIZER IN MAIZE PRODUCTION**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY,** embodies the result of a piece of bonafide research work carried out by **NURUN NAHAR SHAHINUR** Registration No.* **06-2000** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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Dated:
Place: Dhaka, Bangladesh

DEDICATED TO

MY

BELOVED PARENTS

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The author

FEASIBILITY OF REPLACING CHEMICAL FERTILIZER BY ORGANIC FERTILIZER IN MAIZE PRODUCTION

ABSTRACT

Present research work was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2011 to April 2012 to study the feasibility of replacing chemical fertilizer by organic fertilizer in maize production. The experiment comprised 10 different treatments with organic manure and inorganic fertilizer and their combinations viz., T_0: Control (without fertilizer), T_1: All chemical fertilizer (recommended dose), T_2: Cowdung (Recommended dose), T_3: Compost (recommended dose), T_4: ½ Compost + ½ Cowdung, T_5: Full cowdung + Full compost, T_6: Full cowdung + ½ Chemical fertilizer, T_7: Full compost + ½ Chemical fertilizer, T_8: Full cowdung + Full compost + ½ Chemical fertilizer, T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer on growth and yield performance of maize variety of BARI hybrid bhutta 9. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The highest number of cob plant^{-1} (1.67), cob length (22.27 cm), cob diameter (14.12 cm), no. of grains cob^{-1} (531.90), weight of 1000 grain (305.30 g), grain yield (11.75 t ha^{-1}) and stover yield (13.97 t ha^{-1}) were obtained from T_1. The treatments T_7, T_8 and T_9 also showed statistically similar results in respect of yield and yield contributing characters. As T_9 treatment had ½ Cowdung + ½ Compost + ½ Chemical fertilizers combination which would incur least cost along with soil improvement might be suggested to be followed in maize production.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
LAI	=	Leaf area index
ppm	=	Parts per million
et al.	=	And others
N	=	Nitrogen
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
G	=	Gram (g)
Kg	=	Kilogram
µg	=	Micro gram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
HI	=	Harvest Index
No.	=	Number
WUE	=	Water use efficiency
Wt.	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Non significant
mm	=	Millimeter
Max	=	Maximum
Min	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
T	=	Ton
viz.	=	Videlicet (namely)

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) belongs to family Gramineae is one of the most widely distributed crops of the world (Kaul *et al*., 2011). This crop being the highest yielding cereal crop in the world has significant importance for countries like Bangladesh, where rapidly increasing population has already out stripped the available food supplies.

Maize is the third most important cereal crop in the world after wheat and rice (Bukhsh *et al.,* 2011). Maize crop has been included as a major enterprise in the crop diversification and intensive cropping programs (Kaul and Rahman, 1983). It is the most efficient crops which can give high biological yield as well as grain yield in a relatively short period of time due to its unique photosynthetic mechanism as C_4 plant. The area and production of maize was about 409070 acres and 1018282 metric tons respectively (BBS, 2011). The production of maize is likely to grow up by 19% to touch 20 million tons in 2010-2011 crop years on higher acreage and improved yield. Its grain has high nutritive value containing 66.2% starch, 11.1% protein, 7.12% oil and 1.5% minerals. Moreover, 100 g maize grains contain 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin (Chowdhury and Islam, 1993). Maize oil is used as the best quality edible oil. Green parts of the plant and grain are used as the feed of livestock and poultry. Stover and dry leaves are used as good fuel (Ahmed, 1994). The important industrial use of maize includes in the manufacture of starch and other products such as glucose, high fructose sugar, maize oil, alcohols, baby foods and breakfast cereals (Kaul, 1985). This crop has much higher grain protein content than rice.

In Bangladesh, the cultivation of maize was started in the late 19th century but the cultivation has started to gain the momentum as requirements of maize grain are being increased as poultry industry in Bangladesh. About 0.27 million tones of maize grain is necessary for the requirement of poultry birds and fish (BARI, 2000). For its yield potentiality, versatile uses, almost year round growing ability and higher per hectare yield maize is called “queen of cereals”.

Bangladesh is facing a problem of malnutrition due to her high population growth and low productivity of crops. The traditional crop including rice and wheat seems quite unable to meet the nutritional requirement. Maize can be a potential crop for nutritional support and may offer a partial solution to the food shortage if its present yield level and total production can further be raised. Among the agronomic traits that influence growth and yield, fertilizer management is the prominent one.

Intensive use of inorganic fertilizers and pesticides has been an important tool in the drive for increased crop production. In fact more fertilizers consumption is a good indication of agricultural productivity but depletion of soil fertility is commonly observed in soils. Intensive cropping system requires highly fertilized soils and those soils should be maintained through integrated plant nutrient management system (Bationo and Koala, 1998). Chemical fertilizers are attractive due to their convenience, ease application and reliable high yield. However chemical fertilizer’s high energy requirement, nitrate leaching potential, pollution of water resources, destruction of physical structure of soil, microorganisms, friendly insects, crop susceptibility to disease attack, acidification or alkalization of soil, and inability to improve soil nutrient level show its long term sustainability issues. Organic manure provides many advantages such as improves soil tilth, aeration, water holding capacity and stimulates micro-organisms in the soil that make plant nutrients readily available (Choudhary and Bailey, 1994). The fertilization can affect enzymatic activities inside the soil profile (Yang *et al*., 2008; Zhu *et al*., 2008). Maia and Cantaruti (2004) reported that the continuous use of organic fertilizers increased maize productivity whereas chemical fertilizer application showed less expressive effects. They also observed that the continuous use of the organic fertilizers increase in total N-reserve and availability of N, while the chemical fertilizer application had little influence on these characteristics. Proper application of organic and inorganic fertilizers can increase the activities of soil micro-organisms and enzymes and soil available nutrient contents (He and Li, 2004; Saha *et al*., 2008). He and Li (2004) indicated that combined application of organic and inorganic fertilizers can increase the activities of soil interties and available nutrient content. Furthermore, the application of organic manure mixed up with chemical fertilizer can prove to be an excellent procedure in maintaining and improving the soil fertility, and increasing fertilizer use efficiency. For this reason, it could be helpful to study the effect of application of organic manure combined with chemical fertilizer by using integrated nutrient management system, which has been the research focus all over the world (Reganold, 1995). In addition, application of organic manure could improve the soil quality and is more profitable in environment protection when compared with application of chemical fertilizer alone (Reganold, 1995). The soil with organic manure continually applied had lower bulk density and higher porosity values, porous and buffering capacities (Edmeades, 2003).

Maintaining and improving soil quality is crucial if agricultural productivity and environment quality are to be sustained for future generations (Reeves, 1997). Intensive agriculture has had negative effects on the soil environment over the past decades (*e.g.* loss of soil organic matter, soil erosion, water pollution) (Zhao *et al.,* 2009). Management methods that decrease requirements for agricultural chemicals are needed in order to avoid adverse environment impacts (Bilalis *et al.,* 2009). Moreover, emerging evidence indicates that integrated soil fertility management involving the judicious use of combinations of organic and inorganic resources is a feasible approach to overcome soil fertility constraints (Abedi *et al.,* 2010; Kazemeini *et al.,* 2010; Mugwe *et al.,* 2009). Very few research works have been conducted in our country regarding the effects of poultry manure, cowdung and biogas slurry on yield, quality and nutrient uptake by maize. In the view of this fact the study was conducted with the following objectives:

Objectives of the research work:

1) To find out the effect of cowdung, compost and chemical fertilizer on the yield performance of maize,
2) To observe the proper combinations of cowdung, compost and chemical fertilizer on maize, and
3) To select optimum combination(s) rate of cowdung, compost, chemical fertilizer for higher yield of maize.

Chapter II

Review of literature

CHAPTER II

REVIEW OF LITERATURE

Integrated plant nutrient management (IPNM) from organic and inorganic sources bears great significance for sustaining the soil productivity. Inorganic sources mainly include chemical fertilizers, while major organic sources are crop residues, FYM, compost, green manure, oil cakes, bio-fertilizers, bio-gas slurry etc. to improve soil health. From the different experiment, microbial fertilizers like *Rhizobium*, *Azotobacter*, Blue green algae, *Azolla* etc. have increased the yield and also played important role for minimizing the harmful effect of pesticides and herbicides. Organic farming is a practical proposition for sustainable agriculture if adequate attention is paid to this issue. It is crucial to use both types of nutrient sources synergistically for overcoming the problem of soil health, sustainability, escalating price of chemical fertilizers and environmental pollution. Integrated plant nutrients system (IPNS) imparts beneficial effects on soil productivity, crop yields and human health through efficient utilization of plant nutrients.

2.1 Effect of organic fertilizer on growth and yield of maize

Replenishing nutrients through organic sources is essential to maintain the soil health and sustainability in Eastern Himalayan Region, India which is organic by default. Keeping this in mind an experiment was laid out on randomized block design with six treatments *viz.,* T_1: Vermicompost (VC; 2.5 Mg ha^{-1}), T_2: Poultry manure (PM; 1.25 Mg ha^{-1}), T_3: Swine manure (SM; 3.0 Mg ha^{-1}), T_4: Cow dung manure (CDM; 10.0 Mg ha^{-1}), T_5: Farm yard manure (FYM; 10.0 Mg ha^{-1}) and T_6: control and replicated thrice to study the effect of applied organic nutrients on growth and yield attributes of maize. The physical parameters like porosity, maximum water holding capacity (MWHC), field capacity (FC), permanent wilting point (PWP), bulk density (BD) and moisture releasing pattern was measured better when the crop was supplied with FYM followed by CDM. Chemical parameters like pH, Soil organic carbon (SOC), available nitrogen (N), phosphorus (P) and potassium (K) were recorded better on VC followed by PM over control. The growth, physiological parameters, yield attributes and yield were recorded higher on VC. The uptake of nitrogen, phosphorus and potassium was higher on VC followed by PM, whereas least nutrients were taken up by control. Similarly the gross and net return was recorded higher on VC followed by PM, whereas, B: C ratio was recorded higher on PM followed by CDM. However the lowest economic returns were recorded on control. Agronomic efficiency was recorded higher on VC followed by PM (Choudhary *et al*., 2013).

Rahman *et al.* (2012) conducted at the On Farm Research Division (OFRD) farm, Rangpur from 2002-2003 to 2004-2005 to see the effect of inorganic fertilizers along with organic manure and mungbean residue on soil properties and yield of crops. For the first crop (maize), there were five treatments. After harvest of maize, mungbean and dhaincha (*Sesbania*) seeds were sown as per treatments. For T. Aman rice (third crop), each of the treatments (T_2 and T_3 plots) were subdivided into six, so there were altogether 15 treatments. Integrated use of manure and inorganic fertilizers (IPNS basis) produced comparable seed yield of maize with the chemical fertilizers alone irrespective of moderate or high yield goal basis (MYG or HYG). The highest maize yield of 10.02 $ha^{-1}$was obtained from the treatment T_5, which produced significantly highest yield over all other treatments. During the growing period of mungbean, temperature coupled with rainfall encouraged vegetative growth of mungbean and as a result, pod formation was low. The incorporation of *Sesbania* biomass and mungbean residue along with inorganic fertilizers for MYG produced identical grain yields of T. Aman rice with the fertilizers alone for HYG. The highest grain yield 4.31 $ha^{-1}$was found in IPNS dhaincha along with fertilizers for HYG treatment. There was no remarkable change in post harvest soil status during the growing period. It may be concluded that addition of mungbean residues or *Sesbania* biomass before T. Aman rice may ensure higher crop productivity and sustain soil fertility.

Continuous application of FYM enhanced crop growth and increases root biomass (Naeem *et al*., 2009). Montemurro *et al*. (2006) observed that organic manure produced the same maize and barley yields as with the highest rate of mineral fertilizers.

Dong *et al.* (2005) studied the nitrogen transformation in maize soil after application of different organic manure to investigate the nitrogen mineralization on the surface soil, NO_3-N dynamics and distribution in the soil profile, and N_2O emission. The study was conducted at Yucheng Comprehensive Experimental Station in North China Plain. The experiment was laid out in 24 plots in random plot design with 8 treatments, each with 3 replicates: maize plantation without fertilizer (CK_1), bare soil without maize plantation and fertilizer application (CK_2), swine manure (S_1, S_2), poultry manure (P_1, P_2), and cattle manure (C_l, C_2). The result revealed that the emissions of N were affected by the application of organic manures in the order of $P_2 > S_2 > C_2 > P_1 > S_1 > C_l > CK_1 > CK_2$. All these results showed that organic manure applications significantly affect nitrogen transformation and distribution in maize soil.

Rameshwar and Totawat (2002) conducted a field experiment during the kharif season of 1999 in Rajasthan, India, to determine the effect of using biogas slurry and *Azotobacter* as supplement of N fertilizer on maize cv. Navjot performance. Treatments were: chemical urea at 100% (90 kg N ha and 50 and 75%; organic biogas slurry at 100% (90 kg N ha^{-1}), and 50 and 75%, with or without *Azotobacter* and combination of chemical and organic fertilizer at 1:1ratio. All treatments significantly increased maize grain and stover yield, yield attributes and nutrient uptake. The available nutrient status of the soil after maize harvest was highest in the organic treatment, followed by the integrated chemical + organic fertilizer treatment.

Suri and Puri (1997) conducted a field experiment in the low-hill submontane zone of Himachal Pradesh during 1990-91 to evaluate the direct, and residual effects of farmyard manure (0 or 10 t ha^{-1}) and phosphorus (0, 13 or 6 kg ha^{-1}) application in a maize cv. Local/wheat cv. VL 616/maize cropping sequence.

Farmyard manure and P showed significant direct and residual effects on the 3 sequential crops The residual farmyard manure increased the gain yield of the next maize crop by 235 kg ha^{-1}. Application of 26 kg P ha^{-1} to the preceding wheat increased the grain yield of second maize crop by 300 kg 1 A fresh P application of 13 kg ha^{-1} to the second crop increased its grain yield by 357 kg ha^{-1} All the interactions were significant.

Studies conducted by Vadivel *et al.* (2001a) revealed that application of enriched FYM@ 750 kg ha^{-1} increased the grain and stover yield of maize.

Kamalakumari and Singaram (1996) reported that in long term field trials over 20 years initiated in 1972 on a typic Ustochrept clay loam soil at Coimbatore, Tamil Nadu, maize cv. Co.l was given various rates of N, P and K, 0 or 25 kg $ZnSO_4$, 0 or 10 t farmyard manure (FYM) and hand weeding or no weeding. Available P and K in soil increased with rate of NPK fertilizer and with FYM application. Grain yield and uptake of N, P and K were highest with 135 kg N + 67.5 kg P_2O_5 + 35 kg K_2O + 10t FYM ha^{-1}. Continuous application of N only resulted in depletion of Olsen-P in soil.

Ramamurthy and Shivashankar (1996) conducted a study at Hebbal, Bangalore, during 1990-92 on a sandy loam soil to determine the response of Deccan 101 sown in the rainy seasons, to the residual organic matter and phosphorus fertilizers present From application to previous soybean crops. Organic fertilizers were applied to the soybeans at 0, 5 or 10 t ha^{-1} (1:1farmyard manure and rice straw) and inorganic P was applied at 37.5 or 56.25 kg P_2O_5 ha^{-1}. The residual effect of 10 t ha^{-1} organic fertilizer resulted a significant increase in dry matter production, grain yield, protein content and uptake of nutrients by maize. An increase in grain yield of 8% was observed due to a residual response to 56.25 kg P_2O_5 ha^{-1} compared with 37.5 kg P_20_5 ha^{-1} application.

Agarwal *et al*. (1995) observed that farmyard manure improved root and leaf growth of maize. Organic amendments and nitrogen hastened leaf appearance and increased leaf area and leaf longevity. Maize grain yield was positively correlated with leaf area index (r:0.89) and leaf area duration (r:0.87) due to FYM applications.

2.2 Effect of chemical fertilizer on growth and yield of maize

Onasanya *et al*. (2009) conducted an experiment to show the effect of twelve different rates of nitrogen and phosphorus fertilizers on growth and yield of maize (*Zea mays L*.) in southern Nigeria was evaluated between June and October, 2007. The results of the study showed that application of 120 kg N ha^{-1} + 0 kg P ha^{-1} and 60 kg N ha^{-1} + 40 kg P ha^{-1} significantly increased the growth of maize than other treatments. The application rate of 120 kg N ha^{-1} + 40 kg P ha^{-1} significantly (P = 0.05) enhanced grain yield. This study further confirms the role of nitrogen and phosphorus fertilizers in increasing growth and grain yield in maize production. From the result of the study, application rate of 120 kg N ha^{-1} + 40 kg P ha^{-1} may be recommended for increasing maize yield particularly in the study area. However, application of 60 kg N ha^{-1} + 40 kg P ha^{-1} can also bring about increase in the yield of maize. These will greatly benefit farmers in area where supply of nitrogen fertilizer is low and cases where farmers cannot afford the cost of high fertilizer input.

Andrea *et al*. (2006) conducted a study in Argentina to analyze the response to contrasting N availability of morphophysiological traits of maize inbred lines. Traits included in the analysis were related to canopy structure, light interception, shoot biomass production and grain yield. Results indicated that (i) the start of N effects on canopy size was more related to a threshold crop leaf area index (about 2) as compared to a given leaf stage (i.e., Vn), (ii) the light attenuation coefficient value was not affected by N availability, (iii) variations in kernel number per plant were explained by prolificacy (r = 0.59), and (iv) differences in harvest index were related to kernel number per plant (r = 0.77). The most important finding of their research was the detection in some inbreds of a particular response of kernel number to plant growth rate around silking, different from the general model established for hybrids. In these inbreds an additional effect of N availability was detected as reduced kernel set at a given plant growth rate under N deficient conditions (i.e. reduced reproductive efficiency).

Eltelib *et al.* (2006) studied the effect of nitrogen and phosphorus application n growth, forage yield and quality of fodder maize growing in Sudan. The variety used was Giza 2. Nitrogen was applied at the rates of (0, 40 and 80 kg ha^{-1}), while phosphorus levels were (0, 50 and 100 kg $P_2 0_5$ ha^{-1}). Parameters studied were plant height, number of leaves per plant, stem diameter and leaf area index (LAl), days to 50% tasseling, dry matter yield, crude protein and crude fibre contents were studied. Results showed that addition of nitrogen fertilizer significantly increased plant height, stem diameter and LAI, forage dry matter yield and protein content. Phosphorus fertilizer application had no significant effect on growth, days to 50% tasseling, dry matter yield and crude protein content. Neither nitrogen nor phosphorus had a significant effect on the crude fibre content.

Shapiro and Wortmann (2006) conducted field experiments for 3 years to study the effects of four N rates on maize crop performance. Nitrogen rates ranged from 0 to 252 kg N ha^{-1}. Nitrogen application resulted in mean increases of 22% more biomass production and 24% more grain yield. The N response function was linear in 1996, quadratic in 1997, and quadratic with decreased yields at the high N rate (252 kg N ha^{-1}) in 1998.

Abbas (2005) conducted a field study during 1997 and 1998 to find out the effect of 4 rates of nitrogen (0, 100, 200 and 300 kg N ha^{-1}) on maize under varying levels of irrigation. He observed an increase in N rates enhanced crop productivity in both years over control and lesser rate of nitrogen. Averaged over the two years maximum number of cobs m-^{2} (8.17), number of grains m^{-2} (3452), 1000- grain weight (228 g), total dry matter (15.4 t ha^{-1}) and grain yield (6.29 t ha^{-1}) were recorded from plots fertilized with 300 kg N ha^{-1}. These measurements were significantly higher as compared to lower nitrogen rates. They further concluded that increasing rate of nitrogen application increased LAI over nil or lower rate of nitrogen application and the response was cubic in 1997 and quadratic in 1998. Maximum LAI (4.43) in 1997 was recorded in treatment 300 kg ha^{-1}, and equivalent value in 1998 was 4.24. Increasing rate of nitrogen application also increased CGR over control or lower rate of nitrogen application in both the seasons, and this response was cubic in nature. Averaged over two years, maximum mean CGR was recorded 19.21 g m^{-2} d^{-1} in treatment (300 kg N ha^{-1}).

Agba *et al.* (2005) conducted two field experiments to determine the efficacy of nitrogen fertilizer on the growth and yield of improved maize variety in the reaching and research farm department of Agronomy, Cross River University of Technology, Nigeria, during the 2003/2004 cropping seasons. The experiment comprised seven rates of urea (46% N) fertilizer at 0, 50, 90, 130, 170, 210 and 250 kg ha^{-1} with three replications. Urea application significantly increased plant height, number of leaves and ear weight, ear length and ear diameter per plant. The use of 210 kg N ha^{-1} produced the best maize grain yield of 2.43 and 2.96 ton ha^{-1} in 2003 and 2004, respectively.

Ding *et al.* (2005) compared six hybrids to study N deficiency effects on grain weight, plant weight, harvest index, leaf area and photosynthetic traits. N deficiency decreased grain yield and plant weight in all hybrids, especially in the older hybrids. However, there was no significant difference in harvest index, rate of light-saturated photosynthesis (Psat) 20d before flowering, leaf area or plant weight at flowering between the N-deficient and control plants of all hybrids. Dry matter production after flowering of the N-deficient plants was significantly lower as compared to that of the control plants in all hybrids, especially in the older hybrids, and was mostly due to differences in the rate of decrease in photosynthetic capacity during this stage. N deficiency accelerated senescence, i.e. decreased chlorophyll and soluble protein contents, after anthesis more for the earlier released hybrids as compared to for the later ones. They concluded that compared with older (earlier released) hybrids, newer (later released) hybrids maintained greater plant and grain weight under N deficiency because their photosynthetic capacity decreased more slowly after anthesis.

Hassan (2005) studied the effect of NPK at the rate of 0-0-0, 150-100-50, 200-125-75, and 250-150-100 kg NPK ha^{-1} and observed that increased rate of NPK delayed tasseling, silking and maturity and increased the number of cobs per plant, number of grain rows per cob, number of grains per cob, 1000-grain weight, biological yield and grain yield ha^{-1} while plant height showed non -significant effect.

Inman *et al.* (2005) worked on nitrogen uptake at levels ranging from 56 to 268 kg N ha^{-1} in maize and reported that nitrogen uptake and grain yield response to applied nitrogen were found to be statistically significant. Maximum grain yield (11.6 t ha^{-1}) was obtained from the plot fertilized with 268 kg N ha^{-1} in site-specific management zone.

Oktem and Oktem (2005) conducted an experiment on sweet corn as second crop to investigate effect of different nitrogen application rates (150, 200, 250, 300 and 350 kg N ha^{-1}) on some ear characteristics. They observed that increasing nitrogen application up to 350 kg N ha^{-1} increased cob length (20.88 cm), ear diameter (4.44 cm), kernel number per cob (545.4).

Yusuf *et al.* (2005) reported that the response of maize variety TZSR-Y1 grown on soils (mainly Alfisols and Entisols) collected from 30 different locations in northern Nigeria to applied zinc fertilizer application was examined in two greenhouse pot experiments. The Mehlich 1 extractable soil zinc (Zn) ranged from 0.6 to 4.1 mg kg^{-1} with a mean of 2.00 mg kg^{-1}. Due to the wide variations observed in the initial Mehlich 1 extractable Zn and the large sample soils involved, two fertilizer rates (0 and 10 mg kg were used to determine maize response to applied Zn. In many of the soils, yield was increased by the addition of Zn and there were large differences in response pattern. Dry matter production was higher in the first crop, making 55% of the total against 45% from the second crop. This was attributed to the mineralization and subsequent utilization of Zn reserve in the organic complexes of the soil.

Akbar *et al.* (2002) worked on sweet corn by using nitrogen levels (0, 100, 150 and 200 kg N ha^{-1}). They reported that maximum, days to tasseling (57.35days), days to silking (69.50 days), days to maturity (102.7 days), plant height (140.23 cm), and biological yield (12291.1 kg ha^{-1}) were recorded for (200 kg N ha^{-1}). Nitrogen level (150 kg N ha^{-1}) resulted in greater grain yield (2006 kg ha^{-1}), 1000-grain weight (132.7 g) and number of ear per plant (1.45). It showed that increasing nitrogen levels have significant effect on all parameters.

Sangoi *et al.* (2001) evaluated the effect of N rates on grain yield and N use efficiency of hybrids and reported that new hybrids Ag 9012 had higher grain yield as compared to older hybrids regardless of N rates. Under higher doses of N, the old hybrids Ag 12 and Ag 28 took up more N and presented higher values of shoot dry matter at maturity as compared to Ag 9012. Nonetheless, they set less grain per ear which contributed to decrease their grain yield and N use efficiency.
Ali *et al.* (1999) observed the effect of various doses of nitrogen at the rate of 130, 180 and 230 kg N ha^{-1}. They reported that 1000-grain weight, grain yield, biological yield and plant height was increased with increased nitrogen and further reported that increased nitrogen rates delayed silking, tasseling and maturity.

Ogunlela *et al.* (1998) conducted an experiment on growth and yield component of field grown maize by using nitrogen fertilization ranging 50 to 200 kg N ha^{-1}. They estimated that ear diameter, kernel depth, grain and number of ear per plant, plant height and dry matter production increased with nitrogen fertilization while tasseling in maize was hastened.

Haque and Hamid (1998) conducted a field experiment in 1993/94 in Bangladesh on maize cv. Barnali. Crop received 0-150 Kg N ha^{-1}, increased canopy development, plant height, dry matter yield and crop growth rate (CGR) with increase in nitrogen rate.

Mahmood (1997) applied N with 0, 100, 200 and 300 kg ha^{-1} to maize cv. Golden and obtained maximum grain yield of 6.69 t ha^{-1} and protein content of 10.38% with application of N with 300 kg ha^{-1}.

2.3 Combined effect of organic and chemical fertilizer on growth and yield of maize

Verma *et al*. (2012) conducted an experiment during rabi season of 2006-07 and 2007-08 to study the effect of sowing dates and integrated nutrient management on growth, yield and quality of winter maize. The trial was laid out in split plot design with three replications, assigning total 27 treatment combinations i.e. three sowing dates (15 Oct, 25 Oct and 5 Nov) in main plots and three levels of nitrogen from inorganic fertilizer urea (50, 100 and 150 N_20 kg ha^{-1}) and two organic fertilizer (FYM, *Azospirillum*) and control in sub plots. The crop sown on 25 Oct significantly enhanced the growth and grain yield than early sowing 15 Oct and late sowing 5 Nov While, 150 kg of N_2O ha^{-1} application significantly increased over 100 and 50 kg N_2O ha^{-1}. However, N_2O application through FYM was found statistically at par with N_2O application through the *Azospirillum*in growth and grain yield during both years. But, application of 100 kg ha-1 with 7.50 t ha-1 FYM at the sowing of 25 Oct significantly influenced the growth, yield and quality of maize and was recorded 9.35 and 23.07 percent more grain yield over the other treatment combinations.

Seerat *et al.* (2012) conducted a Dry Land Agriculture Project, University of Agricultural Sciences, Bangalore, Karnataka to study the crop growth and yield of maize in response to recommended fertilizers as well as integration of different organics nutrient sources. Treatments were: 100% NPK through fertilizers (T_1), 50% N through fertilizer + 50% N through FYM + balance P and K as fertilizers (T_2), 50% N through fertilizer + 50% through city compost + balance P and K as fertilizers (T_3), 50% N through fertilizer + 50% N through sewage sludge + balance P and K as fertilizers (T_4), 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (T_5), 50% N through fertilizer + 50% N through gliricidia green manure + balance P and K as fertilizers (T_6) and 50% N through fertilizer + 50% N through composted parthenium + balance P and K as fertilizers (T_7). Application of recommended NPK through fertilizers resulted significantly in higher leaf area index and leaf area duration at 60 DAS (3.92 plant^{-1} and 109.3 days) followed by 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (3.72 plant^{-1} and 102.7 days), respectively. Application of recommended NPK through fertilizers produced higher grain and stover yield (4374 kg and 6.68 t ha^{-1}, respectively) with a harvest index of 0.40, followed by 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (3996 kg ha^{-1} grain and 6.46 t ha^{-1} stover) with a harvest index of 0.38 over rest of the treatments. The results of the study clearly indicates that the application of recommended NPK through fertilizers (100: 50: 25 kg ha^{-1} N, P_2O_5 and K_2O) recorded significantly higher grain yield (4374 kg ha^{-1}) and stover yield (6.68 t ha^{-1}) with a harvest index of 0.4, followed by the application of 50% N through fertilizer + 50% N through poultry manure + balance P and K as fertilizers (3996 kg ha^{-1} grain and 6.0 t ha^{-1}stover yields).

Nasim *et. al*. (2012). Conducted a field experiment at Agronomic Research Area, University of Agriculture, Faisalabad-Pakistan to examine the effect of organic and inorganic fertilization on maize productivity. The experiment was laid out in Randomized Complete Block Design (RCBD), with four replications. Two maize hybrids were used in this experiment. The results showed that maize yield and its component such as cobs per plant, cob length, number of grains per cob, 1000-

grain weight were maximum when the plots were fertilized at 100 kg N ha^{-1} as urea + 100 kg N ha^{-1} as poultry manure. Further research is desired to investigate maximum yield by using organic source of fertilizer than inorganic source of fertilizer to avoid lethal effects on human health created by inorganic fertilizers.

Balai *et al.* (2011) noticed that combined application of FYM 10 t ha^{-1} +Soil test recommended dose of NPK (120: 60:30 kg ha^{-1}) recorded highest protein (10.13 %) and carbohydrate (69.98 %) in Maize.

Saracoglu *et al.* (2011) conducted an experiment to evaluate the integrated nutrients effect on growth, yield and quality of maize (Zea mays L.) during spring, 2009, at the Agronomic Research Area, University of Agriculture, Faisalabad. The experiment was laid out in Randomized Complete Block Design (RCBD) having three replications with following treat-ments: T_1 (control), T_2(recommended NPK @ 200-120-125 kg ha^{-1}), T_3 [single spray of multinutrient (a solution mixture of micronutrients i e.; Zn = 2%, Fe = 1%, B = 1%, Mn = 1%, Cu = 0.2% and macronutrients N = 1%, K_2O = 2%, S = 2%) @ 1.25 L ha^{-1}], T_4 (recommended NPK @ 200-120-125 kg ha^{-1} + single spray of multinutrient @ 1.25 L ha^{-1}), T_5 (recommended NPK @ 200-120-125 kg ha^{-1} + two spray of multinutrient @1.25 L ha^{-1}) and T6 (recommended NPK @ 200-120-125 kg ha^{-1} + three spray of multinutrient @ 1.25 L ha^{-1}).The recommended dose of NPK in addition with single spray of multi-nutrients substationally improved all growth parameters, ear characteristics and also enhanced macronutrients use efficiency up to 11.5% which induced significant increase in grain yield as compared to control and also in the treatment where recommended dose of NPK was applied alone. The quality parameter of maize (oil contents) significantly improved by foliar application of multinutrients solution but recommended dose of fertilizer in addition to single spray of multi-nutrients was economical.

Phosphorus (P) is a limited resource, and its efficient use is a main task in sustainable agriculture. Due to high costs of imported fertilizers, focus is now shifting to solutions that utilize local resources. We tested the effect of two inorganic phosphorus (P) fertilizer, di-ammonium phosphate (DAP); triple super phosphate (TSP) and three organic materials farm yard manure (FYM), poultry manure (PM), compost (COM) on growth, yield, energy content and P utilization efficiency (PUE) of maize. DAP and TSP alone or in combination with each of organic materials i. e. FYM, PM and COM in combination (50:50 ratio) were applied to supply 90 kg P ha^{-1}. Both inorganic P fertilizers when applied in combination with either organic material significantly increased plant height, leaf area and chlorophyll content over control. Grain, dry matter, biomass yield and protein content increased by 74-101, 43-60, 55-75 and 42-70% over control. P uptake increased from 14 g kg^{-1} in control to 36 g kg^{-1} where DAP and PM was combined while increase in PUE was 10-27%. When applied in combination with organic materials, DAP+PM was the best treatment among P sources to be utilized (Mohsin *et al.*, 2011).

Aspasia *et al.* (2010) conducted an field experiment to determine the effects of inorganic and combined organic/inorganic fertilization on growth, photosynthesis and yield of a sweet maize crop (*Zea mays* L. F1 hybrid Midas), under Mediterranean climatic conditions. A randomized complete block design was employed with four replicates per treatment (inorganic fertilizer: 21-0-0), control and 12 combined organic (poultry, cow manure and barley) and inorganic fertilization (synthetic fertilizer: 21-0-0) treatments. The amount of N contributed to the soil via the different fertilization treatments was the same (240 kg N ha^{-1}). Organic soil amendments increased the level of soil organic matter and total nitrogen. The highest height, dry weight, leaf area index and yield were recorded with the cow manure treatments (with or without chemical fertilizer). Moreover, combined organic and inorganic fertilizers resulted in higher increase in photosynthetic rate and stomatal conductance compared with those found under inorganic fertilization. A high correlation coefficient ($r=0.926$, $p<0.001$) between yield and photosynthetic rate was found. Sustainability yield indices (sustainable yield index and agronomic efficiency) showed that the maize crop is more stable under combined organic and inorganic fertilization compared with mineral fertilization.

Quansah and Gabriel Willie (2010) conducted an experiment to characterize poultry manure and two composted materials (Household waste + poultry manure and Market waste + faecal sludge mixes in 3:1 ratio) based on their nutrient content and water holding capacity and to evaluate the influence of organic and inorganic fertilizers and their combination on the growth and yield of maize (*Zea mays*) in pot and field experiments at Soil Research Institute of CGSIR, Kwadaso, Kumasi, Ghana. The treatments were studied in a complete randomized design (CRD) in the pot experiment and in a randomized complete block design (RCBD) in the field experiment with three replications each. The results were analyzed by ANOVA and the standard error of differences (SED) was used to separate the means. Regression analysis was used to establish relationships between measured parameters. The experimental results showed that poultry manure was high in nutrients containing 2.06 % N, 0.52 % P and 0.73 % K whilst the composted materials were moderate in N and K but low in P. Percentage moisture of poultry manure at three stages; saturation, field capacity and 16 DAS were 119.51 %, 92.68 % and 63.41 % respectively which were higher than the values obtained under the composted materials. Water use efficiency (WUE) increased significantly with increasing dry matter production in the pot experiment. The combined treatments had WUE values higher than the values obtained by the sole organic or inorganic treatments alone. There were no significant differences ($P > 0.05$) in the vegetative growth of maize for the various treatments; however, the combined treatments gave higher values of plant height, girth, leaf area and number of leaves than organic and inorganic fertilizers used separately. Generally vegetative growth increased rapidly in all the treatments from 28 to 56 days after planting. The field experiment showed trends that were similar to those observed in the pot experiment. The combined applications produced yields, which were significantly higher than organic or inorganic alone and the control. The highest grain and stover yields of 8.0 tons ha^{-1} and 8.9 tons ha^{-1} respectively was recorded by the combined treatment of poultry manure with mineral fertilizer at a rate of 60 kg ha^{-1} N poultry manure and 60-40-40 kg ha^{-1} NPK mineral fertilizer, with the control recording the lowest grain and stover yields of 2.10 tons ha^{-1} and 4.30 tons ha^{-1} respectively. The combined treatments had significantly higher nutrient uptake values than the sole organic and inorganic fertilizers alone. The highest nutrient uptake values of 142.09 kg ha^{-1} N, 41.10 kg ha^{-1} P and 50.87 kg ha^{-1} K was recorded by the combined treatment of household waste and poultry manure mix compost with mineral fertilizer high rate. Differences in soil nutrient concentrations after harvest were marginal for all the treatments. Soil pH and total N decreased in all the treatments while percentage C and available P and K increased generally. Residual nutrients sustained maize plant growth and had yields, which were approximately 50% lower, with the sole application of mineral fertilizer as well as poultry manure high rate performing better than the combined applications contrary to what was observed in the major season.

An experiment was conducted by Ayoola and Makinde (2009) in the growing seasons of 2005 and 2006 at Ibadan, Nigeria, in the degraded tropical rain forest zone to assess the growth and yield of maize with Nitrogen-enriched organic fertilizer made from municipal waste and cow dung (2.5 t ha^{-1} Pacesetter fertilizer + 100 kg ha^{-1} urea)and also with Nitrogen-fortified poultry manure. Their performance was compared with those of inorganic NPK fertilizer and no fertilizer control. Maize growth was significantly ($P = 0.05$) affected by an enrichment of the organic manures. They had plants comparable in height with inorganic fertilizer application. At harvest, plants treated with fortified poultry manure were about 259 cm tall while those treated with fortified Pacesetter fertilizer and the plants treated with inorganic fertilizer were about 253 cm tall. Average plant leaf areas were similar with the fortified fertilizers and with inorganic fertilization. Length of days taken to achieve 50% tasselling was also reduced with fertilization. Inorganic fertilizer application gave plants that achieved 50% tasselling in 50days while fortified poultry manured - plants took 52 days and the fortified Pacesetter fertilizer – treated plants took 53 days.

Fertilization of maize gave significantly (P = 0.05) higher seed yields. Fortified poultry manure gave an average yield of 3.97 t ha^{-1} while fortified Pacesetter fertilizer had an average of 3.78 t ha^{-1}. Inorganic fertilizer gave a yield of 3.70 t ha^{-1} while a significantly lower yield of 2.48 t ha^{-1} was given by the unfertilized plants. Maize growth and yield from the enriched organic manures were comparable with inorganic fertilizer, indicating the potentials of the use of fortified organic manures as alternatives to inorganic fertilizers. Poultry manure required lesser N-fortification to give comparable seed yields as cow dung. Although both organic manures increased the soil N and P, poultry manure gave higher values while the soil K, Ca and Mg contents were more increased with the cow dung than poultry manure. Poultry manure, fortified with 100kg Urea can be applied at 2.5 t ha^{-1} to cultivate maize. It gives a comparable yield as inorganic fertilizer and increases the soil N and P.

Shah *et al*, (2009) conducted an field experiment to study growth and yield response of maize to organic and inorganic sources of N at the Agronomic Research Area, Univ. of Agriculture, Faisalabad. Two maize varieties namely Composite-78 and Composite-79 were fertilized with farm yard manure @15000 kg ha^{-1} and urea @ 260 kg ha^{-1} on a sandy clay loamy soil. Composite varieties differed significantly in plant height, numbers of cobs per plant, number of grains per cob, 1000-grains weight, grains yield and harvest index. Composite -78 performed best with respect to all growth and yield parameters expect numbers of plants per unit area and number of cob bearing plants. Combined use of urea and farm yard manure performed best than their sole application in respect of grain yield which was 6.13 tons ha^{-1}.

Mugwe *et al.* (2009) observed that use of green manures viz. *Calliandra calothyrsus*, *Leucaena trichandra* and *Tithonia diversifolia* or cattle manure contributing 30 kg N ha^{-1} in combination with chemical fertilizer (30 kg N ha^{-1}) produced higher maize yields compared to that with only chemical fertilizer (60 kg N ha^{-1}). Alone use of these manures contributing 60 kg N ha^{-1} also gave maize yields superior to that from N fertilizer alone at the same rate.

The FYM 20 t ha^{-1} + 60 kg N ha^{-1} increased plant height, 1000-grain weight, leaf area index and yield of maize over sole 120 kg N ha^{-1} (Khan *et al.,* 2009).

Efthimiadou *et al.* (2009) observed that growth and yield of sweet corn were significantly higher with poultry manure than obtained from conventional fertilizers. Moreover, poultry manure increased the photosynthesis rate, stomatal conductance and chlorophyll content in the plants. Similarly, an increase from 83.9 to108.7 % in yield of maize grain was recorded with the integration of organic and inorganic fertilizers (Sial *et al.*, 2007).

Yadav *et al.* (2006) observed that combined use of N, FYM and Zn proved the best in term of maize grain and stover yield, nutrient uptake, gross return, net return and benefit cost ratio against their sole application and farmers' practice. Macro and micro nutrient concentrations in leaves were greater with organic manure than with mineral fertilizer.

Wakene *et al.* (2005) initiated an experiment in 1997 cropping season to study the effect of supplementing low rates of NP fertilizers with farmyard manure FYM in the maize based farming systems of western Oromia, Ethiopia. The treatments used were 0/0, 20/20, 40/25 and 60/30 kg N/P ha^{-1} and 0, 4, 8, and 1 2 metric tonnes (t) of FYM ha^{-1} in factorial combination. The residual effects of FYM were investigated for Lagakalla, Walda and Shoboka during the 1998 cropping season. The result revealed that the main effects of N/P fertilizers and FYM significantly increased maize grain yields in all locations except for Valda in case of N/P fertilizers and except for Harato in case of FYM in 1997. In the same year, the interaction effects of the FYM and the low rates of NP fertilizers on grain yield were significant at all locations except for Shoboka. The interaction of the residual effects of the FYM and the low rates of NP fertilizers on grain yield were significant at Shoboka and LagaKalla sites during the 1998 season. Therefore, the integrated use of properly handled FYM and low rates NP fertilizers could be used for improved maize production in the areas under consideration.

A field experiment was implemented during the two successive seasons of 2002 and 2003 at the Agricultural Experimental Station of National Research Centre located at Qalubeya, Egypt involving *Azospirillum brasilense* and *Rhodotorula glutinis* in the presence of low rates of NPK and sulfur on maize crop. In comparison with the positive control (100 % NPK), comparable results for plant height, ear height and straw yield were obtained due to the biofertilization associated with half doses of NPK in the presence of either half or full dose of sulfur. Inclusion of sulfur to the recommended doses of NPK resulted in significant increases for the straw weight parameter. Application of *Azospirillum* significantly augmented maize growth parameters while the associative effect of *Azospirillum* and *Rhodotorula* was more pronounced. Maize yield and its attributes responded well to biofertilization supported with half doses of NPK and sulfur where the differences were not significant when compared with the positive control. A positive and significant correlation was found between maize yield and each of plant height, ear height, ear weight, ear length, ear diameter, grains weight, shelling percent, grain index, straw yield and biological yield while this correlation was not significant with rows number/ear, grains number/row, crop index and harvest index. Comparable results to the positive control were observed due to the associative action of biofertilizers, low rates of NPK and sulfur for the nutrient elements content of maize grains i.e., nitrogen, phosphorus, potassium sulfur, zinc, iron and manganese (El-Kholy *et al.*, 2005).

Oad *et al.* (2004) conducted an experiment at experimental farm, Sindh Agriculture University , Tandojam, Pakistan to assess the maize growth and fodder yield under varying combinations of organic manure Farm Yard Manure (FYM) at the rate of 1500, 3000, 4500 kg ha^{-1} and inorganic fertilizers (0, 60, 90, 120 and 150 kg N ha^{-1}). The results revealed that all the maize plant parameters were significantly affected with the incorporation of FYM and nirtrogen levels. Among the plant characters, tall plants, maximum stem girth, more green leaves and highest maize fodder yield were observed with the application of 120 kg N ha^{-1} with the application of 120 kg N ha^{-1} with combination of 3000 kg FYM. It was concluded that the inorganic nitrogen application is the common practice of the farmers, but if, farmyard manure will be supplemented there may be significant increase in maize fodder yield.

Integration of mineral fertilizers and FYM significantly enhances the grain yields of maize and wheat as compared to that with chemical fertilizers (Sharma and Subehia, 2003).

Ahmad *et al.* (2002) observed that root length and nutrient uptake of wheat increased significantly by combining organic manure and N fertilizer, which ultimately enhanced grain and straw yield.

Application of distillery effluent increased the leaf area, chlorophyll contents, nitrate reductase activity and grain yield of maize; however, the best grain yield was recorded with NPK+FYM (Ramana *et al.*, 2002).

Similar results for yield increase of maize and wheat with synergistic use of organic matter and mineral N fertilizers were obtained by Thind *et al*. (2002) observed that plant height and leaf area of wheat and maize significantly increased by combining organic and inorganic N fertilizers.

Positive effects of synergistic use of organic and chemical fertilizers are well established. Crop yields are improved if organic manure is supplemented with mineral fertilizers (Kanchikerimath and Singh, 2001).

Integrated use of FYM and inorganic fertilizers (NPK + Zn) significantly increased maize grain yield by 89% over NPK fertilizer alone (Adhikari *et al.*, 2001). It was result of organic matter increase in soil that sustains productivity in the long-term.

Pursushottani and Pun (2001) conducted a field experiment in Salooni, Himachal Pradesh India, during the rainy seasons of 1996 and 1997 to study the response of maize cultivars (Earlycomposite, parvati, and Salooni Local) to farmyard manure (0 and 15 t ha^{-1}) and N (0, 45, and 90 kg ha^{-1}) application. Among the cultivars, Salooni Local gave the tallest plant and longest cosbs as well as his highest number of cobs, 1000grain weight stover yield and grain yield. The application of 90 kg N and 15 t farmyard manure ha^{-1} gave the highest cob length, number of grains per cob, 1000 grain weight, grain and stover yields, and harvest index. The highest agronomic efficiency was obtained with 45 kg N and 15 t farmyard manure ha^{-1}. Grain yield was also highest with 90 kg N + 15 t farmyard manure ha^{-1}. Without farmyard manure, the yield obtained with 90 kg N ha^{-1} was equal to that obtained with 45 kg N + 15t farmyard manure ha^{-1}

Vadivel *et al.* (2001b) conducted a field experiment in Coimbatoire, Tamil Nadu, India, during winter of 1995-96 and 1996-97 to study the effects of organic N sources and N rate (0, 20, 40, and 60 kg ha on the growth and yield of maize cv. Co 1. The organic N sources were composted coir pith (6.25 t ha^{-1}) and enriched farmyard manure (750 kg supplied as basal and *Azospirillum* inoculated on seeds and soil. Enriched farmyard manure and 60 g N ha^{-1} gave the tallest plants and the highest leaf area index; cob length, girth and weight; 1000-grain weight; dry matter production; and grain and straw yields in both years.

Tripathi and Shrestha (2000) conducted field experiments in 3 systems rice cultivars Makawanpur-1and Ekie) wheat (cultivars Rohini and Annapurna-4) in bunded terraces (Chambas and Pakuwa) upland rice(cv. Tauii) blackgram v. Mash) in rainfed ancient terraces (Dordor Tar) and maize (cv. Manakamana-1) finger millet (cv. Okhle) in rainfed upland (Dordor Gaun) in Nepal from 1997 to 2000 to determine the response of different levels of N and farmyard manure

(FYM) and chemical fertilizers, alone or in combinations, on rice—wheat, upland rice—blackgram and maize—cropping systems. Full dose of nutrients through chemical fertilizers were matter than 5 FYM in upland rice increased organic c and full dose of chemical fertilizer increased available P. soil pH and exchangeable K decreased in all the treatments. At Dordor Tar, full dose of chemical fertilizer sustain organic C but decreased soil pH, total N and exchangeable K while 50% FYM 50% chemical fertilizers sustained available P.

Sahoo and Panda (1999) revealed that the grain yield of maize was 3682 kg ha^{-1} with NPK dose of 80:40:40 kg ha^{-1} when compared to application of FYM @ 5 t ha^{-1} + half the recommended NPK fertilizer (2246 kg ha^{-1}). The highest grain yield (5746 kg ha^{-1}) recorded with application of FYM @ 5 t ha^{-1} along with recommended dose of NPK fertilizer.

Reddy *et al*. (1987) found that application of NPK to maize @ 120:26.4:33.6 kg ha^{-1} recorded significantly higher grain yield attributes such as cob length, cob girth, grains per cob, 1000 grain weight, and grain yield over control which was on par with the treatment FYM 5 t ha^{-1} + 60: 32 :16.8 NPK kg ha^{-1}. The significant increase in yield attributes resulted in significant increase in grain yield (6074 kg ha^{-1}), stover yield (8779 kg ha^{-1}) and harvest index (43.72%) of maize.

Chapter III

Materials and Methods

CHAPTER III
MATERIALS AND METHODS

The experiment was undertaken during November 2011 to April 2012 to come across the optimum combination of chemical fertilizer, cowdung and compost aiming reduction of usage of chemical fertilizer in Maize variety-BARI hybrid maize 9 with 10 combinations of fertilizers. The materials and methods of this experiment are presented in this chapter under the following headings-

3.1 Experimental Site

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU). It is situated at 23°74$^{/}$ North latitude and 90°35$^{/}$ East longitude (Anon., 1989). The land was 8.6 m above the sea level. It belongs to Madhupur Tract (AEZ 28). For better understanding about experimental site it is shown in the Map of AEZ of Bangladesh in Appendix- I.

3.2 Climate

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Meteorological data related to the temperature, relative humidity and rainfall during the experiment period of was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix- III.

3.3 Soil

The field belongs to the general soil type which was characterized by shallow red brown terrace soil. The land of the selected experimental plot was medium high under the Tejgaon series. There was available sunshine during the experimental period. Soil sample was collected from 15 cm depth of the experimental site and was sent to SRDI, Dhaka for analysis. The result of analysis was given in Appendix-II.

3.4 Materials

(a) Seeds- BARI hybrid maize 9 was collected from Bangladesh Agricultural Research Institute (BARI).

(b) Fertilizers- Urea, TSP, MP, Gypsum, $ZnSO_{4,}$ Boric Acid, Cowdung and compost. Compost was collected from a project named "Adaptation of Button Mushroom in Bangladesh" under the Dept. of Biochemistry, SAU. Rest of the fertilizers was collected from the farm of SAU. Sample of cowdung and compost were sent to SRDI, Dhaka for analysis. The result of analysis was given in Appendix-III.

3.5 Description of the variety

BARI hybrid maize 9

Identifying character: Higher yield potential, resistant to diseases and pests.

Developed by (Centre/Division): Plant Breeding Division, BARI.

Year of release: 2007

Crop duration: 145-155

Yield : 10.2-13.8 t ha^{-1}

Suitable area: All over Bangladesh

Sowing time: 15 November – 15 December

Harvesting time: After attaining physiological maturity.

Major diseases and Management:

Diseases: Mainly leaf blight disease occurs at vegetative stage.

Management: Clean cultivation with timely sowing and balance fertilizer application.Seed treatment with vitavax- 200 @ 2.5g kg^{-1} seed, spraying with Tilt or Folicure @ 0.5% and burning of crop residues.

Major insect/pest and Management:

Insect pests: Cut worm and Stem borer attack at vegetative stage of maize. Ear worm attack in cob at reproductive stage in maize.

Mangement:

For cut worm: The larvae are killed after collecting from soil near the cut plants in morning. Dursban or Pyrifos 20 EC 5 ml liter^{-1} water sprayed especially at the base of plants to control cutworms

For ear worm: The larvae are killed after collecting from the infested cobs. Cypermethrin (Ripcord 10 EC/Cymbush 10 EC) @ 2 ml litre^{-1} water sprayed to control this pest

For stem borer: Marshall 20 EC or Diazinon 60 EC @ 2 ml litre^{-1} water sprayed properly to control the pest. Furadan 5 G or Carbofuran 5 G @ 20kg ha^{-1} applied on top of the plants in such a way so that the granules stay between the stem and leaf base. Such type of application of insecticides is known as whorl application.

3.6 Layout of the experiment

The experiment was laid out according to the experimental design (RCBD). The field was divided into 3 blocks to represent 3 replications. There were 30 unit plots altogether in the experiment. The size of each unit plot was 4m × 3m. Row to row and plot to plot distances were 75 cm and 25 cm, respectively. Distance maintained between replication and plots were 1.0m and 75m. The treatments were assigned in plot at random. Details layout of the experimental plot has been presented in Appendix III.

3.7 Experimental treatments

The experiment comprised with the following ten treatments including control

T_0: Control (without fertilizer)

T_1: All chemical fertilizer (recommended dose)

T_2: Cowdung (Recommended dose)

T_3: Compost (Recommended dose)

T_4: ½ Compost + ½ Cowdung

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

Recommended dose:

cowdung and compost - 6.0 t ha^{-1} , Urea, TSP, MP, Gypsum, $ZnSO_4$, Boric acid - 500-250-200-250-10-5 kg ha^{-1}, respectively.

3.8 Detail of experimental preparation

3.8.1 Land preparation

The plot selected for the experiment was opened in the second week of November 2011 with a power tiller and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross- ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed.

3.8.2 Fertilization

Well rotten cowdung and compost were applied @ 6.0 t ha^{-1} before final land preparation according to treatment. The recommended chemical fertilizer dose used for hybrid variety was 500-250-200-250-10-5 kg ha^{-1} of Urea, TSP, MP, Gypsum, $ZnSO_4$, Boric acid respectively. Fertilization (basal dose) was completed on 21 November, 2011. One third of urea along with full amount of other fertilizers as per treatment applied during final land preparation as basal dose and the rest urea as per treatment was applied in two equal installments as side dressing. The first installment of fertilizer was given on 26 December, 2011 and the second installment of fertilizer was given on 31 January, 2012.

3.8.3 Seed sowing:

Seeds of the variety BARI hybrid bhutta 9 was sown on 21 November, 2011 in lines maintaining a line to line distance of 75 cm and plant to plant distance of 25 cm having 2 seeds hole^{-1} in the well prepared plot.

3.9 Intercultural operations

3.9.1 Irrigation

First irrigation was given on 5 December, 2011 which was 15 days after sowing. Second irrigation was given on 21 December, 2011 which was 31 days after sowing. Third irrigation was given on 25 January, 2012 which was 65 days after sowing and fourth irrigation was given on 15 February, 2012 which was 85 days after sowing.

3.9.2 Gap filling, thinning, and weeding

Gap filling was done on 30 November, 2011 which was 10 days after sowing. During plant growth period one thinning and two weeding were done, thinning was done on 6 December, 2011which was 16 days after sowing and the weeding was done on 20 December, 2011 and 21 January, 2012 which was 30 and 60 days after sowing , respectively.

3.9.3 Earthing up

Earthing up was done on 26 December, 2011 which was 35 days after sowing. It was done to protect the plant from lodging and for better nutrition uptake.

3.9.4 Plant protection measures

Insecticides Diazinon 60 EC @ 2 ml litre^{-1} water were sprayed to control Stem borer on 5, 15 and 24 February, 2012 and Ripcord 10 EC @2 ml litre^{-1} water were sprayed to control ear worm on 10 and 17 March, 2012 to protect the crop.

3.9.5 Harvesting

The crops were harvested when the husk cover was completely dried and black coloration was found in the grain base. The cobs of five randomly selected plants of each plot were separately harvested for recording yield attributes and other data. The inner two lines were harvested for recording grain yield and stover yield. Harvesting was done on 25 April, 2012.

3.9.6 Drying

The harvested products were taken on the threshing floor and it was dried for about 3-4 days.

3. 10 Data collection

It was done on the basis of following parameter-

3.10.1 Plant height at different DAS (30, 50, 70, 90 DAS and at harvest)

At different stages of crop growth (30, 50, 70, 90 DAS and at harvest), the height of five randomly selected plants from the inner rows per plot was measured from ground level to the tip of the plant portion and the mean value of plant height was recorded in cm.

3.10.2 Leaf Area Index (LAI)

Leaf area index were estimated manually by counting the total number of leaves per plant and measuring the length and average width of leaf and multiplying by a factor of 0.70 (Kluen and Wolf, 1986). It was done at 30, 50, 70, 90 days after sowing (DAS) and at harvest.

$$\text{Leaf area index} = \frac{\text{Surface area of leaf sample } (\text{m}^2) \times \text{correction factor}}{\text{Ground area from where the leaves were collected}}$$

3.10.3 Dry matter content of shoot at different DAS (30, 50, 70, 90 DAS and at harvest)

From each plot 3 plants were uprooted randomly. Then the stem, leaves and roots were separated. The shoot sample (stem and leaves) was sliced into very thin pieces and put into envelop and placed in oven maintaining 70^0 C for 72 hours. Then the shoot sample was transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. It was performed at 30, 50, 70, 90 DAS and at harvest.

3.10.4 Dry matter content of root at different DAS (30, 50, 70, 90 DAS and at harvest)

Dry matter content in root was collected at 30, 50, 70, 90 DAS and at harvest. The root sample was put into envelop and placed in oven maintaining 70^0C for 72 hours. Then the root sample was transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken.

3.10.5 Crop Growth Rate (CGR)

The crop growth rate values at different growth stages were calculated using the following formula (Beadle, 1987).

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1} \text{ gm}^{-2}\text{day}^{-1}$$

Where,

W_1= Total dry matter production at previous sampling date

W_2= Total dry matter production at current sampling date

T_1= Date of previous sampling

T_2= Date of current sampling

GA= Ground area (m^2)

3.10.6 Relative Growth Rate (RGR)

The relative growth rate (RGR) values at different growth stages were calculated using the following formula (Beadle, 1987).

$$RGR = \frac{Log_e W_2 - Log_e W_1}{T_2 - T_1} \text{ g g}^{-1} \text{ day}^{-1}$$

Where,

W_1= Total dry matter production at previous sampling date

W_2= Total dry matter production at current sampling date

T_1= Date of previous sampling

T_2= Date of current sampling

Log_e= Natural logarithm

3.10.7 Days to tasseling

Days to flowering of male was recorded as the number of days from planting date to pollen shedding in 50% of plants in the plot.

3.10.8 Days to silking

The number of days recorded from the date of planting to the emergence of silks in 50% plants in the plots.

3.10.9 Days to maturity

Maturity time was recorded in days from the date of planting to the date of black layer formation of grain base of 50% population.

3.10.10 Tassel length

Tassel length was measured in centimeter from the base of the tassel to the top portion of tassel at each of the five randomly selected plants in each plot.

3.10.11 Cob to tassel height

It was measured in centimeter from the base of the topmost cob to the top portion of tassel at each of the five randomly selected plants in each plot.

3.10.12 Number of cobs plant^{-1}

The number of cobs plant^{-1} was counted from eight randomly sampled plants. It was done by counting total number of cobs and divided by total number of sampled plants.

3.10.13 Length of cob (cm)

Ten randomly selected cobs were taken from each plot to measure the length from the base to the tip of the ear. The average result was recorded in cm.

3.10.14 Diameter of cob (cm)

Ten cobs were randomly selected plot^{-1} and the diameter was taken from 3 portion of each cob (upper, middle and lower portion). Then average result was recorded in cm.

3.10.15 Number of grain rows cob^{-1}

Eight cobs from each plot were selected randomly and the number of rows was counted and then the average result was recorded.

3.10.16 Number of grains cob^{-1}

The numbers of grains cob^{-1} was measured from the base to tip of the ear collected from ten randomly selected cobs of each plot and finally averaged.

3.10.17 Weight of 1000 grains

From the seed stock of each plot 1000 seeds were counted and the weight was measured by an electrical balance. It was recorded in gram.

3.10.18 Shelling percentage

Eight cobs were randomly selected plot^{-1} and shelling percentage was calculated by using the following formula -

$$\text{Shelling percentage} = \frac{\text{Grain weight}}{\text{Cob weight}} \times 100$$

3.10.19 Grain yield (t ha^{-1})

Grain yield was calculated from cleaned and well dried grains collected from the central 1.5 m^2 area of all 2 inner rows of the each plot (leaving two boarder rows) and expressed as t ha^{-1} on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

3.10.20 Stover yield (t ha^{-1})

Stover yield was determined from the central 1.5m length of all 2 inner rows of the each plot. After threshing, the sub sample was oven dried to a constant weight and finally converted to t ha^{-1}.

3. 10. 21 Biological yield (t ha^{-1})

It was the total yield including both the economic and stover yield.

3.10.22 Harvest index (HI)

Harvest index is the ratio of economic (grain) yield and biological yield. It was calculated by dividing the economic yield grain from the harvested area by the biological yield of the same area (Donald, 1963) and multiplying by 100.

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (t/ ha)}}{\text{Biological yield (t/ ha)}} \times 100$$

Here, Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Stover yield (t ha^{-1})

3.11 Quality analysis

Sample of grain was made from each plot of each three replication and was sent to Bangladesh Agricultural Research Institute (BARI). Percent of protein and percent of carbohydrate was measured by using automatic grain analyzer machine (Model no.1241).

3.12 Statistical analysis

The obtained data for different characters were statistically analyzed with the computer based software MSTAT-C to find out feasibility of replacing chemical fertilizer by using organic fertilizer on the performance of maize and the mean values of all characters were evaluated and analysis of variances were performed by the F-test. The significance of the difference among treatment means were estimated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the feasibility of replacing chemical fertilizer by organic fertilizer in maize production. Data on different growth, yield contributing characters and yield of maize were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix V-XV . The results have been presented and discussed with the help of Tables and Graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height is an important morphological character that acts as a potent indicator of availability of growth resources in its vicinity. Plant height varied significantly at 30, 50, 70 and 90 DAS, and at harvest for different chemical and organic fertilizer and their combinations under the present trial (Appendix V). At 30 DAS, the longest plant (42.67cm) was recorded from T_1 (All chemical fertilizer as recommended dose), which was statistically similar with T_8 (Cow dung + Compost + ½ Chemical fertilizer), T_9 (½ Cow dung + ½ Compost + ½ Chemical fertilizer), while the shortest plant (31.98 cm) was obtained from T_0 (control condition). At 50 DAS, the tallest plant (95.13 cm) was recorded from T_1 treatment, whereas the shortest plant (61.43 cm) was obtained from T_0. At 70 DAS, the longest plant (149.70 cm) was recorded from T_1, which was statistically at per with T_8 and T_9 (146.8 cm, 147.7 cm, respectively) and the shortest plant (97.00 cm) was found from T_0. At 90 DAS, the longest plant (229.30 cm) was recorded from T_1, which was statistically similar with T_9, T_8, T_7, (228.10cm, 227.80 cm, 226.00 cm, respectively) and, whereas the shortest plant was recorded from T_0 (148.70 cm). At harvest, the tallest plant was attained from T_1 (240.50 cm), which was statistically similar with T_8, T_9, T_7 and T_6 (240.30, 239.20, 238.30, 236.00 cm, respectively) and the shortest plant (188.90 cm) was recorded from T_0 (Table 1). Application of all chemical fertilizer in recommended doses ensured the essential macro and micro nutrients for the vegetative growth of the maize and the ultimate results were the longest plant. Combination of cow dung, compost and chemical fertilizers half in recommended doses also created a favorable condition for the growth and development of maize plant for that combination of cow dung, compost and half chemical fertilizers also gave the similar results. The variation of plant height due to different fertilizer use was also reported by Eltelib *et al.* (2006) and Agba *et al.* (2005). These results also collaborate the findings of Mohsin *et al.* (2011), Oad *et al.* (2004), Akbar *et al*. (2002), Thind *et al.* (2002), Vadivel *et al.* (2001b), Ali *et al.* (1999) and Ogunlela *et al*. (1998).

Table 1. Effect of chemical and organic fertilizers and their combinations on plant height of maize

Treatments	Plant height (cm)				
	30 DAS	50 DAS	70 DAS	90 DAS	at harvest
T_0	31.98 d	61.43 e	97.0 e	148.7 e	188.9 C
T_1	42.67 a	95.13 a	149.7 a	229.3 a	240.5 A
T_2	33.47 cd	69.45 de	108.8 de	169.7 d	200.5 Bc
T_3	35.59 b-d	72.96 cd	116.9 c-e	179.2 cd	205.4 Bc
T_4	36.13 b-d	75.47 cd	124.4 b-d	185.9 cd	208.6 Bc
T_5	37.73 a-c	78.25 cd	128.3 a-d	199.2 bc	214.5 B
T_6	39.51 ab	79.96 cd	138.4 a-c	217.1 ab	236.0 A
T_7	39.67 ab	82.51 bc	140.2 ab	226.0 a	238.3 A
T_8	42.05 a	92.01 ab	146.8 a	227.8 a	240.3 A
T_9	42.44 a	93.31 ab	147.7 a	228.1 a	239.2 A
$LSD_{(0.05)}$	4.848	10.73	20.02	21.04	20.92
CV (%)	7.41	7.81	8.99	6.10	5.51

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

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.2 Leaf Area Index (LAI)

Leaf Area Index (LAI) expresses the ratio of leaf surface area to the ground area. It is one of the important determinants of dry matter (DM) production. Crop production practically means the efficient interception of photo synthetically active radiation (PAR) and its conversion into food and other useable materials. Efficient interaction of PAR by a crop canopy requires adequate leaf area expansion. According to Gay and Bloc (1992), LAI values above 5.0 under typical conditions in Europe are suggestive of a high yield potential of maize. Statistically significant variation was recorded for leaf area index at 30, 50, 70 and 90 DAS, and at harvest for different chemical and organic fertilizers and their combinations (Appendix VI). At 30 DAS, the maximum leaf area index was recorded from T_1 (0.235), whereas the minimum leaf area index was found from T_0 (0.091). At 50 DAS, the maximum leaf area index was recorded from T_1 (1.201), which was statistically at similar with T_7 (1.15), T_8 (1.082), T_9 (1.117), while the minimum values was recorded from T_0 (0.452). At 70 DAS, the maximum values of leaf area index was recorded from T_1 (3.926), again the minimum leaf area index was found from T_0 (1.310). At 90 DAS, the maximum values of leaf area index was recorded from T_1 (6.149), which was statistically similar with T_7 (6.105), T_8 (6.031), while the minimum leaf area index was observed from T_0 (2.955). At harvest, the maximum values of leaf area index was obtained from T_1 (4.957), which was closely followed by T_8 (4.721) and the minimum leaf area index was recorded from T_0 (2.959) (Table 2). The variation of LAI due to different fertilizer use was also reported by Saracoglu *et al.* (2011), Khan *et al.* (2009), Eltelib *et al.* (2006), Thind *et al.* (2002) and Vadivel *et al.* (2001b).

Table 2. Effect of chemical and organic fertilizers and their combinations on Leaf Area Index (LAI) of maize

Treatments	Leaf Area Index (LAI)				
	30 DAS	50 DAS	70 DAS	90 DAS	at harvest
T_0	0.091 f	0.452 e	1.310 g	2.955 e	2.959 e
T_1	0.235 a	1.206 a	3.926 a	6.149 a	4.957 a
T_2	0.105 f	0.630 d	1.558 fg	3.644 de	3.270 de
T_3	0.126 e	0.726 cd	1.724 ef	4.237 d	3.370 de
T_4	0.134 e	0.799 bc	1.836 e	4.381 cd	3.377 de
T_5	0.151 d	0.829 bc	2.316 d	5.041 bc	3.723 cd
T_6	0.178 c	0.873 b	2.409 d	5.468 ab	4.140 bc
T_7	0.191 c	1.150 a	3.509 b	6.105 a	4.605 ab
T_8	0.210 b	1.082 a	2.747 c	6.093 a	4.721 a
T_9	0.188 c	1.112 a	2.914 c	5.645 ab	4.600 ab
LSD $_{(0.05)}$	0.017	0.133	0.249	0.744	0.491
CV (%)	9.98	8.88	5.97	8.72	7.21

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

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.3 Dry matter content

4.3.1 Dry weight of shoot

Different chemical and organic fertilizers and their combinations showed significant variation for dry weight of shoot at 30, 50, 70 and 90 DAS, and at harvest (Appendix VII). At 30 DAS, the highest dry weight of shoot was recorded from T_1 (0.70 g), which was statistically similar with T_8 and T_9, (0.65 g and 0.68 g, respectively), whereas the lowest was obtained from T_0 (0.25 g). At 50 DAS, the highest dry weight of shoot was observed from T_1 (6.85 g), which was statistically similar with T_9 (6.76 g) and followed by T_8 (6.58 g), whereas the lowest was obtained from T_0 (1.71 g). At 70 DAS, the highest dry weight of shoot was obtained from T_1 (43.70 g), which was statistically similar with T_8 and T_9 (42.46 g and 42.05 g, respectively), while the lowest was obtained from T_0 (17.27 g). At 90 DAS, the highest dry weight of shoot was recorded from T_1 (101.60 g) and that of lowest from T_0 (36.86 g). At harvest, the highest dry weight of shoot was attained in T_1 (250.10 g), which was statistically similar with T_8, T_9, T_7 and T_6 (249.40 g, 248.00 g, 241.10 and 240.00 g, respectively) again the lowest was obtained from T_0 (114.60g) (Table 3). Application of all chemical fertilizer in recommended doses gave the highest dry matter accumulation followed by the combination of cowdung, compost and chemical fertilizers half in recommended doses.

Table 3. Effect of chemical and organic fertilizers, and their combinations on dry weight of shoot of maize

Treatments	Dry weight of shoot (g)				
	30 DAS	50 DAS	70 DAS	90 DAS	at harvest
T_0	0.25 e	1.71 g	17.27 e	36.86 d	114.60 c
T_1	0.70 a	6.85 a	43.70 a	101.60 a	250.10 a
T_2	0.32 de	3.92 e	19.82 de	42.82 d	138.50 c
T_3	0.35 c-e	3.24 f	21.12 de	46.10 d	139.30 c
T_4	0.38 c-e	4.48 d	22.87 cd	59.22 c	187.80 b
T_5	0.46 b-d	4.62 d	25.55 c	62.12 c	192.60 b
T_6	0.52 a-c	5.97 c	36.49 b	88.68 b	240.00 a
T_7	0.62 ab	6.19 bc	36.90 b	90.38 ab	241.10 a
T_8	0.65 a	6.58 ab	42.46 a	99.88 ab	249.40 a
T_9	0.68 a	6.76 a	42.05 a	99.85 ab	248.00 a
LSD $_{(0.05)}$	0.16	0.49	3.91	11.67	35.05
CV (%)	11.69	5.61	7.39	9.35	10.21

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

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.3.2 Dry weight of root

Different chemical and organic fertilizers and their combinations treatments showed significant variation for dry weight of root at 30, 50, 70 and 90 DAS, and at harvest (Appendix VIII). At 30 DAS, the highest dry weight of root was recorded from T_1 (0.15 g), whereas the lowest was obtained from T_0 (0.04 g). At 50 DAS, the highest dry weight of root was observed from T_1 (1.08 g) whereas the lowest was obtained from T_0 (0.24 g). At 70 DAS, the highest dry weight of root was obtained from T_1 (5.40 g), which was statistically similar with T_8, T_9 and T_7 (5.32, 5.37 g and 4.85 g, respectively), while the lowest was obtained from T_0 (1.96 g). At 90 DAS, the highest dry weight of root was recorded from T_1 (12.49 g), which was statistically similar with T_8 and T_9 (12.33 g and 12.47 g, respectively) and that of lowest from T_0 (3.75 g). At harvest, the highest dry weight of root was attained in T_1 (34.59 g), which was statistically similar with T_8 and T_9, (34.07 g, and 34.22 g respectively) again the lowest was obtained from T_0 (11.85g) (Table 4). Agarwal *et al.* (1995) observed that farmyard manure improved root and leaf growth of maize. This type of variation in dry weight was also reported by Mohsin *et al*. (2011), Khan *et al*. (2009), Eltelib *et al.* (2006), Abbas (2005), Thind *et al*. (2002),Vadivel *et al.* (2001b) , Ogunlela *et al*. (1998), Haque and Hamid (1998) and Ramamurthy and Shivashankar (1996).

Table 4. Effect of chemical and organic fertilizers, and their combinations on dry weight of root of maize

Treatments	Dry weight of root (g)				
	30 DAS	50 DAS	70 DAS	90 DAS	at harvest
T_0	0.04 f	0.24 e	1.96 e	3.75 e	11.85 E
T_1	0.15 a	1.08 a	5.40 a	12.49 a	34.59 A
T_2	0.06 ef	0.47 d	2.41 de	4.36 e	14.05 De
T_3	0.06 de	0.48 d	2.66 d	5.19 d	15.46 c-e
T_4	0.07 c-e	0.59 cd	2.91 cd	5.77 cd	17.46 Cd
T_5	0.08 cd	0.63 c	3.37 c	6.16 c	18.51 C
T_6	0.09 c	0.90 b	4.17 b	8.62 b	25.92 B
T_7	0.11 b	0.90 b	4.85 a	8.94 b	27.04 B
T_8	0.11 b	1.00 ab	5.32 a	12.33 a	34.07 A
T_9	0.12 b	1.02 ab	5.37 a	12.47 a	34.22 A
$LSD_{(0.05)}$	0.02	0.12	0.65	0.80	3.89
CV (%)	9.79	11.08	9.79	5.82	9.73

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

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.4 Crop Growth Rate

Crop Growth Rate (CGR) varied significantly for different chemical and organic fertilizers and their combinations at 30-50 DAS, 50-70 DAS , 70-90 DAS and 90-harvest (Appendix IX). At 30-50 DAS, the highest CGR was found in T_1 (1.88g m^{-2} day^{-1}), while the lowest CGR was recorded in T_0 (0.443 g m^{-2} day^{-1}). At 50-70 DAS, the highest CGR was found in T_1 (11.04 g m^{-2} day^{-1}), while the lowest CGR was recorded in T_0 (4.605 g m^{-2} day^{-1}). At 70-90 DAS, the highest CGR was found in T_1 (17.77 g m^{-2} day^{-1}), while the lowest CGR was recorded in T_0 (5.696 g m^{-2} day^{-1}). At 90-harvest, the highest CGR was found in T_8 (14.04 g m^{-2} day^{-1}), while the lowest CGR was recorded in T_0 (7.04 g m^{-2} day^{-1}) (Table 5). Increase N level increases CGR. Similar results was also reported by Abbas (2005) and Haque and Hamid (1998).

4.5 Relative Growth Rate

Relative Growth Rate (RGR) showed significant variation for different chemical and organic fertilizers and their combinations at 30-50 and 50-70 DAS (Appendix X). At 30-50 DAS, the highest RGR was found in T_1 (0.122 g g^{-1} day^{-1}), which was statistically similar with all treatment and the lowest RGR was recorded in T_0 (0.085 g g^{-1} day^{-1}). At 50-70 DAS, the highest RGR was found in T_2 (0.114 g g^{-1} day^{-1}) and the lowest RGR was recorded in T_0 (0.080 g g^{-1} day^{-1}). At 70-90 DAS, the highest RGR was found in T_4 (0.044 g g^{-1} day^{-1}), which was statistically similar with all treatment and the lowest RGR was recorded in T_0 (0.037 g g^{-1} day^{-1}). At 90-at harvest, the highest RGR was found in T_2 (0.0183 g g^{-1} day^{-1}) and the lowest RGR was recorded in T_1, T_8, and T_9 (0.0140 g g^{-1} day^{-1}) (Table 6).

Table 5. Effect of chemical and organic fertilizers, and their combinations on Crop Growth Rate (CGR) of maize

Treatments	Crop Growth Rate (g m^{-2} day^{-1}) at different DAS			
	30-50	50-70	70-90	90-harvest
T_0	0.443 g	4.605 d	5.696 c	7.04 c
T_1	1.880 a	11.040 a	17.770 a	13.96 a
T_2	1.069 e	4.756 d	6.647 c	8.644 bc
T_3	0.880 f	5.345 cd	7.331 c	8.485 bc
T_4	1.228 d	5.521 cd	10.450 b	11.5 ab
T_5	1.256 d	6.307 c	10.490 b	11.72 ab
T_6	1.452 c	9.220 b	15.090 a	13.83 a
T_7	1.696 b	9.237 b	15.340 a	13.85 a
T_8	1.840 a	10.670 a	16.820 a	14.04 a
T_9	1.847 a	10.540 a	17.200 a	13.96 a
LSD $_{(0.05)}$	0.1329	1.195	2.995	3.363
CV (%)	7.03	9.22	9.48	5.65

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

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

Table 6. Effect of chemical and organic fertilizers, and their combinations on Relative Growth Rate (RGR) of maize

Treatments	Relative growth rate (g g^{-1} day^{-1}) at different DAS			
	30-50	**50-70**	**70-90**	**90- harvest**
T_0	0.085 b	0.080 e	0.037	0.0173
T_1	0.122 a	0.091 b-d	0.043	0.0140
T_2	0.121 a	0.114 a	0.038	0.0183
T_3	0.110 a	0.092 bc	0.039	0.0170
T_4	0.120 a	0.081 e	0.046	0.0177
T_5	0.114 a	0.085 de	0.043	0.0170
T_6	0.116 a	0.095 b	0.043	0.0157
T_7	0.115 a	0.088 cd	0.044	0.0153
T_8	0.116 a	0.093 bc	0.041	0.0140
T_9	0.113 a	0.090 b-d	0.044	0.0140
LSD $_{(0.05)}$	0.017	0.005	NS	NS
CV (%)	9.85	6.52	8.43	6.75

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

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.6 Days to tasseling

Statistically significant variation was recorded for days to tasseling for different chemical and organic fertilizers, and their combinations treatments (Appendix XI). Delayed tasseling (99 days) was found in T_1 treatment and tasseling was earliest (88.67 days) in T_0 (Table 7). Increased rate of NPK delayed tasseling. Similar observation was also reported by Hassan (2005), Akbar *et al.* (2002) and Ali *et al.* (1999). But this result was dissimilar with the findings of Ogunlela *et al.* (1998) who observed increased nitrogen fertilization hastened tasseling in maize.

4.7 Days to silking

Days to silking showed statistically significant variation for different chemical and organic fertilizers, and their combinations (Appendix XI). Delayed silking (106.70 days) was found in T_1 treatment and silking was earliest (93.00 days) in T_0 treatment (Table 7). Increased rate of NPK delayed silking. Similar observation was also reported by Hassan (2005), Akbar *et al.* (2002) and Ali *et al*. (1999).

4.8 Days to maturity

There was a marked difference among the different chemical and organic fertilizers, and their combinations on the days to maturity (Appendix XI). Delayed maturity (151.3 days) was found in T_1 treatment and maturity was earliest (140.7 days) in T_0 treatment (Table 8). Increased rate of NPK delayed days to maturity. Similar observation was also reported by Hassan (2005), Akbar *et al.* (2002) and Ali *et al*. (1999).

Table 7. Effect of chemical and organic fertilizers and their combinations on days to tasseling, days to silking and days to maturity of maize

Treatments	Days to 50% tasseling	Days to 50% silking	Days to 50% maturity
T_0	88.67 c	93.00 c	140.70 d
T_1	99.00 a	106.70 a	151.00 a
T_2	91.00 bc	95.00 bc	141.30 d
T_3	93.33 a-c	98.33 a-c	141.00 d
T_4	95.33 ab	98.67 a-c	142.70 cd
T_5	93.67 a-c	98.67 a-c	142.30 cd
T_6	94.33 a-c	101.00 a-c	145.70 c
T_7	96.33 ab	102.00 a-c	146.30 bc
T_8	97.67 a	104.70 a-c	150.30 a
T_9	95.00 ab	101.00 a-c	142.70 cd
$LSD_{(0.05)}$	5.28	9.76	3.85
CV (%)	6.26	5.69	5.14

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

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.9 Tassel length

Significant variation was recorded in case of tassel length for different chemical and organic fertilizers, and their combinations (Appendix XII). The longest tassel was observed in T_1 (41.87 cm), and closely followed by T_8 and T_9 (41.54 and 41.47 cm, respectively), again the shortest tassel was recorded from T_0 (34.47 cm) (Table 8). Application of all chemical fertilizer as per recommended doses gave longest tassel with ensuring optimum vegetative growth as well as reproductive growth of Maize followed by the combination of cowdung, compost and chemical fertilizers half in recommended doses.

4.10 Cob to tassel height

Significant variation was recorded in cob to tassel height for different chemical and organic fertilizer, and their combinations (Appendix XII). The maximum cob to tassel height was observed in T_5 (72.13 cm), which was statistically similar with T_8 and T_7 (71.60 cm and 71.17 cm, respectively), again the minimum cob to tassel height was recorded from T_0 (62.20 cm) (Table 8).

4.11 Number of cobs plant^{-1}

Number of cobs plant^{-1} showed statistically significant variation for different chemical and organic fertilizers, and their combinations (Appendix XII). The maximum number of cobs plant^{-1} was found in T_1 (1.67), which was statistically similar with T_8, T_9, T_7 and T_6 (1.63, 1.61, 1.53, and 1.43, respectively), while the minimum number from T_0 (1.00) (Table 8). Increased rate of NPK increased the number of cobs per plant. These result were in agreement with Hassan (2005), Akbar *et al.* (2002) and Ogunlela *et al*. (1998). The result was consistence with the findings of Shah *et al*. (2009) who reported positive influence of the addition of organic matter.

Table 8. Effect of chemical and organic fertilizers, and their combinations on tassel length, cob to tassel height and cob plant^{-1} of maize

Treatments	Tassel length (cm)	Cob to tassel height (cm)	Number of cobs plant^{-1}
T_0	34.470 d	62.200 b	1.00 b
T_1	41.870 a	69.400 ab	1.67 a
T_2	35.270 d	70.130 ab	1.03 b
T_3	36.470 cd	67.770 ab	1.07 b
T_4	36.800 bcd	70.070 ab	1.07 b
T_5	38.320 abcd	72.130 a	1.10 b
T_6	39.000 abcd	68.330 ab	1.43 a
T_7	40.790 abc	71.170 a	1.53 a
T_8	41.540 ab	71.600 a	1.63 a
T_9	41.470 ab	68.370 ab	1.61 a
LSD $_{(0.05)}$	4.256	7.649	0.282
CV (%)	6.43	7.91	12.44

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

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.12 Cob length

Significant variation was recorded in case of cob length for different chemical and organic fertilizers, and their combinations (Appendix XII). The longest cob was observed in T_1 (22.27 cm), which was statistically similar with T_8 and T_9 (22.16 cm and 22.14 cm, respectively), again the shortest cob was recorded from T_0 (17.39 cm) (Figure 1). Application of all chemical fertilizer as per recommended doses gave longest cob with ensuring optimum vegetative growth as well as reproductive growth of Maize followed by the combination of cowdung, compost and chemical fertilizers half in recommended doses. The result was in agreement with those stated by Agba *et al*. (2005), Hassan (2005) and Oktem and Oktem (2005) who observed the similar result. That with the reduction of chemical fertilizer, the cob length was also reduced.

4.13 Diameter of cob

The different chemical and organic fertilizers, and their combinations had significant effect on cob diameter. Agba *et al*. (2005), Oktem and Oktem (2005), Vadivel *et al*. (2001b) and Ogunlela *et al*. (1998) also reported that the similar higher cob diameter was found due to the various level nitrogenous fertilizer application. Reduction of normal chemical fertilizer dose also reduced the cob diameter of maize. The highest cob diameter (14.12 cm) was obtained with T_1 treatment, which was statistically similar with T_8 and T_9 (13.79 cm and 13.60 cm, respectively). The lowest cob diameter (12.14 cm) was found in the T_0 (Figure 2).

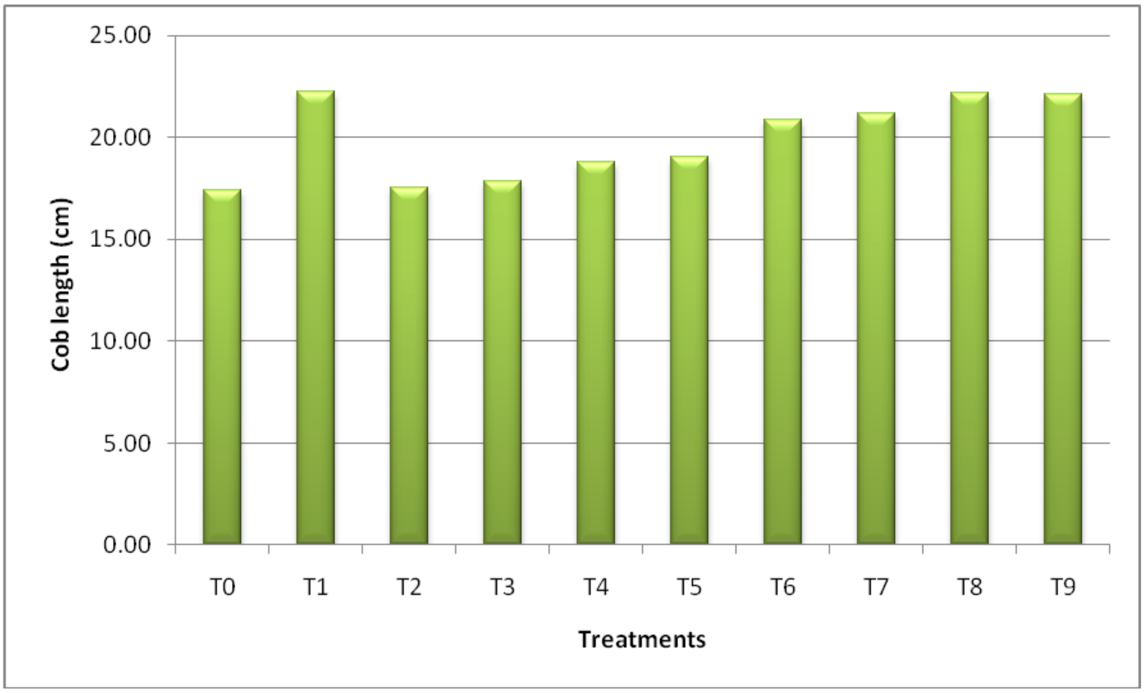

Figure 1. Effect of chemical and organic fertilizers and their combinations on cob length of maize (LSD $_{(0.05)}$ = 2.17)

Here,

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

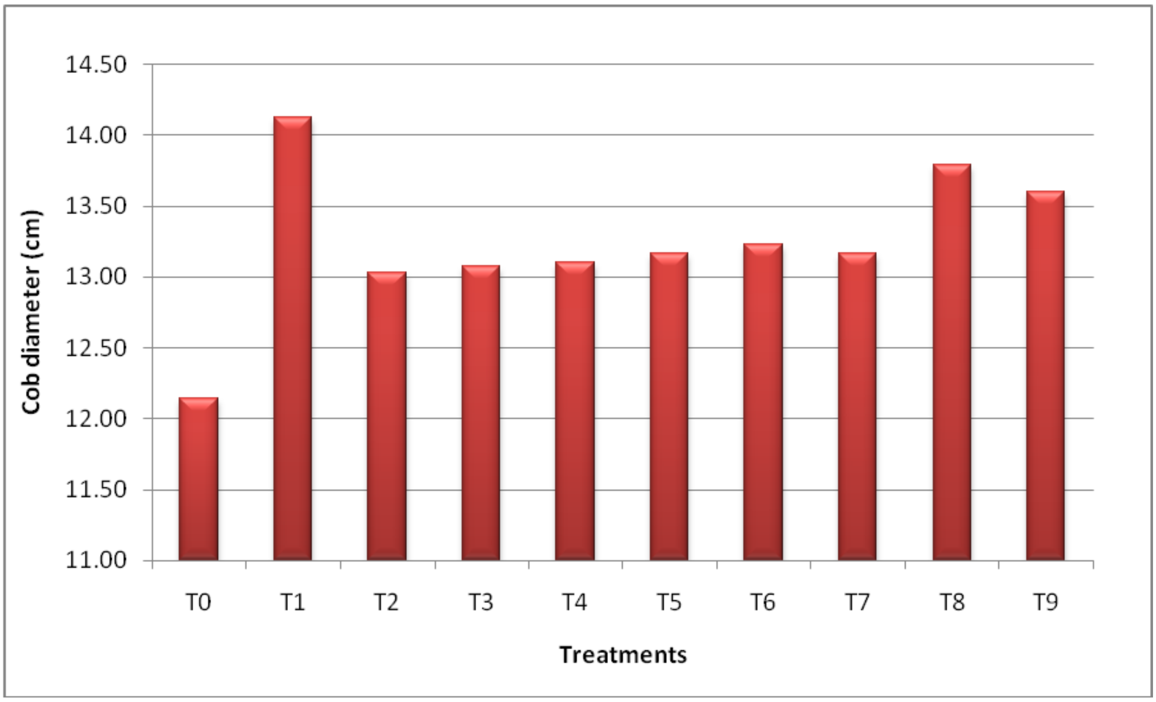

Figure 2. Effect of chemical and organic fertilizers and their combinations on cob diameter of maize (LSD $_{(0.05)}$ = 1.11)

Here,

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.14 Number of grain rows cob^{-1}

Statistically significant variation was recorded for number of grain rows cob^{-1} for different chemical and organic fertilizers, and their combinations (Appendix XIII). The highest number of grain rows cob^{-1} was obtained from T_1 (15.62), which were statistically similar with T_8, T_7, T_9 and T_6, while the lowest number was recorded from T_0 (14.25), (Table 9). These finding was in agreement with Hassan (2005) who showed that increased rate of NPK increased the number of grain rows cob^{-1}.

4.15 Number of grains cob^{-1}

Statistically significant variation was recorded for grains cob^{-1} for different chemical and organic fertilizers and their combinations (Appendix XIII). The highest total grains cob^{-1} was obtained from T_1 (531.90), while the lowest total grain per cob was recorded from T_0 (435.60), (Table 9). Similar findings were reported by Hassan (2005), Oktem and Oktem (2005) and Ogunlela *et al.* (1998).

4.16 Weight of 1000 grains (g)

Weight of 1000 seed varied significantly due to different chemical and organic fertilizers, and their combinations treatments (Appendix XIII). Hassan (2005), Akbar *et al.* (2002) and Ali *et al.* (1999) observed that increasing nitrogen application increased weight of 1000 seeds. The highest weight of 1000 seeds was recorded from T_1 (305.30 g), which was statistically similar with T_8 and T_9 treatments and the lowest weight was recorded from T_0 (234.50 g) (Table 9).

Table 9. Effect of chemical and organic fertilizers, and their combinations on number of rows cob^{-1}, grains cob^{-1} and thousand seed weight of maize

Treatments	Number of grain rows cob^{-1}	Number grains cob^{-1}	Thousand seed weight (g)
T_0	14.25 c	435.60 b	234.50 C
T_1	15.62 a	531.90 a	305.30 A
T_2	14.43 bc	440.80 b	248.30 Bc
T_3	14.82 a-c	436.50 b	250.80 Bc
T_4	15.06 ab	491.40 ab	251.50 Bc
T_5	15.13 ab	491.10 ab	270.20 a-c
T_6	15.21 a	519.80 ab	287.50 Ab
T_7	15.50 a	522.50 ab	290.60 Ab
T_8	15.57 a	521.90 ab	303.10 A
T_9	15.35 a	521.60 ab	304.90 A
$LSD_{(0.05)}$	0.703	79.690	45.000
CV (%)	7.69	9.46	9.55

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

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.17 Shelling percentage

Shelling percentage varied significantly due to different chemical and organic fertilizers, and their combinations (Appendix XIII). The highest shelling percentage was recorded from T_1 (78.95) and the lowest shelling percentage was recorded from T_0 (71.26) (Figure 3). Reduction of recommended chemical fertilizer, the Shelling percentage was reduced. The similar result was found by El-Kholy *et al.* (2005).

4.18 Grain yield (t ha^{-1})

Statistically significant variation was recorded in the grain yield ha^{-1} for different chemical and organic fertilizers, and their combinations (Appendix XIV). The highest yield was obtained from T_1 (11.75 t ha^{-1}), which was statistically similar with T_8, T_9, T_7 and T_6 (respectively for 11.67 t ha^{-1}, 11.56 t ha^{-1}, 10.90 t ha^{-1} and 10.81 t ha^{-1}). On the other hand, the lowest yield was found in T_0 (4.16 t ha^{-1}) (Table 10). Ahmed and Hossain (1992) reported that chemical and organic fertilizer, the major essential plant nutrient, plays an important role in producing higher grain yield of maize. The result was consistence with the findings of Baron *et al.* (1995) who reported positive influence of the addition of organic matter not only on soil properties but also on the mineral nutrient of plants and yield. This result also collaborate with the findings of Khan *et al.* (2009), Sial *et al.* (2007). Hassan (2005), Sharma and Subehia (2003), Sahoo and Panda (1999) and Ali *et al.* (1999).

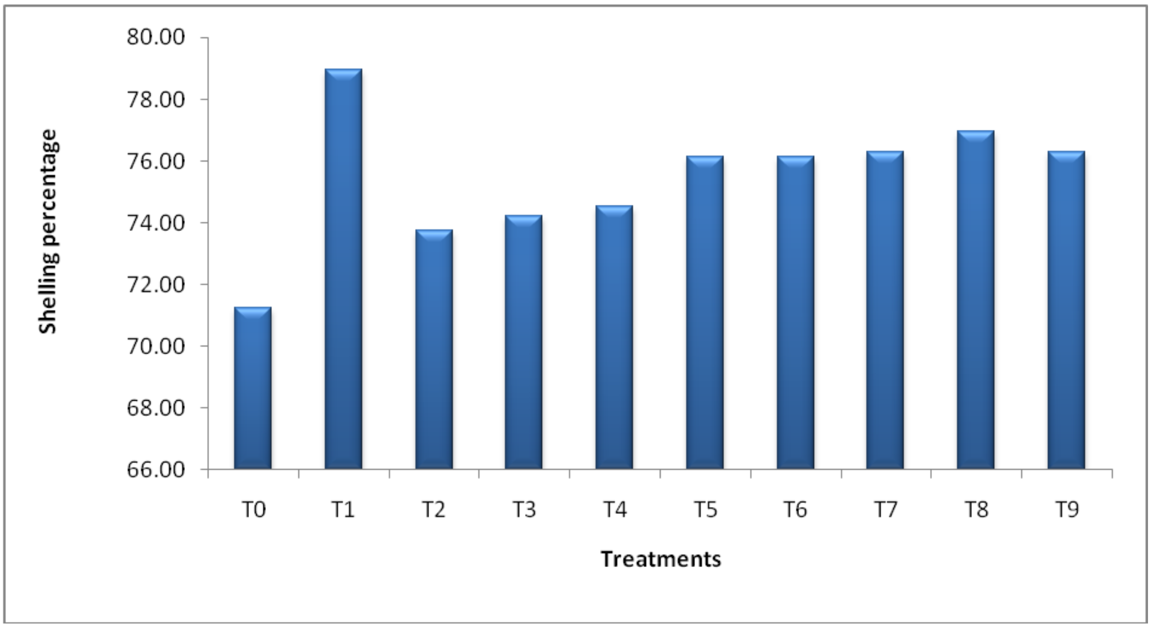

Figure 3. Effect of chemical and organic fertilizers and their combinations on shelling percentage of maize (LSD $_{(0.05)}$ = 4.39)

Here,

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.19 Stover yield (t ha^{-1})

Different chemical and organic fertilizers, and their combinations exerted significant variation on stover yield per hectare of Maize (Appendix XIV). The highest stover yield was observed in T_1 (13.97 t ha^{-1}), which was statistically at per with T_9, T_8, T_7 and T_6 (13.53, 13.38, 12.55, and 12.33 t ha^{-1}, respectively). Again the lowest yield was recorded from T_0 (4.94 t ha^{-1}) (Table 10). Vadivel *et al.* (2001a) reported that application of enriched FYM @ 750 kg ha^{-1} increased the stover yield of maize. Pursushottam *et al.* (2001) also reported that stover yield increased with FYM 15 t ha^{-1} over conventional method in maize.

4.20 Biological yield (t ha^{-1})

Significant variation was recorded in biological yield of Maize for different chemical and organic fertilizers, and their combinations (Appendix XIV). The highest biological yield was found in T_1 (25.72 t ha^{-1}) and that of the lowest 9.10 t ha^{-1} from T_0 (Table 10). Application of all chemical fertilizer in recommended doses ensured the essential macro and micro nutrients for the vegetative and reproductive growth of Maize and the ultimate results were the highest grain and straw yield as well as maximum biological yield. Combination of cow dung, compost and chemical fertilizers half in recommended doses also created a favorable condition for the growth and development of Maize plant for that combination of cowdung, compost and half chemical fertilizers also gave the similar results. Similar findings also reported by Khan *et al.* (2009), Hassan (2005) , Akbar *et al.* (2002), Vadivel *et al.* (2001b) and Ali *et al.* (1999).

Table 10. Effect of chemical and organic fertilizers and their combinations on grain, straw and biological yield of maize

Treatments	Grain yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)
T_0	4.16 c	4.94 c	9.10 e
T_1	11.75 a	13.97 a	25.72 a
T_2	5.10 c	6.50 bc	11.60 d
T_3	5.24 c	6.79 b	12.03 d
T_4	6.76 b	8.16 b	14.92 c
T_5	6.97 b	8.22 b	15.19 c
T_6	10.81 a	12.33 a	23.14 b
T_7	10.90 a	12.55 a	23.45 b
T_8	11.67 a	13.53 a	25.20 ab
T_9	11.56 a	13.38 a	24.94 ab
$LSD_{(0.05)}$	1.162	1.606	2.026
CV (%)	7.97	9.33	6.37

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

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.21 Harvest index (%)

Harvest index for different chemical and organic fertilizers, and their combinations treatments showed significant differences (Appendix XIV). The highest harvest index was recorded from T_7 (46.55%), which was similar with T_6 (46.53%) and the lowest harvest index was recorded from T_0 (43.08%) (Figure 4). Reddy *et al.* (1987) reported the significant increase in yield attributes resulted in significant increase in harvest index (%).

4.22 Quality analysis

The data pertaining to quality parameters of maize viz., protein and carbohydrate contents (%) as influenced by different organic and inorganic sources of fertilizer management practices are depicted in Figure 5 and 6, respectively.

4.22.1 Protein contents (%)

Protein content in grains for different chemical and organic fertilizers, and their combinations treatments showed significant differences (Appendix XV). The highest protein contents was recorded from T_8 (11.80 %), and the lowest protein contents was recorded from T_0 (10.30 %) (Figure 5). Balai *et al.* (2011) reported that combined application of FYM 10 t ha^{-1} + Soil test recommended dose of NPK (120: 60:30 kg ha^{-1}) recorded the highest protein contents (10.13 %) in maize. This result also collaborate with Mahmood (1997).

4.22.2 Carbohydrate contents (%)

Carbohydrate contents in grains for different chemical and organic fertilizers, and their combinations treatments showed significant differences (Appendix XV). The highest carbohydrate contents was recorded from T_0 (73.70 %), and the lowest contents was recorded from T_8 (71.00 %) (Figure 6). Balai *et al.* (2011) noticed that combined application of FYM 10 t ha^{-1} + Soil test recommended dose of NPK (120: 60: 30 kg ha^{-1}) recorded the highest carbohydrate contents (69.98 %) in maize.

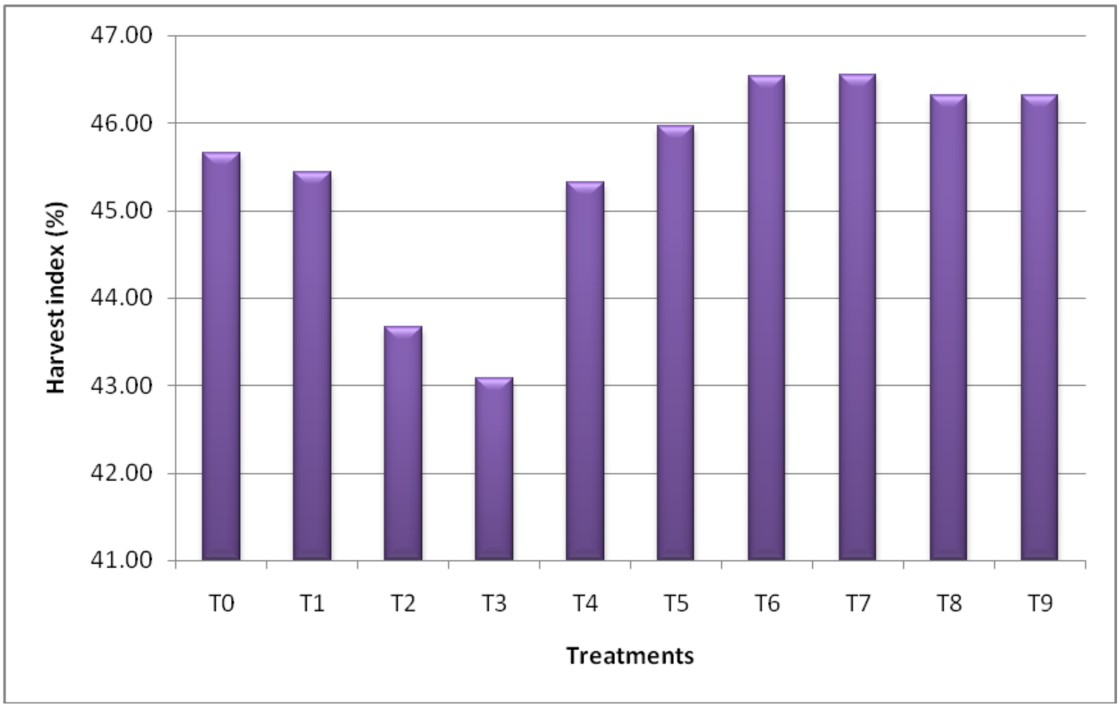

Figure 4. Effect of chemical and organic fertilizers and their combinations on harvest index of maize (LSD $_{(0.05)}$ = 0.73)

Here,

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8 Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

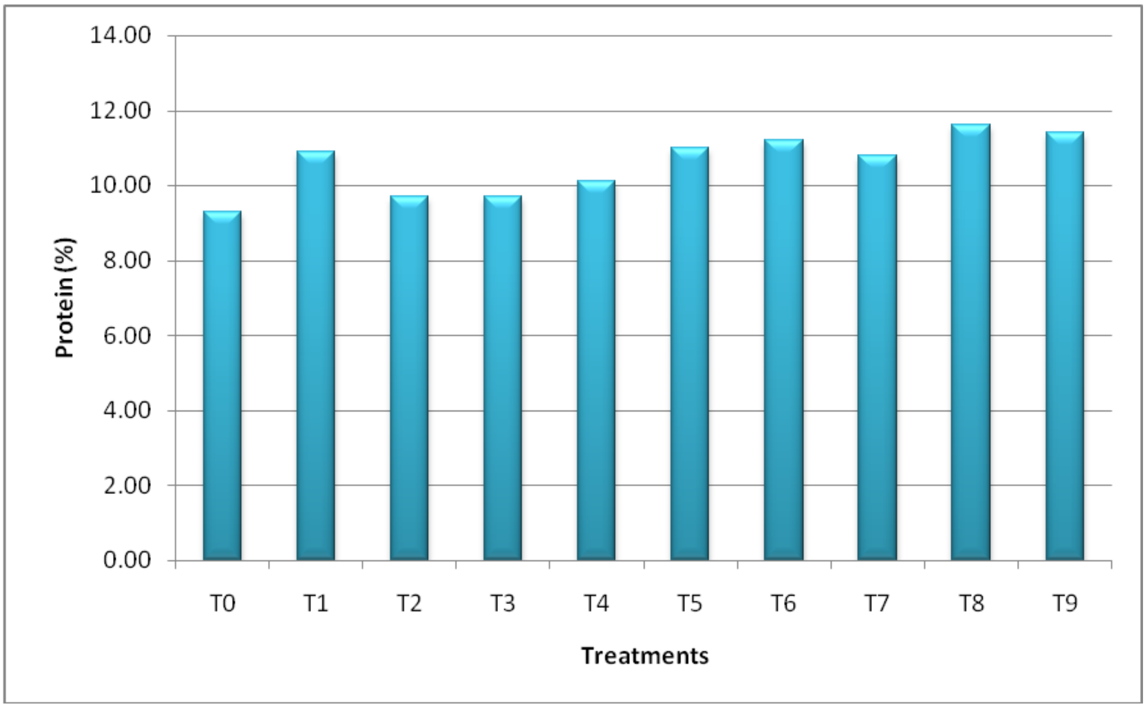

Figure 5. Effect of chemical and organic fertilizers and their combinations on protein percentage of maize seed (LSD $_{(0.05)}$ = 1.84)

Here,

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

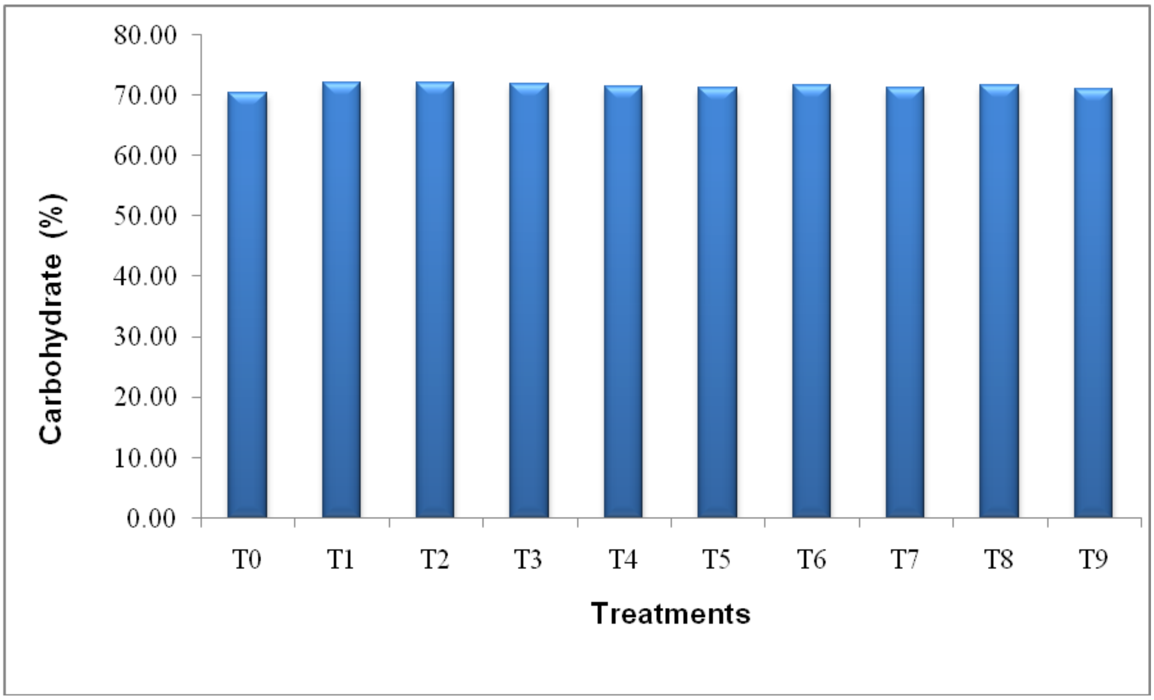

Figure 6. Effect of chemical and organic fertilizers and their combinations on carbohydrate percentage of maize seed (LSD $_{(0.05)}$ = 1.202)

Here,

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizer as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Full Cowdung + Full Compost

T_6: Full Cowdung + ½ Chemical fertilizer

T_7: Full Compost + ½ Chemical fertilizer

T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

Chapter V

Summary and Conclusion

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SUMMARY AND CONCLUSION

The present research work was conducted at the exprimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2011 to April, 2012 to study the feasibility of replacing chemical fertilizer by using organic fertilizer on growth, yield components and yield performance in Maize. The experiment comprised 10 different treatments of organic and inorganic fertilizer and their combination viz., T_0: Control (without fertilizer), T_1: All chemical fertilizer (recommended dose), T_2: Cowdung (Recommended dose), T_3: Compost (Recommended dose), T_4: ½ Compost + ½ Cowdung, T_5: Full Cowdung + Full Compost, T_6: Full Cowdung + ½ Chemical fertilizer, T_7: Full Compost + ½ Chemical fertilizer, T_8: Full Cowdung + Full Compost + ½ Chemical fertilizer, T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer on growth and yield performance of maize variety of BARI hybrid maize 9. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

Results showed that a significant influence was observed among the treatments regarding all of the parameters observed. The collected data were statistically analyzed for evaluation of the treatment effect.

Among the applied treatments T_1 (all chemical fertilizer as recommended dose) produced the superior growth and T_0 (control) gave the lowest performance at every stage of data recording. Plant height varied significantly at 30, 50, 70 and 90 DAS, and at harvest for different chemical and organic fertilizer and their combinations under the present trial. However, the tallest plant (42.67, 95.13, 149.7, 229.3 and 240.5 cm at 30, 50, 70, 90 DAS and at harvest, respectively) was recorded in T_1 (all chemical fertilizer at recommended dose). Treatment T_1 (all chemical fertilizer as recommended dose) also produced the maximum leaf area index value (0.235, 1.206, 3.926, 6.149 and 4.957 at 30, 50, 70, 90 DAS and at harvest, respectively). Dry weight of shoot was the highest (0.70, 6.85, 43.70, 101.60, 250.10g) in T_1 treatment. The maximum dry weight of root (0.15, 1.08, 5.40, 12.49, 34.59 g at 30, 50, 70, 90 DAS and at harvest, respectively) was found in T_1 treatment. The highest CGR was found in T_1 (1.880, 11.040 and 17.770 g m^{-2} day^{-1} at 30-50, 50-70 and 70-90 DAS, respectively) and T_8 (14.04 g m^{-2} day^{-1} at 90- at harvest). RGR were performed the best in T_1 (0.122 g g^{-1} day^{-1} at 30-50DAS), T_2 (0.114 g g^{-1} day^{-1} at 50-70 DAS), T_4 (0. 46 g g^{-1} day^{-1} at 70-90 DAS), and T_2 (0. 0183 g g^{-1} day^{-1} at 90- at harvest). Tasseling, silking and maturity was earliest (88.67,93.00 and 140.7 days respectively) in T_0 treatment.

The longest tassel was observed in T_1 (41.87 cm). The maximum cob to tassel height was observed in T_5 (72.13 cm). The maximum number of cobs $plant^{-1}$ was found in T_1 (1.67). The longest cob was observed in T_1 (22.27 cm). The highest cob diameter (14.12 cm) was obtained with T_1 treatment. The maximum grains cob^{-1} was obtained from T_1 (531.90). The highest weight of 1000 seeds (305.30 g) was recorded from T_1 treatment. The highest shelling percentage (78.95) was recorded from T_1 treatment. The highest yield (11.75 t ha^{-1}**)** was obtained from T_1 treatment. On the other hand, the lowest yield (4.16 t ha^{-1}) was found in T_0 treatment. The highest stover yield was observed in T_1 (13.97 t ha^{-1}).

Significant variation was recorded in biological yield and harvest index of maize for different chemical and organic fertilizer and their combinations. The highest biological yield was found in T_1 (25.72 t ha^{-1}) and that of the lowest 9.10 t ha^{-1} from T_0. The highest harvest index was recorded from T_7 (46.55%), which was similar with T_6 (46.53%) and the lowest harvest index was recorded from T_3 (43.08%). The highest protein was recorded from T_8 (11.60). The highest charbohydrate was recorded from T_1 (72.23).

From the above results, it may be concluded that all chemical fertilizer at recommended dose showed the better performance on growth and yield contributing characters of maize but organic cowdung and compost in combination with half chemical fertilizer produced similar result with all chemical fertilizer applied treatment T_1 and also half cowdung and half compost with half chemical fertilizer showed statistically similar performance. So, considering the above observation cowdung and compost in the combination with half chemical fertilizer or half cowdung and half compost with half chemical fertilizer may be possible to use in replacing chemical fertilizer which will reduce production cost without significant yield reduction.

Recommendations

Considering the above observation of the present experiment, further studies in the following areas may be suggested.

- As T_9 treatments had ½ cowdung + ½ compost + ½ chemical fertilizers combinations which would incur least cost along with soil improvement might be suggested to be followed in maize production.
- Expansion of integrated fertilizer management study to know the growth and yield performance of maize in different agro-ecological zones (AEZ) of Bangladesh for regional variability.
- Innovations to supply of more inorganic and organic fertilizer to confirm the replacement of chemical fertilizer.

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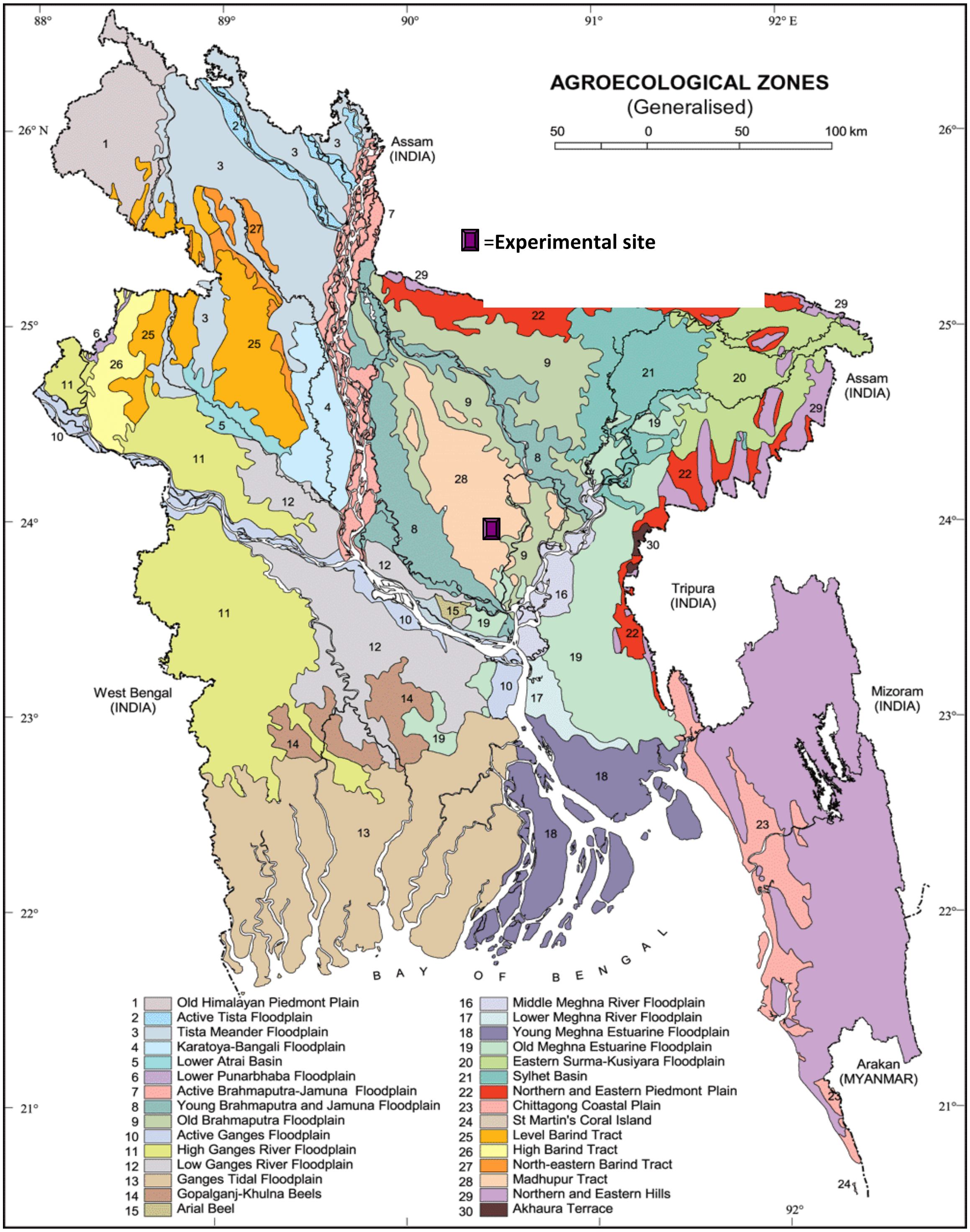
Appendices

APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0-15 cm depth)

Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Lab. No.	Soil characters	Value
14233	Organic carbon (%)	0.45
	Organic matter (%)	0.54
	Total nitrogen (%)	0.027
	Phosphorus	6.3 µg/g soil
	Sulphur	8.42 µg/g soil
	Magnesium	1.17 meq/100 g soil
	Boron	0.88 µg/g soil
	Copper	1.64 µg/g soil
	Zinc	1.54 µg/g soil
	Potassium	0.10 meg/100g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka

Appendix III. The chemical analysis of cowdung and compost

Lab. No.	Fertilizers	Results
S-7062 Code No. 6678	Compost(%)	Nitrogen(N)=1.91
		Phosphorus(P)=0.55
		Potassium(K)=1.40
		Zinc(Zn)=0.04
		Boron(B)=0.0026
S-7063 Code No. 6679	Cowdung(%)	Nitrogen(N)=1.47
		Phosphorus(P)=0.48
		Potassium(K)=1.40
		Zinc(Zn)=0.01
		Boron(B)=0.0022

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka

Appendix IV. Monthly average air temperature, rainfall and relative humidity of the experimental site during the period from November 2011 to April 2012

Months	Air temperature (^oC)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
November, 2011	25.82	16.04	78	00
December, 2011	22.40	13.50	74	00
January, 2012	24.50	12.40	68	00
February, 2012	27.10	16.70	67	30
March, 2012	31.40	19.60	54	11
April, 2012	33.5	22.6	61	160.4

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka- 1207

Appendix V. Analysis of variance of the data on plant height (cm) of maize as influenced by chemical and organic fertilizers and their combinations

Sources of variation	Degrees of freedom	Mean square values at				
		30DAS	50 DAS	70DAS	90 DAS	at harvest
Replication	2	11.214	318.288	223.246	538.831	364.537
Treatment	9	42.993*	361.912*	967.071*	2520.099*	1167.580*
Error	18	7.987	39.131	136.159	150.456	148.727

* = Significant at 5% level of probability

Appendix VI. Analysis of variance of the data on leaf area index of maize as influenced by chemical and organic fertilizers and their combinations

Sources of variation	Degrees of freedom	Mean square values at				
		30 DAS	50 DAS	70 DAS	90 DAS	at harvest
Replication	2	0.133	0.002	0.119	1.243	0.196
Treatment	9	0.007*	0.184*	2.205*	3.783*	1.551*
Error	18	0.001	0.006	0.021	0.188	0.082

* = Significant at 5% level of probability

Appendix VII. Analysis of variance of the data on dry weight of shoot (g) of maize as influenced by chemical and organic fertilizers and their combinations

Sources of variation	Degrees of freedom	Mean square values at				
		30 DAS	50 DAS	70DAS	90 DAS	at harvest
Replication	2	0.016	0.010	6.830	3.549	308.312
Treatment	9	0.079*	8.966*	328.801*	2019.769*	8500.608*
Error	18	0.009	0.080	5.190	46.263	417.505

* = Significant at 5% level of probability

Appendix VIII. Analysis of variance of the data on dry weight of root (g) of maize as influenced by chemical and organic fertilizers and their combinations

Sources of variation	Degrees of freedom	Mean square values				
		30 DAS	50 DAS	70 DAS	90 DAS	at harvest
Replication	2	0.375	0.004	0.140	0.348	12.978
Treatment	9	0.004*	0.354*	5.381*	35.927*	239.604*
Error	18	0.000	0.005	0.142	0.218	5.151

* = Significant at 5% level of probability

Appendix IX. Analysis of variance of the data on crop growth rate (g m^{-2} day^{-1}) of maize as influenced by chemical and organic fertilizers and their combinations

Sources of variation	Degrees of freedom	Mean square values at			
		30-50	**50-70**	**70-90**	**90-har**
Replication	2	0.005	0.469	0.580	1.883
Treatment	9	0.468*	16.683*	52.055*	22.086*
Error	18	0.007	0.402	1.123	3.844

* = Significant at 5% level of probability

Appendix X. Analysis of variance of the data on relative growth rate (g g^{-1} day^{-1}) of maize as influenced by chemical and organic fertilizers and their combinations

Sources of variation	Degrees of freedom	Mean square values at			
		30-50	**50-70**	**70-90**	**90-har**
Replication	2	0.002	0.002	0.004	0.0105
Treatment	9	0.001*	0.001*	0.001^{NS}	1.3527^{NS}
Error	18	0.000	0.001	0.001	0.0001

* = Significant at 5% level of probability

NS= Non significant

Appendix XI. ANOVA showing the mean square values of Days to tasseling, silking and maturity of maize as influenced by chemical and organic fertilizers and their combinations

Sources of variation	Degrees of freedom	Days to 50% tasseling	Days to 50% silking	Days to 50% maturity
Replication	2	7.900	2.500	31.600
Treatment	9	27.636*	50.819*	43.343*
Error	18	9.456	32.352	55.044

* = Significant at 5% level of probability

Appendix XII. ANOVA showing the mean square values of tassel length (cm), cob to tassel height (cm), cob plant^{-1} (no.), cob length (cm) and cob diameter (cm) of maize as influenced by chemical and organic fertilizers and their combinations

Sources of variation	Degrees of freedom	Tassel length	Cob to tassel height	Cobs plant^{-1}	Cob length	Cob diameter
Replication	2	5.439	23.131	0.000	1.912	0.363
Treatment	9	22.856*	24.113*	0.242*	12.228*	0.840*
Error	18	6.156	19.881	0.027	1.611	0.421

* = Significant at 5% level of probability

Appendix XIII. ANOVA showing the mean square values of rows cob^{-1} (no.), grains cob^{-1} (no.), thousand grain weight (g), shelling percentage of maize as influenced by chemical and organic fertilizers and their combinations

Sources of variation	Degrees of freedom	No. of rows cob^{-1}	Grains cob^{-1}	Thousand grain weight	Shelling percentage
Replication	2	3.234	1342.047	1171.133	21.06
Treatment	9	0.656*	4645.000*	2171.317*	13.25*
Error	18	1.346	2157.926	688.225	16.58

* = Significant at 5% level of probability

Appendix XIV. ANOVA showing the mean square values of grain yield (t ha^{-1}), Stover yield (t ha^{-1}), Biological yield (t ha^{-1}), Harvest index (%) of maize as influenced by chemical and organic fertilizers and their combinations

Sources of variation	Degrees of freedom	Grain yield	Stover yield	Biological yield	Harvest index
Replication	2	13.869	2.959	29.020	73.609
Treatment	9	29.154*	35.420*	128.696*	4.338*
Error	18	0.459	0.877	1.395	13.179

* = Significant at 5% level of probability

Appendix XV. ANOVA showing the mean square values of protein content (%) and CHO content (%) of maize as influenced by chemical and organic fertilizer and their combinations

Sources of variation	Degrees of freedom	Protein	CHO
Replication	2	67.600	67.605
Treatment	9	1.947*	0.843*
Error	18	1.156	1.491

* = Significant at 5% level of probability

Plate 1. Photograph showing general view of experimental plot at vegetative stage

Plate 2. Photograph showing general view of experimental plot at maximum vegetative stage

Plate 3. Photographs showing growth performance and cob size of treatment T_1 (All chemical fertilizers at recommended dose)

Plate 4. Photographs showing growth performance and cob size of treatment T_2 (cowdung as recommended dose)

Plate 5. Photographs showing growth performance and cob size of treatment T_3 (compost as recommended dose)

Plate 6. Photographs showing growth performance and cob size of treatment T_7 (Full compost + ½ chemical fertilizer)

Plate 7. Photographs showing growth performance and cob size of treatment T_8 (Full cowdung + Full compost + ½ chemical fertilizer)

Plate 8. Photographs showing growth performance and cob size of treatment T_9 (½ cowdung + ½ compost + ½ chemical fertilizer)

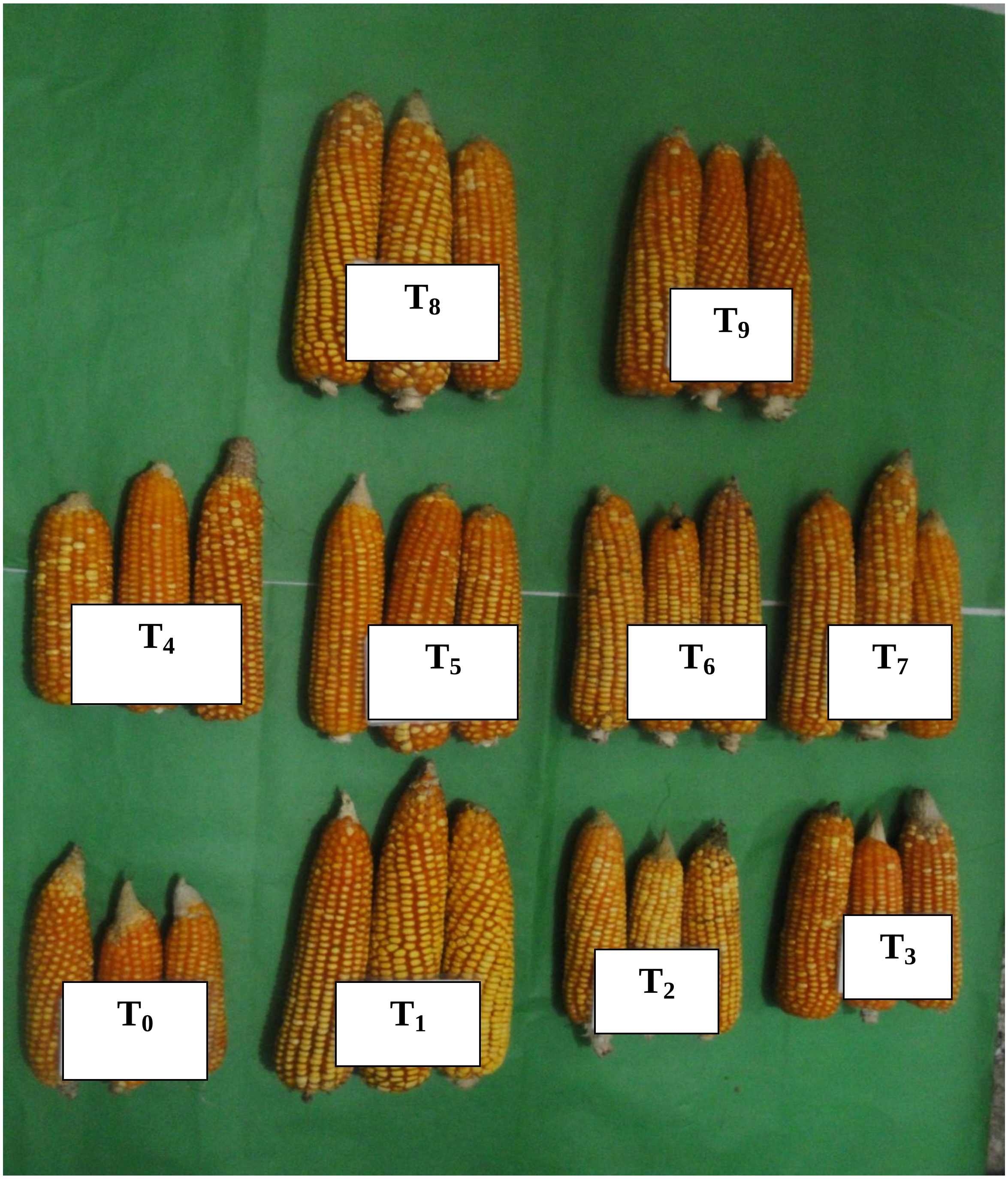


Plate 9. Photograph showing cob size of different treatments T_0, T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9

Here,

T_0: Control (without manure and fertilizer),T_1: All chemical fertilizer as recommended dose, T_2:Cowdung as recommended dose, T_3: Compost as recommended dose, T_4: ½ Cowdung + ½ Compost, T_5: Full Cowdung + Full Compost, T_6: Full Cowdung + ½ Chemical fertilizer, T_7: Full Compost + ½ Chemical fertilizer, T_8: Full Cowdung + Full Compost +½ Chemical fertilizer, T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer