FEASIBILITY OF REPLACING CHEMICAL FERTILIZER BY USING ORGANIC FERTILIZER IN WHEAT (*Triticum aestivum*)

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CERTIFICATE

This is to certify that the thesis entitled "**Feasibility of Replacing Chemical Fertilizer by Using Organic Fertilizer in Wheat (*Triticum aestivum*)**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in 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 **Zayeda Akhter**, Registration number: **08-03226** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:

Dhaka, Bangladesh

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ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2010 to March 2011 to study the feasibility of replacing chemical fertilizer by using organic fertilizer in wheat. The experiment comprised of 10 treatments, such as T_0: Control condition; 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: Cowdung + Compost; T_6: Cowdung + ½ Chemical fertilizer; T_7: Compost + ½ Chemical fertilizer; T_8: Cowdung + Compost +½ Chemical fertilizer and T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth characters and yield were recorded. Among the treatments all chemical fertilizers as recommended dose (T_1) and cowdung + compost + ½ chemical fertilizer (T_8) were found superior considering all yield contributing characters and yield. The treatments T_7 (compost + ½ chemical fertilizer) and T_9 (½ cowdung + ½ compost + ½ chemical fertilizer) also showed statistically similar results in respect of grain yield and most of the yield contributing characters. So, it is possible to reduce the use of chemical fertilizers by combined use of organic and chemical fertilizers without significant yield loss in wheat.

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CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops followed by rice and it is as well as staple food and has the large acreage among all the field crops in the world (FAO, 2010). About two third of the total world's population consume wheat as staple food (Majumder, 1991). The crop is grown under different environmental condition ranging from humid to arid, subtropical to temperate zone. Dubin and Ginkel (1991) reported that the largest area of wheat cultivation in the warmer climates exists in the South-East Asia including Bangladesh, India and Nepal. In Bangladesh, wheat is the second most important cereal crops that contribute to the national economy by reducing the volume of import of cereals for fulfilling the food requirements of the country (Razzaque *et al.*, 1992). Wheat grain is rich in food value containing 69.60% carbohydrate, 12.00% protein, 1.72% fat 17.20% and minerals (BARI, 2006). Besides these, wheat straw are also used as animal feed. Wheat straw is also used as fuel or house material of the poor man of Bangladesh.

Wheat is a well adapted cereal crop for its vegetative growth and development in our native climatic condition. Though the crop was introduced in Bangladesh during the former East Pakistan in 1967, its reputation increased after 1975. Now the popularity of wheat as staple food is rising day by day in our country. Wheat cultivation has been increased manifolds to meet up the food shortage in the country. The area, production and yield of wheat have been increasing dramatically during the last two decades, but its present yield is too low in comparison to that of some developed countries like Japan, France, Germany and UK producing 3.76, 7.12, 7.28, and 8.00 t ha^{-1}, respectively (FAO, 2000). In Bangladesh, the position of wheat is second in respect of total area (0.80 million hectares) and production (2.80 million ton) after rice and the average yield is only 3.44 t ha^{-1} (BBS, 2010) but it can be increased up to 6.8 t ha^{-1} (RARS, 2010).

Low yield of wheat in Bangladesh, is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons, viz., unavailability of quality seeds of high yielding varieties, limitation in adoption of modern and improved agronomic practices, such as optimum seed rate, delay sowing after harvesting transplanted aman rice, judicious application of irrigation, fertilizer management and other inputs. In order to break the above yield barriers, sustain the productivity and obtain sufficiency in food, the overall management system of crop needs to be improved especially through the nutrient management of the crop. Proper utilization of different sources of nutrients in context of crop-soil productivity must be explored for sustaining the productivity. The sources of nutrients for crops are nutrient reserve in soil, organic and inorganic fertilizers. None of the sources is complete and therefore, no one is sufficient to sustain soil fertility and productivity. Combination of organic and inorganic fertilizers is being stressed now-a-days.

The application of different fertilizers and manures influences the physical and chemical properties of soil and enhance the biological activities. It is also positively correlated with soil porosity and enzymatic activity. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter. Application of both chemical and organic fertilizers is neede for the improvement of soil physical properties and quick supply of essential plant nutrients for higher yield. The combined effect of organic manure and inorganic fertilizer on crop yield was also reported by many workers (Davarynejad *et al*., 2004; Singh and Singh, 2000).

Therefore, the present study was undertaken to formulate an input package with a combination of organic and inorganic fertilizer, so that it will be technically effective and feasible, economically viable, socially acceptable and environmentally sound for wheat production. Considering the present situation the present piece of research work was undertaken with following objectives-

i. To observe the effect of chemical fertilizer on the performance of wheat,

ii. To observe the effect of organic fertilizer on the performance of wheat,

iii. To observe the effect of different combination of chemical and organic fertilizer on wheat, and

iv. To find out the best combination of chemical and organic fertilizer for higher yield of wheat.

CHAPTER II

REVIEW OF LITERATURE

Organic manure and inorganic/chemical fertilizer are the essential factor for sustaining soil fertility and crop productivity because they are the store house of plant nutrients. Organic manure and inorganic fertilizer act as a source of essential plant nutrient. Experimental evidences in the use of cowdung, compost, and nitrogen, phosphorus, potassium, sulphur and boron showed an intimate effect on the yield and yield attributes of wheat. Yield and yield contributing characters of wheat are considerably influenced by different doses of cowdung, compost and NPKSB fertilizers and their combined application. Some literatures related to the "Effect of level of various organic manure and inorganic fertilizer on the yield and yield attributes of wheat" are reviewed under the following heading in this chapter.

2.1. Effect of organic manure on growth and yield of wheat

Elsharawy *et al.* (2003) examined the effect of the compost of some plant residues i.e. rice straw and cotton stalks on some physical and chemical properties of the sandy soil. Application of cotton stalks or rice straw composts significantly improved the physical properties of the tested soil, i.e. bulk density, hydraulic conductivity and moisture contents namely field capacity, wilting point and available water that leads to the growth and highest yield of the crops. Concerning the effect of composts application on the availability of N, P and K in the cultivated soils, rice straw was better than cotton stalks.

According to HDRA (1999) compost derived from organic wastes, such as segregated household waste, green botanical waste and food processing waste are becoming available in increasing quantities. These supply a complex mixture of nutrients in organic and mineral forms and are also used as soil condition to maintain and improve soil structure that ensured proper growth of the crops.

Chittra and Janaki (1999) stated that application of composted coir pith improved the soil available K status and increased the uptake of potassium by grain and straw of rice. Application of 50 kg N with green leaf manure gave the highest grain and straw yield in both seasons, followed by composted coir pith.

BARC (1997) reported that organic matter content of a particular soil was an indicator of its productivity. It helped in binding the soil particles into aggregates thereby improving drainage and reducing erosion, reduced leaching loss of nutrients through enhanced ion exchange activity, increased water holding capacity, supported the activities of micro organisms, increased the benefit from chemical fertilizers, and promote the production of beneficial plant hormones.

Saerah *et al.* (1996) evaluated the effect of compost in optimizing the physical condition of sandy soil. Compost @ 0, 16.5, 33.0, 49.5 and 66.0 t ha^{-1} was incorporated into the soil and then wheat was grown. The results indicated that the various application rates were significantly correlated with improvement in physical properties of soil as well as straw and grain yields of wheat.

Verma (1995) concluded that the organic materials commonly used to improve soil conditions and fertility include crop residues, urban wastes, green manures, biogas spent slurry, microbial preparations, vermicomposts and biodynamic preparation.

Rai (1965) observed that compost when incorporated in the soil improved the physical structure of the soils. Sandy soils are compacted and clay soils become loose. The water holding and heat absorbing capacity of soils increase and thus compost improves the permeability of soils and makes the working of soils easier.

Cho *et al*. (1986) reported that organic matter could be considered as the life to the soil and was the store house of the plant nutrients. Organic matter is the principal sources of N and other nutrient elements increases the soil buffering capacity protect soil erosion and maintain healthy community of soil organisms.

In a 12 year study in typical clayey rice soil (Aeric Albaquept) of Bangladesh by Farid *et al.* (1998) showed that incorporation of compost or rice straw and subsequent decomposition increased and maintained OM level at 2.5% that was higher than that in traditionally managed rice soil (<2%).

The use of compost of rice straw as a partial substitute of fertilizer N in flooded rice production may be possible in certain limited circumstances (Park *et al.*, 1990). It was also observed the continuous application of organic manure to flooded rice soil caused the accumulation of organic matter at a greater rate than the optimum level of around 2.5%.

Method of composting is one of the important factors to accumulate from the waste for organic manuring. FSES (1996) reported that composting by pit polythene method accumulated three times more compost over farmers conventional method. Quality compost also produced by this method gave better yield of crops and improved soil organic matter.

The influence of the addition of organic matter through crops was studied by Baron *et al.* (1995). The result showed the positive influence of the addition of organic matter not only on soil properties but also on the mineral nutrient of plants and yield.

In a long term trial Mani *et al.* (1980) showed that the organic matter content of the soil increased from 1.45 to 2.61% with farmyard manure, from 1.46 to 2.70% with green leaf manure and from 1.45 to 2.58% with compost.

Aga *et al.* (2004) assessed the effect of compost on the growth and yield of rice. Plant growth characters such as plant height were highest with application of 15 t compost ha^{-1}. Grain yield increased significantly with the graded levels of compost application @ 10 t ha^{-1}, but the response decreased with the increase of compost from 10 to 15 t ha^{-1}.

Prasad *et al.* (2004) carried out an experiment on management of rice root nematode, *Hirschmanniella oryzae,* in Hyderabad, Andhra Pradesh, India in relation to application of fresh leaves of *Azadirachta indica, Sesbania aculeata* or water hyacinth. Compost @ 60 kg ha^{-1} were found useful for managing this nematode and increasing grain yield.

Tejada and Gonzalez (2003) studied the influence of four doses of a compost originating from residues of crushed cotton gin on wheat in dry land conditions (Guadalquivir Valley, Andalusia, Spain). The results showed that this compost was of a great agricultural interest product because of its organic matter content. The application of this byproduct to the soil resulted in an increase in soil microbial activity, structural stability and soil porosity. Mineralization of organic matter produced a higher concentration of NO_3-N in soil, an increase on the yield parameters and grain yield in both seasons.

Tamaki *et al.* (2002) examined the correlation between growth and yield of rice and duration of organic farming (compost mixed with straw) in comparison with conventional farming. In organic farming plant height of rice was shorter and shoot number $hill^{-1}$ was lesser than in conventional farming, but both of these values increased as the duration of organic farming increased. The maximum tiller number was smaller and panicle number was also smaller in organic farming. However, both the panicle number and panicle length increased as the duration of organic farming increased. The grain-straw ratio was higher in organic farming than in conventional farming. These results suggested that the growth and yield of rice increased with continuous organic farming and the yield increased with increase in number of panicle $hill^{-1}$ and number of grain $panicle^{-1}$.

Rani and Srivastsva (1997) tested that vermicompost in pot experiment for its ability to replace a proportion of the urea fertilizer applied to rice. Compared with N fertilizer alone, supplying one-third or one-quarter of N as vermicompost increased plant height, grain yield and yield components of rice.

Fan and Yu (1990) showed that by continuous application of farmyard manure, river sludge, green manures and wheat straw increased the soil organic matter content by 52%, 32.2%, 15.1% and 15%, respectively and increased total wheat production by 40.4, 11.1, 13.1 and 2.7%, respectively.

Bangar *et al.* (1989) reported that compost of paddy straw can be enriched using urea and Mussooric rock phosphate for N and P enrichment, respectively. In plot trial during two years, wheat grain and straw yields increased significantly.

2.2. Effect of chemical fertilizer on growth and yield of wheat

Of the 16 essential nutrient elements nitrogen is one of the major and primary element for the growth, development and better yield of crops. Besides, plants response best to nitrogen compared to other nutrient elements. Urea has been found to be very effective nitrogenous fertilizers. Nitrogen is play pivotal role is different growth stages and yield of wheat.

Saren and Jana (2008) conducted a field experiment in West Bengal, India, in winter to study the effects of irrigation depth (4.5, 6.0, 9.0 and 12.0 cm), N rate (50 and 100 kg/ha) and N application date (50% N before or after irrigation) on the yield, yield components and nutrient uptake of wheat cv. UP-262. The half rate of N (urea) and full rate of P (50 kg single super phosphate/ha) and K (50 kg muriate of potash/ha) were applied as basal. The application of 100 kg N/ha as top dressing after irrigation gave the longest plant, highest length of spike, number of effective tillers, grains and straw yields and N, P, K uptake by grain and straw.

Awasthi and Bhan (1993) reported that increasing levels of nitrogen up to 60 kg ha^{-1} influenced LAI and dry matter production of wheat. Patel and Upadhaya (1993) found that plant height of wheat increased significantly with increasing rates of N up to 150 kg Nha^{-1}. Plant height was significantly increased with 0-200 kg N ha^{-1} (Meneses and Ivan-Marcelo, 1992) Highest plant height of wheat was found when nitrogen was applied at the rate of 120 kg N ha^{-1} (Ellen, 1987; Dhuka *et al.*, 1991). Ahmed and Hossain (1992) observed that plant height of wheat were 79.9, 82.3 and84.4 cm with 45, 90 and 135 kg N ha^{-1}, respectively. Plant height increased with increasing nitrogen fertilizer doses. Gami *et al.* (1986) reported that plant height of wheat increased up to 160 kg N ha^{-1} which was at par with that of 120 kg N ha^{-1}. Chandra *et al.* (1992) carried out an experiment during 1979-80 at Varanast, Uttar Pradesh (India) and reported that plant height and dry matter increased with increasing the rate of N up to 120 kg N ha^{-1}. Further increment of 3 kg N ha^{-1} decreased this parameter.

Bellido *et al.* (2000) evaluated a field experiment with 4 level of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and reported that the amount of total dry matter was significantly greater at the N fertilizer rates of 100 and 150 kg N ha^{-1}. Kumar and Sharma (1999) conducted a field experiment with 4 levels of N (0, 40, 80 and 120 kg N ha^{-1}) and observed that dry matter accumulation in wheat increased from 0-40 kg N ha^{-1} at 40 DAS, 0-120 kg N ha^{-1} at 60 DAS, 0-80 kg N ha^{-1} at 80 DAS. Verma and Achraya (1996) observed that LAI increased significantly at maximum tillering and flowering stages with increasing levels of nitrogen. Tanaka (1983) observed that the LAI above a certain limit causes decrease in NAR. Kumar *et al.* (1995) reported that increasing levels of N tended to show higher meristematic activities, formation and functioning of protoplasm, which consequently increased the plant growth.

Frederick and Camberato (1995) observed that increase in N rate resulted in higher LAI and maximum LAI values were found at 90 kg N ha^{-1}. Plant height of wheat remarkably influenced with different levels of N application (Behera, 1995). Patel *et al.* (1995) observed that plant height of wheat increased with increasing rates of N up to 120 kg N ha^{-1}. Singh *et al.* (1996) evaluated 3 levels of N (40, 80 and 120 kg N/ha) and found the growth parameters were significantly improved by nitrogen application. Plant height, number of tillers and ear length were significantly increased with nitrogen application up to 80 kg N ha^{-1}, grain and straw yields were significantly increased up to 120 kg N ha^{-1}.

Kumar *et al.* (1995) carried out field experiment with 4 levels of nitrogen (0, 60, 120 and 180 kg N/ha) and reported that productive tillers increased significantly with the increase of N doses from 0 to 120 kg ha^{-1}, but differences in productive tillers between 120 and 180 kg N ha^{-1} were not significant.

Effective tillers m^{-2} responded significantly to the applications of N-fertilizer (Behera, 1995). Effective tillers increased significantly with increase the level of N up to 80 kg N ha^{-1} (Singh and Singh, 1991). Patel and Upadhyay (1993) conducted an experiment with 3 levels of N (90, 120 and 150 kg N ha^{-1}) and reported that total and effective tillers m^{-2} increased significantly with increasing rates of N up to 120 kg N ha^{-1}.

Ayoub *et al.* (1994) conducted an experiment at the Lods Agronomy Research Centre, McGill University, Macdonald Campus and at the Crop Federee Research Farm, Ste-Rosalie, Canada in 1990 and 1991 on 4 cultivars (Columbus, Max, Katepwa and Hege) with 4 doses of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and reported that the formation of tillers was significantly increased with increasing N fertilizer level. Upadhyay and Tiwari (1996) conducted a field experiment on two wheat varieties (Sonalika and Lok 1) with three levels of N (90, 120 and 150 kg ha^{-1}) and observed that nitrogen application up to 120 kg ha^{-1} increased the number of fertile spikelets $spike^{-1}$ with lower dose (90 kg N ha^{-1}). Application of N beyond 120 kg N did not increase the value of this character.

Johnson *et al.* (1990) stated that higher leaf number of short and narrow leaved had high LAI that gave high yield by producing more tillers.

Geethadevi *et al*. (2000) found that 120 kg nitrogen ha^{-1} in the form of urea, 50% nitrogen was applied in four splits resulted in higher number of tillers, grains $spike^{-1}$, and higher grain weight $plant^{-1}$. They also observed that dry matter $hill^{-1}$ increased almost linearly with the increase in N level, but its effect was more conspicuous after the heading stage. Tillers plant^{-1} increased linearly with the increase in N fertilizer levels. Grain yield and most of the yield attributes varied significantly. The highest grain yield (3804 kg ha^{-1}) obtained from 180 kg N ha^{-1}, which was similar to the yield obtained at 80 kg N ha^{-1} (3810 kg ha^{-1}).

Bayan and Kandasamy (2002) noticed that the application of recommended doses of N in four spilts at 10 days after sowing, active tillering, panicle initiation and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz., effective tillers m^{-2}.

Maurya and Verma (1990) conducted an experiment with 3 levels of N (0, 60, 90 kg N ha^{-1}) and observed that application of N significantly increased the spike length of wheat, 90 kg N ha^{-1} gave the maximum spike length. Dhuka *et al*. (1991) conducted a field experiment on “GW 120” wheat with 3 level of N (40, 80 and 120 kg ha^{-1}) and observed that spike length of whet was significantly increased by N application. Maximum spike length was obtained at 120 kg N ha^{-1}. Patel and Upadhyay (1993) conducted an experiment with levels of N (90, 120 and 150 kg ha^{-1}) and the result showed that spike length of wheat increased significantly with increasing rates of N upto 120 kg N ha^{-1}. Singh *et al*. (1996) carried out a field experiment with three level of nitrogen (40, 80 and 120 kg ha^{-1}) and found that the growth parameters were significantly improved by nitrogen application. Plant height, number of tillers m^{-2} and ear length were significantly increased owing to nitrogen application up to 120 kg ha^{-1}.

The number of spikelets spike^{-1} may be changed with different levels of nitrogen. Nitrogen had a significant impact on number of spikelets spike^{-1}. Number of spikelets spike^{-1} increaed with increasing of N rate up to 120 kg N ha^{-1} (Malik *et al*., 1987 and Singh *et al*., 1992).

Shen *et al*. (2007) conducted a field experiment in China to identify the effects of N application rates (180 and 240 kg/ha) on grain yield, protein and its components in wheat cv. Ningyan 1. The grain number per spike increased with the increase of N application rate, while the 1000-grain weight decreased. The ear number per unit area, dry matter accumulation amount after flowering, leaf area index at heading stage and grain yield increased with the increase of N application rate. The suitable amount of N rate for high yield and good quality in Ningyan 1 was 180 kg N ha^{-1} and 240 kg N ha^{-1}, respectively.

Chaturvedi (2006) conducted a field experiment in India to evaluate the effects of different rates of nitrogen (0, 25, 50, 75, 100 and 125 kg/ha) applied as urea on the growth, yield and nutrient uptake of wheat (*Triticum aestivum*) cv. Raj 3077. Various growth and yield parameters of the crop were influenced differently by various nitrogen rates. Nitrogen at 125 kg/ha was optimum for the growth, yield and nutrient uptake of wheat. Application of 125 kg N/ha significantly increased plant height (95.2 cm), spike length (16.22 cm), total number of tillers (1402 m^2), number of green leaves (1067/m^2), dry matter accumulation (14.65 t/ha), number of grains per spike (40.5), 1000 grain-weight (48.1 g), grain and straw yields (4667 kg/ha based on pooled data), and uptake of N (102.3 kg/ha), respectively.

Cerny *et al*. (2005) conducted a field experiments to study the effects of different levels of nitrogen fertilizer and different forms of N fertilizers on the qualitative and quantitative parameters of the durum wheat cultivar Istrodur and Martondur. Grain yield technology quality parameters were significantly influenced by fertilizer application. Istrodur produced the highest grain yield (3.85 t/ha; increased by 4.37%) with the application of 80 kg N/ha. Matondur yielded the highest (3.96 t/ha, increased by 16%) at the rate of 120 kg N/ha. Istrodur achieved the highest protein content (13.66%) and glassiness (83.63%) at a rate of 1.20 kg N/ha and the protein content and glassiness was 16.65 and 85.89%, respectively for Martondur applied with 80 kg N/ha.

Zhang *et al*. (2000) measured various crop response to a mixed municipal solid waste (refuse) bio-soilds co-compost (named Nutrin Plus) and examined the fate of certain metals associate with Nutri Plus compost. There were six treatments: check 50, 100 and 200 t compost ha^{-1}, NPKS (75 kg N ha^{-1}, 20 kg P ha^{-1}, 45 kg K ha^{-1} and 18 kg S ha^{-1}), PK (2 kg P, 45 kg K ha^{-1}), and three crops: rape, wheat and barley. The research results showed that the compost slightly increased heavy metal concentrations in the soil but did not cause and photo-toxicity to crops. Yield from 100 and 200 t ha^{-1} compost application was higher than with NPKS treatment. However, the yield of 50 t ha^{-1} compost application was similar to that of NPKS treatment. The compost apparently was more beneficial in the year of application. The results suggested that Nutri Plus compost application generated positive yield responses in all three crops. Crop yield increased as the application rate increased.

Aal *et al*. (2003) measured the usefulness of supplementing different organic materials viz., water hyacinth compost, town refuse compost to minimize consuming chemical fertilizers. The result showed that the application of organic materials either alone or in combination with chemical fertilizers caused a substantial increase in total N, available P, K and micronutrients (Fe, Mn, Cu, Zn) as well as wheat yield (straw and grain). The importance of organic farming practices in desert sandy soils was emphasized to minimize chemical fertilizer consumption and to avoid environmental pollution.

Singh and Singh (2000) reported that the effect of sewage sludge-based compost on the growth attributes and yield of wheat during 1997, in Allahabad, Uttar Pradesh, India. The treatment were control, Jamuna compost at 2520 g ha^{-1} + rear at 986.60 g ha^{-1}, Jamuna compost at 5040 g ha^{-1} + urea at 657.33 g ha^{-1}, Jamuna compost at 7560 g ha^{-1} + urea at 328.60 g ha^{-1}, Jamuna compost at 10083 g ha^{-1}, and urea at 1315 g ha^{-1}. All the treatments equally received P at 2268.75 g ha^{-1} and potash at 403.33 g ha^{-1}. The plant height was maximum at 100% urea application compared to 76.7 cm in Jamuna compost at 105 days after sowing. Similar effect was observed is the number of tillers m^{-2} row length. The fresh and dry weight of wheat samples from 100% urea application was 102.8 g and 22.1 g, respectively, in sludge-based Jamuna compost at 75 DAS. The highest grain yield of 44.58 q ha^{-1} was observed in 100% urea application, and it was the least in Jamuna compost (13.74 q ha^{-1}). However, application of Jamuna compost, along with urea at 25 and 50%, showed an increase in the growth and yield parameters of wheat, which was on par with 100% urea application.

Abdel-Maksoud *et al*. (2002) conducted a field experiment on the growth of wheat plants with the treatments of (i) NPK chemical fertilizer; (ii) accelerator free MSW (*municipal solid waste*) compost; (iii) composted MSW with chemical accelerator (NPK and $CaCO_3$); and (iv) composted MSW with organic accelerator (sewage effluent). Result showed that organic fraction amounted to 54% whereas the recyclable items and dust reached 30 and 11%, respectively. The composting process increased the fertilizing value as indicated by the increase of nutrient availability. Regardless of the method used in compost preparation, manuring wheat plants with any of the three composts increased root length, plant height, tiller number and whole plant dry matter. Significant increase was also observed in grain yield and grain N and P contents of wheat fertilized with composted MSW. This application also improved wheat quality as indicated by the increase of grain N content.

From the above discussion it is observed that both the organic and the inorganic fertilizers exerted significant effects on grain yield of wheat. Many researchers opined that use of compost from different sources alone can mitigate the requirements of crop damaged as done by chemical fertilizers. But it is better to use both organic and inorganic fertilizer for crop production because combination of organic and inorganic fertilizer generates positive response to both the crop yield and soil properties.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to study the feasibility of replacing chemical fertilizer by using organic fertilizer in wheat during the period from October 2010 to March 2011. The details of the materials used and methods that were followed for conducting the experiment have been presented below:

3.1. Description of the experimental site

3.1.1. Location

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The site of the study was $23^0 74^/$ N latitude and $90^0 35^/$ E longitude with an elevation of 8.2 meter from sea level.

3.1.2. Soil

The soil belonged to "The Modhupur Tract", AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix I.

3.1.3. Climate

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al.*, 1979). Details of the metrological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from Bangladesh Meteorological Department (Climate & Weather Division) Agargaon and presented in Appendix II.

3.2. Experimental details

3.2.1. Treatments

The experiment comprised the following 10 treatments

T_0: Control (without manure and fertilizer)

T_1: All chemical fertilizers as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Cowdung + Compost

T_6: Cowdung + ½ Chemical fertilizer

T_7: Compost + ½ Chemical fertilizer

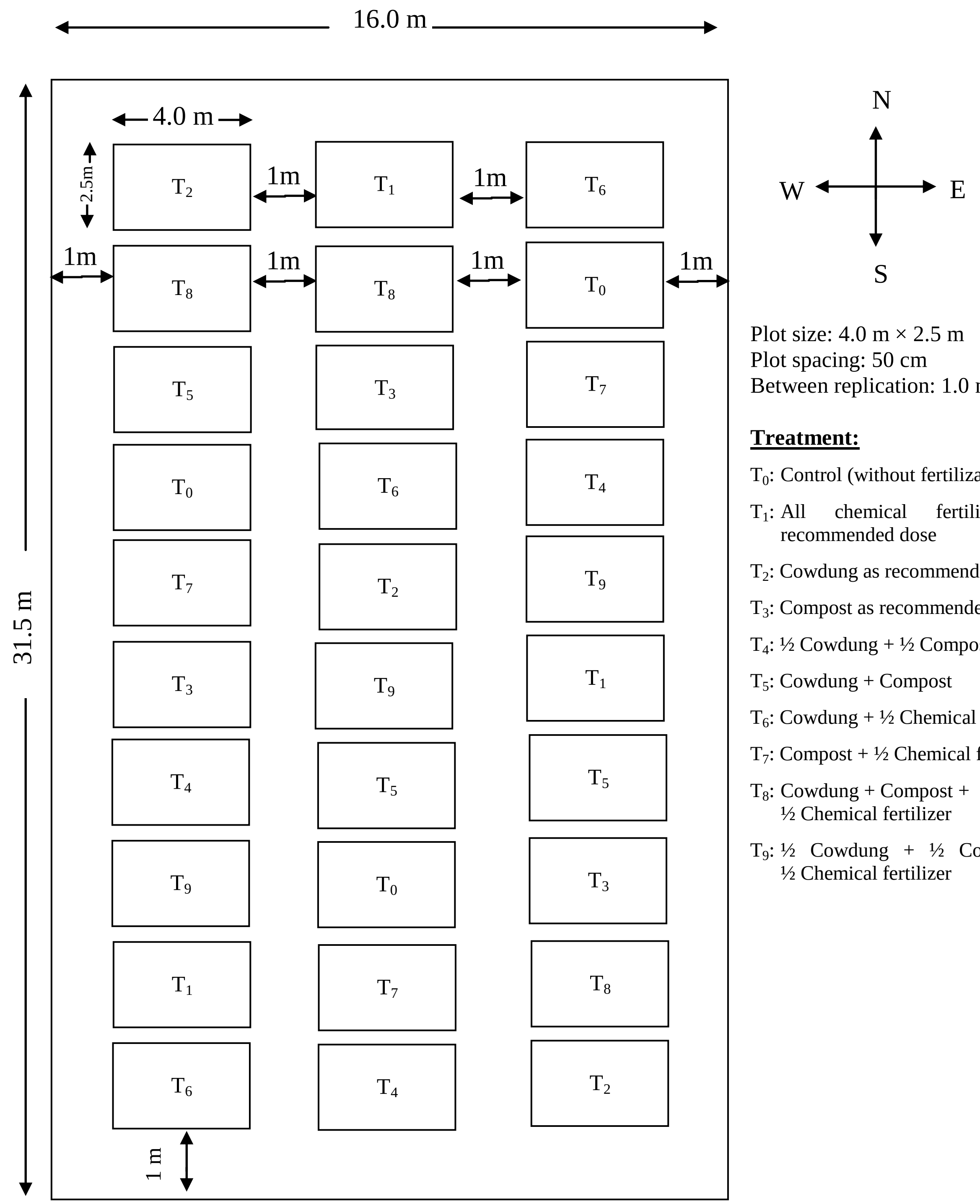
T_8: Cowdung + Compost +½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

Recommended dose of chemical fertilizer, cowdung and compost for this experiment are presented in section 3.3.3

3.2.2. Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 30 plots having size 4.0 m × 2.5 m. The treatments of the experiment randomly distributed into the experimental plot. Details layout of the experimental plot were presented in Figure 1.



Plot size: 4.0 m × 2.5 m
Plot spacing: 50 cm
Between replication: 1.0 m

Treatment:

T_0: Control (without fertilization)

T_1: All chemical fertilizers as recommended dose

T_2: Cowdung as recommended dose

T_3: Compost as recommended dose

T_4: ½ Cowdung + ½ Compost

T_5: Cowdung + Compost

T_6: Cowdung + ½ Chemical fertilizer

T_7: Compost + ½ Chemical fertilizer

T_8: Cowdung + Compost + ½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

Figure 1. Layout of the experimental plot

3.3. Growing of crops

3.3.1. Seed collection

The seeds of the test crop of this experiment BARI Ghum 24 (Prodip) collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur**.**

3.3.2. Preparation of the main field

The plot selected for the experiment was opened in the last week of October 2010 with a power tiller, and was exposed to the sun for a week after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally a desirable tilth of soil was obtained for sowing of seed.

3.3.3. Fertilization

The dose and method of application of fertilizer are shown in Table 1.

Table 1. Dose and method of application of organic and inorganic fertilizers in wheat field (BARI, 2006)

Fertilizers	Dose (ha^{-1})	Application (%)	
		Basal	1st installment
Urea	180 kg	66.66	33.33
TSP	140 kg	100	--
MP	40 kg	100	--
Gypsum	140 kg	100	--
Zinc oxide	5 kg	100	--
Boric acid	6 kg	100	--
Cowdung	7 ton	100	--
Compost	8 ton	100	--

All the organic and inorganic fertilizers were applied in the field at their recommended doses and as per treatment mention in section 3.2.1.

3.3.4. After care

After the germination of seedlings, various intercultural operations such as irrigation and drainage, weeding, thinning, top dressing of urea and plant protection measure were accomplished for better growth and development of the wheat seedlings as per the recommendation of BARI (2006).

3.3.4.1. Irrigation and drainage

Flood irrigation was given at tillering (25 DAS), panicle initiation stage (55 DAS) and grain filling stage (75 DAS). Proper drainage system was also developed for draining out excess water.

3.3.4.2. Weeding

Weedings were done to keep the plots free from weeds which ultimately ensured better growth and development of wheat seedlings. The newly emerged weeds were uprooted carefully at tillering (30 DAS) and panicle initiation stage (55 DAS) manually.

3.3.4.3. Thinning

Thinning was done followed by weeding to keep optimum number of plant in the plot to get optimum spacing.

3.3.4.4. Plant protection

The crop was attacked by leaf hopper and aphid during the growing period. Triel-20 ml was applied on 2 January and Sumithion-40 ml/20 litre of water was applied on 20 January as plant protection measure.

3.4. Harvesting, threshing and cleaning

The crop was harvested manually depending upon the maturity from each plot starting from 11th March, 2011. The harvested area was 3 m^2. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of wheat grain. Fresh weight of wheat grain and straw were recorded plot wise. The grains were cleaned and weighted. The weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of wheat grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}.

3.5. Data collection

3.5.1. Growth parameters

3.5.1.1. Plant height

The height of plant was recorded in centimeter (cm) at 30, 50, 70, 90 DAS (Days after sowing) and at harvest. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.5.1.2. Number of tillers hill^{-1}

The number of tillers hill^{-1} was recorded at 30, 50, 70, 90 DAS (Days after sowing) and at harvest. Data were recorded as the average of 10 hills selected at random from the inner rows of each plot.

3.5.1.3. Dry matter plant^{-1} (g)

Dry matter was recorded at 30, 50, 70, 90 DAS and at harvest from 5 randomly collected plants from inner rows. Collected plants including roots, leaves, grain and straw were oven dried at 70^0C for 72 hours then transferred into desiecator and allowed to cool down at room temperature, final weight was taken and converted into dry matter content plant^{-1}.

3.5.1.4. Estimated growth parameter

Crop Growth Rate (CGR)

Crop growth rate was calculated using the following formula:

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1} \quad g\ m^{-2}\ day^{-1}$$

Where,

GA = Ground area (m^2)

W_1 = Total dry weight at previous sampling date

W_2 = Total dry weight at current sampling date

T_1 = Date of previous sampling

T_2 = Date of current sampling

Relative Growth Rate (RGR)

Relative growth rate was calculated using the following formula:

$$RGR = \frac{LnW_2 - LnW_1}{T_2 - T_1} \quad g\ g^{-1}\ day^{-1}$$

Where,

W_1 = Total dry weight at previous sampling date

W_2 = Total dry weight at current sampling date

T_1 = Date of previous sampling

T_2 = Date of current sampling

Ln = Natural logarithm

3.5.2. Yield contributing characters and yield

3.5.2.1. Number of plants m^{-2}

The total number of plant m^{-2} was estimated by counting the number of plant exists in 3 m^2 area and then averaged to have number of plant m^{-2} area.

3.5.2.2. Number of spikes $plant^{-1}$

The total number of spike $plant^{-1}$ was estimated by counting the number of spike from 10 plant and then averaged to have number of spike $plant^{-1}$.

3.5.2.3. Spike length

The length of spike was measured with a meter scale from 10 randomly selected spikes and the average value was recorded.

3.5.2.4. Number of spikelets spike^{-1}

The total number of spikelets spike^{-1} was counted as the number of spikelets from 10 randomly selected spikes from each plot and average value was recorded.

3.5.2.5. Number of spikes m^{-2}

The total number of spikes m^{-2} was estimated by counting the number of spikes exists in 3 m^2 area then averaged to have number of spike m^{-2}.

3.5.2.6. Weight of 1000 seeds

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

3.5.2.7. Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 3 m^2 area used to record grain yield plot^{-1} and converted this into t ha^{-1}.

3.5.2.8. Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 3 m^2 area was used to record the final straw yield plot^{-1} which was finally converted to t ha^{-1}.

3.5.2.9. Biological yield

Grain yield and straw yield together were regarded as biological yield of wheat. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield

3.5.2.10. Harvest index

Harvest index was calculated from per hectare grain and straw yield that were obtained from each unit plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (total dry weight)}} \times 100$$

3.6. Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment. The mean values of all the characters were calculated and analyses of variance were performed. The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the feasibility of replacing chemical fertilizer by using organic fertilizer in wheat. Data on different growth, yield contributing characters and yield were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix III-VI. 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 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 III). At 30 DAS, the longest plant (27.93 cm) was recorded from T_8 (cowdung + compost +½ chemical fertilizer), which was statistically similar with T_1 (all chemical fertilizer as recommended dose), T_3 (compost as recommended dose), T_4 (½ cowdung + ½ compost), T_5 (cowdung + compost), T_6 (cowdung + ½ chemical fertilizer), T_7 (compost + ½ chemical fertilizer), T_9 (½ cowdung + ½ compost + ½ chemical fertilizer) and T_2 (cowdung as recommended dose) (27.75 cm, 27.59 cm, 27.54 cm, 27.36 cm, 27.28 cm, 27.13 cm, 26.87 cm, 26.59 cm, respectively), while the shortest plant (23.13 cm) was obtained from T_0 (control condition). At 50 DAS, the longest plant (52.13 cm) was recorded from T_1, which was statistically similar with T_8, T_9, T_7, T_6, T_5 and T_4 treatments and closely followed by T_2 and T_3, whereas the shortest plant (41.14 cm) was obtained from T_0. At 70 DAS, the longest plant (82.13 cm) was recorded from T_1, which was statistically at per with T_8, T_9, T_7, T_6, T_5, T_4, T_3 and T_2 (81.02 cm, 78.27 cm, 77.73 cm, 77.53 cm, 76.07 cm, 75.27 cm, 74.87 cm and 74.13 cm, respectively) and the shortest plant (65.84 cm) was found from T_0. At 90 DAS, the longest plant (85.93 cm) was recorded from T_1, which was statistically similar with T_8, T_9, T_7, T_6, T_5 and T_4 (83.79 cm, 81.60 cm, 80.67 cm, 80.27 cm, 80.13 cm and 77.87 cm, respectively) and closely followed by T_2 and T_3 (75.67 cm and 75.43 cm, respectively), whereas the shortest plant was recorded from T_0 (70.77 cm). At harvest, the longest plant was attained from T_1 (95.21 cm), which was statistically similar with T_8, T_9, T_6, T_7,T_5, T_4, T_2 and T_3 (93.67 cm, 90.36 cm, 89.67 cm, 89.53 cm, 89.05 cm, 85.87 cm, 84.73 cm and 84.36 cm, respectively and the shortest plant (76.00 cm) was recorded from T_0 (Table 2). Application of all chemical fertilizer in recommended doses ensured the essential macro and micro nutrients for the vegetative growth of the wheat and the ultimate results were the longest plant. Combination of cowdung, compost and chemical fertilizers half in recommended doses also created a favorable condition for the growth and development of wheat plant for that combination of cowdung, compost and half chemical fertilizers also gave the similar results. Aga *et al.* (2004) reported that plant growth characters such as plant height were highest with application of 15 t compost ha^{-1}.

Table 2. Effect of chemical and organic fertilizers and their combinations on plant height of wheat

Treatment	Plant height (cm) at				
	30 DAS	50 DAS	70 DAS	90 DAS	Harvest
T_0	23.13 b	41.14 c	65.84 b	70.77 c	76.00 b
T_1	27.75 a	52.13 a	82.13 a	85.93 a	95.21 a
T_2	26.59 a	45.16 bc	74.13 a	75.67 bc	84.73 ab
T_3	27.59 a	45.06 bc	74.87 a	75.43 bc	84.36 ab
T_4	27.54 a	46.99 a-c	75.27 a	77.87 a-c	85.87 ab
T_5	27.36 a	48.40 ab	76.07 a	80.13 ab	89.05 a
T_6	27.28 a	48.66 ab	77.53 a	80.27 ab	89.67 a
T_7	27.13 a	49.06 ab	77.73 a	80.67 ab	89.53 a
T_8	27.93 a	51.16 ab	81.02 a	83.79 ab	93.67 a
T_9	26.87 a	49.33 ab	78.27 a	81.60 ab	90.36 a
SE	0.866	1.96	2.75	2.67	3.40
CV(%)	5.57	7.11	6.23	5.83	6.69

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: Cowdung + Compost
T_6: Cowdung + ½ Chemical fertilizer
T_7: Compost + ½ Chemical fertilizer
T_8: Cowdung + Compost +½ Chemical fertilizer
T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.2. Number of tillers hill^{-1}

Statistically significant variation was recorded for number of tillers hill^{-1} at 30, 50, 70 and 90 DAS, and at harvest for different chemical and organic fertilizers and their combinations (Appendix IV). At 30 DAS, the maximum number of tillers hill^{-1} was recorded from T_1 (2.00), which was statistically similar with T_8, T_9, and T_7 (1.87, 1.80 and 1.68, respectively) and was closely followed by T_4 (1.60), whereas the minimum number was found from T_0 (1.33), which was statistically similar with T_3, T_5, and T_2 (1.40, 1.40 and 1.47, respectively). At 50 DAS, the maximum number of tillers hill^{-1} was recorded from T_1 (5.64), which was statistically at per with T_8 (5.47) and closely followed by T_9 (5.13), while the minimum number was recorded from T_0 (2.87). At 70 DAS, the maximum number of tillers hill^{-1} was recorded from T_1 (6.93), which was statistically similar with T_8 (6.80) and closely followed by T_6, T_9, and T_7 (6.30, 6.26 and 6.23, respectively), again the minimum number was found from T_0 (4.20), which was statistically similar with T_2 (4.60). At 90 DAS, the maximum number of tillers hill^{-1} was recorded from T_1 (6.15), which was statistically similar with T_8 (5.67) and closely followed by T_9 (5.47), while the minimum number was observed from T_0 (3.94), which was statistically similar with T_2 and T_3 (4.25 and 4.43, respectively). At harvest, the maximum number of tillers hill^{-1} was obtained from T_1 (5.78), which was closely followed by T_8 (5.13) and the minimum number was recorded from T_0 (3.72), which was statistically similar with T_2, T_3 and T_4 (3.87, 3.92 and 4.03, respectively) (Table 3). It was revealed that all chemical fertilizer as recommended dose produced maximum tillers hill^{-1} at different days after sowing.

Table 3. Effect of chemical and organic fertilizer and their combinations on number of tillers hill^{-1} of wheat

Treatment	Number of tillers hill^{-1} at				
	30 DAS	50 DAS	70 DAS	90 DAS	Harvest
T_0	1.33 d	2.87 g	4.20 e	3.94 f	3.72 g
T_1	2.00 a	5.64 a	6.93 a	6.15 a	5.78 a
T_2	1.47 cd	3.70 ef	4.60 de	4.25 ef	3.87 fg
T_3	1.40 cd	3.60 f	4.73 d	4.43 d-f	3.92 fg
T_4	1.60 b-d	3.87 d-f	4.93 d	4.60 de	4.03 e-g
T_5	1.40 cd	4.27 d	5.63 c	4.87 d	4.17 d-f
T_6	1.52 b-d	4.13 de	6.30 b	5.00 cd	4.35 c-e
T_7	1.68 a-d	4.87 c	6.23 b	5.03 cd	4.47 cd
T_8	1.87 ab	5.47 ab	6.80 a	5.67 ab	5.13 b
T_9	1.80 a-c	5.13 bc	6.26 b	5.47 bc	4.62 c
SE	0.121	0.143	0.164	0.186	0.130
CV(%)	13.03	5.67	5.04	6.51	5.15

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: Cowdung + Compost
T_6: Cowdung + ½ Chemical fertilizer
T_7: Compost + ½ Chemical fertilizer
T_8: Cowdung + Compost +½ Chemical fertilizer
T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.3. Dry matter plant^{-1}

Different chemical and organic fertilizers and their combinations showed significant variation for dry matter content plant^{-1} at 30, 50, 70 and 90 DAS, and at harvest (Appendix V). At 30 DAS, the highest dry matter content plant^{-1} was recorded from T_1 (0.30 g), which was statistically similar with T_8, T_9, T_5 and T_7 (0.29 g, 0.28 g, 0.25 g and 0.25 g, respectively) and closely followed by T_6 (0.24 g), whereas the lowest was obtained from T_0 (0.18 g), which was statistically similar with T_2, T_3, and T_4 (0.20 g, 0.20 g and 0.22 g, respectively). At 50 DAS, the highest dry matter content plant^{-1} was observed from T_1 (3.87 g), which was statistically similar with T_8 and T_9 (3.71 g and 3.67 g, respectively) and followed by T_7 (3.30 g), whereas the lowest was obtained from T_0 (2.49 g). At 70 DAS, the highest dry matter content plant^{-1} was obtained from T_1 (8.84 g), which was statistically identical with T_8, T_9, T_7, T_6 and T_3 (8.71 g, 8.37 g, 8.30 g, 8.11 g and 7.95 g, respectively), while the lowest was obtained from T_0 (6.50 g). At 90 DAS, the highest dry matter content plant^{-1} was recorded from T_1 (19.58 g), which was statistically similar with T_8 (17.90 g) and closely followed by T_7, T_6 and T_5 (17.03 g, 16.38 g and 16.07 g, respectively) and that of lowest from T_0 (11.80 g). At harvest, the highest dry matter content plant^{-1} was attained in T_1 (30.18 g), which was statistically similar with T_8, T_9 and T_7 (29.11 g, 28.01 g and 27.61 g, respectively) and closely followed by T_6 and T_5 (26.82 g and 26.74 g, respectively), again the lowest was obtained from T_0 (18.08 g) (Table 4). 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 4. Effect of chemical and organic fertilizers and their combinations on dry matter plant^{-1} of wheat

Treatment	Dry matter plant^{-1} (g) at				
	30 DAS	50 DAS	70 DAS	90 DAS	Harvest
T_0	0.18 d	2.49 d	6.50 d	11.80 e	18.08 d
T_1	0.30 a	3.87 a	8.84 a	19.58 a	30.18 a
T_2	0.20 cd	2.91 c	7.53 c	15.34 d	25.67 c
T_3	0.20 cd	2.98 c	7.95 a-c	15.47 d	25.86 c
T_4	0.22 cd	3.05 c	7.86 bc	15.82 cd	25.99 c
T_5	0.25 a-c	3.15 c	7.76 bc	16.07 b-d	26.74 bc
T_6	0.24 b-d	3.17 c	8.11 a-c	16.38 b-d	26.82 bc
T_7	0.25 a-c	3.30 bc	8.30 a-c	17.03 b-d	27.61 a-c
T_8	0.29 ab	3.71 a	8.71 ab	17.90 ab	29.11 ab
T_9	0.28 ab	3.67 ab	8.37 a-c	17.62 bc	28.01 a-c
SE	0.018	0.132	0.291	0.616	0.885
CV(%)	10.24	7.06	6.30	6.55	5.80

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: Cowdung + Compost
T_6: Cowdung + ½ Chemical fertilizer
T_7: Compost + ½ Chemical fertilizer
T_8: Cowdung + 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, 50-70, 70-90 and 90-harvest (Appendix VI). At 30-50 DAS, the highest CGR was found in T_1 (5.35 g m^{-2} day^{-1}), while the lowest CGR was recorded in T_0 (3.46 g $m^{-2}day^{-1}$). At 50-70 DAS, the highest CGR was found in T_7 (8.34 g $m^{-2}day^{-1}$), while the lowest CGR was recorded in T_0 (6.70 g $m^{-2}day^{-1}$). At 70-90 DAS, the highest CGR was found in T_1 (17.89 g $m^{-2}day^{-1}$), while the lowest CGR was recorded in T_0 (8.83 g m^{-2} day^{-1}). At 90-harvest, the highest CGR was found in T_8 (18.69 g $m^{-2}day^{-1}$), while the lowest CGR was recorded in T_0 (10.47 g $m^{-2}day^{-1}$) (Table 5).

4.5. Relative Growth Rate

Relative Growth Rate (RGR) showed significant variation for different chemical and organic fertilizers and their combinations at 30-50, 50-70, 70-90 and 90-harvest (Appendix VII). At 30-50 DAS, the highest RGR was found in T_3 (0.134 g g^{-1} day^{-1}) and the lowest RGR was recorded in T_5 and T_8 (0.127 g g^{-1} day^{-1}). At 50-70 DAS, the highest RGR was found in T_3 (0.049 g g^{-1} day^{-1}) and the lowest RGR was recorded in T_9 (0.041 g g^{-1} day^{-1}). At 70-90 DAS, the highest RGR was found in T_3 (0.040 g g^{-1} day^{-1}) and the lowest RGR was recorded in T_0 (0.030 g g^{-1} day^{-1}). At 90-110 DAS, the highest RGR was found in T_3 (0.026 g g^{-1} day^{-1}) and the lowest RGR was recorded in T_0 (0.021 g g^{-1} day^{-1}) (Table 6).

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

Treatment	Crop Growth Rate (g $m^{-2}day^{-1}$) at			
	30-50 DAS	50-70 DAS	70-90 DAS	90-Harvest
T_0	3.46 d	6.70 b	8.83 c	10.47 b
T_1	5.35 a	8.29 a	17.89 a	17.67 a
T_2	4.07 c	7.69 a	13.03 b	17.21 a
T_3	4.17 c	8.28 a	12.53 b	16.32 a
T_4	4.25 c	8.02 a	13.26 b	17.94 a
T_5	4.35 c	7.70 a	13.84 b	17.79 a
T_6	4.39 c	8.24 a	13.78 b	17.41 a
T_7	4.56 bc	8.34 a	14.55 b	17.63 a
T_8	5.13 ab	8.32 a	15.32 ab	18.69 a
T_9	5.09 ab	7.82 a	15.43 ab	17.31 a
SE	0.197	0.243	0.859	0.838
CV(%)	7.60	5.29	10.74	8.62

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: Cowdung + Compost
T_6: Cowdung + ½ Chemical fertilizer
T_7: Compost + ½ Chemical fertilizer
T_8: Cowdung + 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 wheat

Treatment	Relative growth rate (g g^{-1} day^{-1}) at			
	30-50 DAS	50-70 DAS	70-90 DAS	90-Harvest
T_0	0.131 ab	0.048 ab	0.030 c	0.021 e
T_1	0.128 ab	0.042 cd	0.040 a	0.022 de
T_2	0.133 a	0.047 a-c	0.036 ab	0.026 a
T_3	0.134 a	0.049 a	0.033 bc	0.025 ab
T_4	0.132 ab	0.047 a-c	0.035 a-c	0.025 a-c
T_5	0.127 b	0.045 a-d	0.036 ab	0.025 ab
T_6	0.130 ab	0.047 a-d	0.035 a-c	0.025 a-c
T_7	0.128 ab	0.046 a-d	0.036 ab	0.024 bc
T_8	0.127 b	0.043 b-d	0.036 ab	0.024 a-c
T_9	0.129 ab	0.041 d	0.037 ab	0.023 cd
SE	0.002	0.002	0.002	0.001
CV(%)	7.60	6.06	8.16	6.15

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: Cowdung + Compost

T_6: Cowdung + ½ Chemical fertilizer

T_7: Compost + ½ Chemical fertilizer

T_8: Cowdung + Compost +½ Chemical fertilizer

T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

4.6. Number of plants m^{-2}

Statistically significant variation was recorded for number of plants m^{-2} for different chemical and organic fertilizers and their combinations (Appendix VIII). The maximum number of plants m^{-2} was found in T_1 (45.33) which was statistically similar with T_8, T_9, T_6, T_5, T_7, T_4 and T_3 (45.00, 43.67, 43.33, 42.33, 42.00, 41.00 and 39.67, respectively) and closely followed by T_2 (37.67), whereas the minimum number was recorded from T_0 (32.67) (Table 7). Application of chemical fertilizers in their recommended doses ensured the essential macro and micro nutrients for the plant and the ultimate results were the maximum number of hill in m^2 area. Combination of cowdung, compost and chemical fertilizers half in recommended doses also created a favorable condition for the growth and development of wheat hence this treatment also gave the higher number of plants m^{-2}.

4.7. Number of spikes $plant^{-1}$

Number of spikes $plant^{-1}$ showed statistically significant variation for different chemical and organic fertilizers and their combinations (Appendix VIII). The maximum number of spikes $plant^{-1}$ was found in T_1 (4.61), which was statistically similar with T_8, T_7, T_9, T_6 and T_5 (4.50, 4.45, 4.40, 4.29 and 4.24, respectively) and closely followed by T_4 (3.95), while the minimum number from T_0 (3.73), which was statistically similar with T_3 and T_2 (3.74 and 3.86, respectively) (Table 7). The results corroborates with the findings of Tamaki *et al.* (2002) who observed that continuous organic farming increase in spike number $plant^{-1}$.

Table 7. Effect of chemical and organic fertilizers and their combinations on number of plants m^{-2}, number of spikes $plant^{-1}$ and number of spikelets $spike^{-1}$ of wheat

Treatment	Number of plants m^{-2}	Number of spikes $plant^{-1}$	Number of spikelets $spike^{-1}$
T_0	32.67 c	3.73 d	14.18 d
T_1	45.33 a	4.61 a	20.33 a
T_2	37.67 bc	3.86 cd	15.06 cd
T_3	39.67 ab	3.74 d	15.16 cd
T_4	41.00 ab	3.95 b-d	15.43 b-d
T_5	42.33 ab	4.24 a-d	16.04 b-d
T_6	43.33 ab	4.29 a-d	17.88 a-d
T_7	42.00 ab	4.45 a-c	17.50 a-d
T_8	45.00 ab	4.50 ab	19.07 ab
T_9	43.67 ab	4.40 abc	18.33 a-c
SE	2.23	0.180	1.121
CV(%)	9.35	7.46	11.49

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

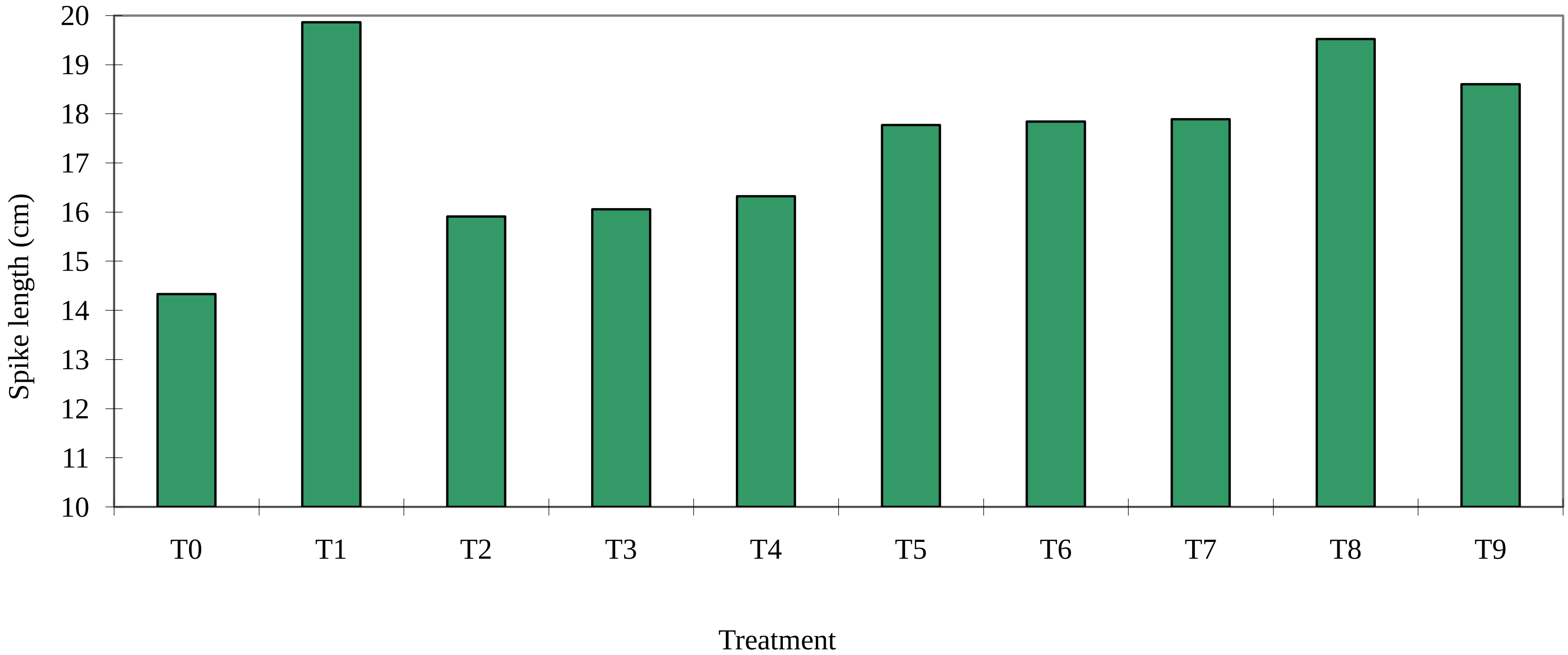
T_0: Control (without manure and fertilizer)
T_1: All chemical fertilizer as recommended dose
T_2: Cowdung as recommended dose
T_3: Compost as recommended dose
T_4: ½ Cowdung + ½ Compost
T_5: Cowdung + Compost
T_6: Cowdung + ½ Chemical fertilizer
T_7: Compost + ½ Chemical fertilizer
T_8: Cowdung + Compost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

4.8. Number of spikelets spike^{-1}

Different chemical and organic fertilizers and their combinations showed significant variation for number of spikelets spike^{-1} (Appendix VIII). The maximum number of spikelets spikes^{-1} was recorded from T_1 (20.33), which was statistically at per with T_8, T_9, T_6 and T_7 (19.07, 18.33, 17.88 and 17.50, respectively) and followed by T_5 and T_4 (16.04 and 15.16), whereas the minimum number was recorded from T_0 (14.18) which was statistically similar with T_2 and T_3 (15.06 and 15.43, respectively) (Table 7). It was revealed that all chemical fertilizer as recommended dose produced maximum number of spikelets spike^{-1} but combination of manure with chemical fertilizers gave the similar results.

4.9 Spike length

Significant variation was recorded in case of spike length for different chemical and organic fertilizers and their combinations (Appendix IX). The longest spike was observed in T_1 (19.86 cm), which was statistically similar with T_8, T_9, T_7, T_6, T_5 and T_4 (19.52 cm, 18.60 cm, 17.89 cm, 17.84 cm, 17.77 cm and 16.32 cm, respectively) and closely followed by T_3 and T_2 (16.06 and 15.91 cm, respectively), again the shortest spike was recorded from T_0 (14.33 cm) (Figure 2). Application of all chemical fertilizer as per recommended doses gave longest spike with ensuring optimum vegetative growth as well as reproductive growth of wheat followed by the combination of cowdung, compost and chemical fertilizers half in recommended doses.



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: Cowdung + Compost
T_6: Cowdung + ½ Chemical fertilizer
T_7: Compost + ½ Chemical fertilizer
T_8: Cowdung + Compost +½ Chemical fertilizer
T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

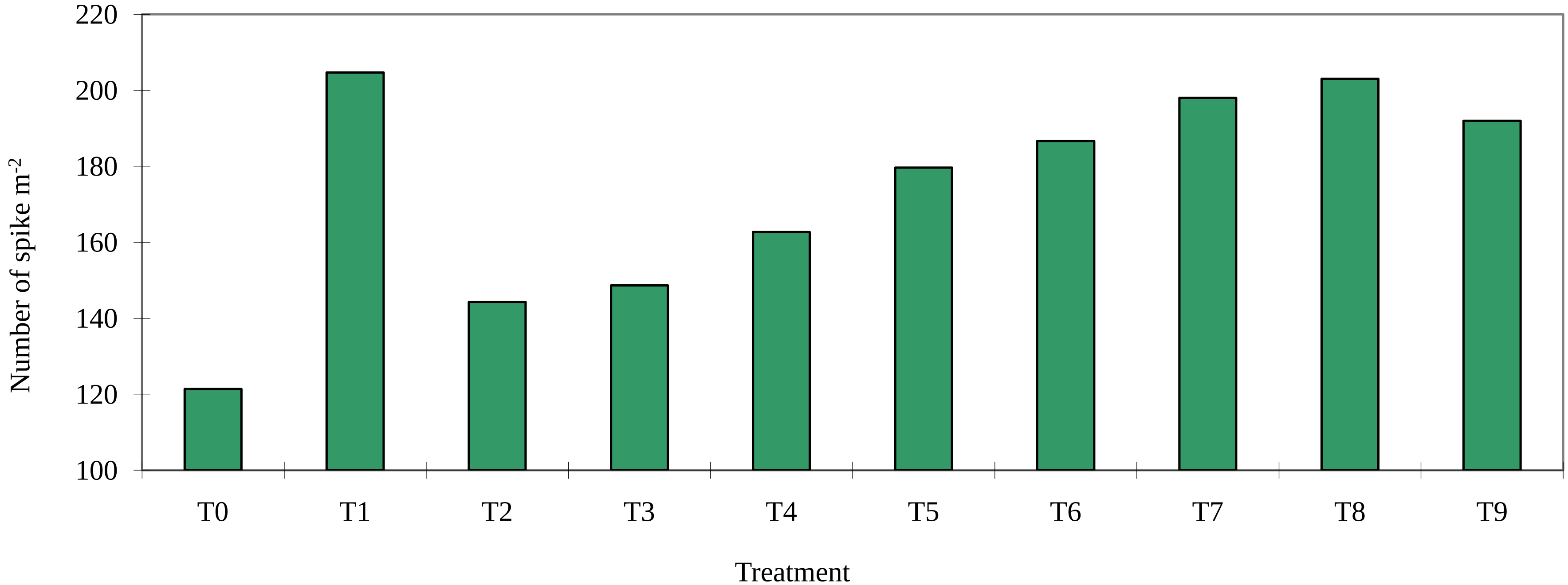
Figure 2. Effect of chemical and organic fertilizer sand their combinations on spike length of wheat (Sx=1.073)

4.10. Number of spikes m^{-2}

Statistically significant variation was recorded for number of spikes m^{-2} for different chemical and organic fertilizers and their combinations (Appendix IX). The maximum number of spikes m^{-2} was obtained from T_1 (204.67), which was statistically similar with T_8, T_7, T_9, T_6, T_5 and T_4 (203.00, 198.00, 192.00, 186.67, 179.67 and 162.67, respectively) and closely followed by T_3 (148.67), while the minimum number was recorded from T_0 (121.33), which was statistically similar with T_2 (144.33) (Figure 3). Application of all chemical fertilizer as recommended dose ensured the macro and micro nutrients for the vegetative growth of the wheat that leads to the optimum reproductive growth and the ultimate results was the maximum number of tillers m^{-2} as well as maximum number of spikes m^{-2}. Combination of cowdung, compost and chemical fertilizers in half recommended doses of chemical fertilizers also created a favorable condition for the growth and development of wheat plant for that combination of cowdung, compost and half chemical fertilizers gave the similar results.

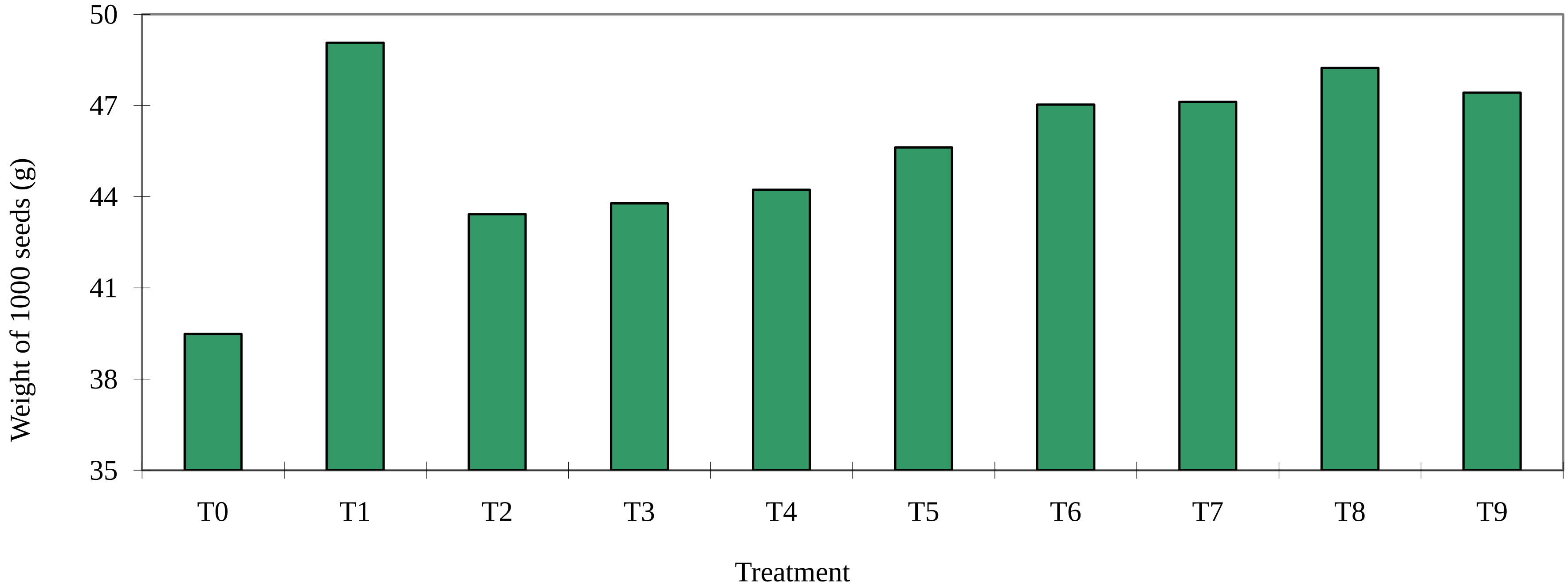
4.11. Weight of 1000 seeds

Weight of 1000 seed varied significantly due to different chemical and organic fertilizers and their combinations (Appendix IX). The highest weight of 1000 seeds was recorded from T_1 (49.06 g), which was statistically similar with T_8, T_9, T_7, T_6, T_5, T_4, T_3 and T_2 (respectively for 48.23 g, 47.42 g, 47.12 g, 47.03 g, 45.62 g, 44.23 g, 43.78 g and 43.42 g) and the lowest weight was recorded from T_0 (39.48 g) (Figure 4). It was revealed that all chemical fertilizer as recommended dose gave the highest weight of 1000 seeds.



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: Cowdung + Compost
T_6: Cowdung + ½ Chemical fertilizer
T_7: Compost + ½ Chemical fertilizer
T_8: Cowdung + Compost +½ Chemical fertilizer
T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

Figure 3. Effect of chemical and organic fertilizers and their combinations on number of spike m^{-2} (Sx = 13.86)



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: Cowdung + Compost
T_6: Cowdung + ½ Chemical fertilizer
T_7: Compost + ½ Chemical fertilizer
T_8: Cowdung + Compost +½ Chemical fertilizer
T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer

Figure 4. Effect of chemical and organic fertilizers and their combinations on weight of 1000 seeds (Sx= 1.812)

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

Statistically significant variation was recorded in the grain yield per hectare for different chemical and organic fertilizer and their combinations (Appendix X). The highest yield was obtained from T_1 (3.71 t ha^{-1}), which was statistically similar with T_8, T_9 and T_7 (respectively for 3.66 t ha^{-1}, 3.51 t ha^{-1} and 3.38 t ha^{-1}) and closely followed by T_6 and T_5, (3.22 t ha^{-1} and 3.17 t ha^{-1}, respectively). On the other hand, the lowest yield was found in T_0 (2.06 t ha^{-1}) (Table 8). 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 wheat. 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.

4.13. Straw yield (t ha^{-1})

Different chemical and organic fertilizer and their combinations exerted significant variation on straw yield per hectare of wheat (Appendix X). The highest straw yield was observed in T_1 (5.78 t ha^{-1}), which was statistically at per with T_9, T_8, T_7, T_6, T_5 and T_4 (5.72 t ha^{-1}, 5.65 t ha^{-1}, 5.61 t ha^{-1}, 5.45 t ha^{-1}, 5.41 t ha^{-1} and 5.16 t ha^{-1}, respectively) and closely followed by T_3 and T_2 (4.93 t ha^{-1} and 4.81 t ha^{-1}, respectively). Again the lowest yield was recorded from T_0 (4.49 t ha^{-1}) (Table 8).

Table 8. Effect of chemical and organic fertilizers and their combinations on grain, straw and biological yield of wheat

Treatment	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)
T_0	2.06 d	4.49 c	6.54 f
T_1	3.71 a	5.78 a	9.49 a
T_2	3.03 c	4.81 bc	7.84 e
T_3	3.05 c	4.93 bc	7.98 de
T_4	3.11 c	5.16 ab	8.27 de
T_5	3.17 bc	5.41 ab	8.58 cd
T_6	3.22 bc	5.45 ab	8.67 b-d
T_7	3.38 a-c	5.61 a	8.99 a-c
T_8	3.66 ab	5.65 a	9.31 ab
T_9	3.51 a-c	5.72 a	9.23 a-c
SE	0.151	0.206	0.220
CV(%)	8.14	6.73	7.49

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

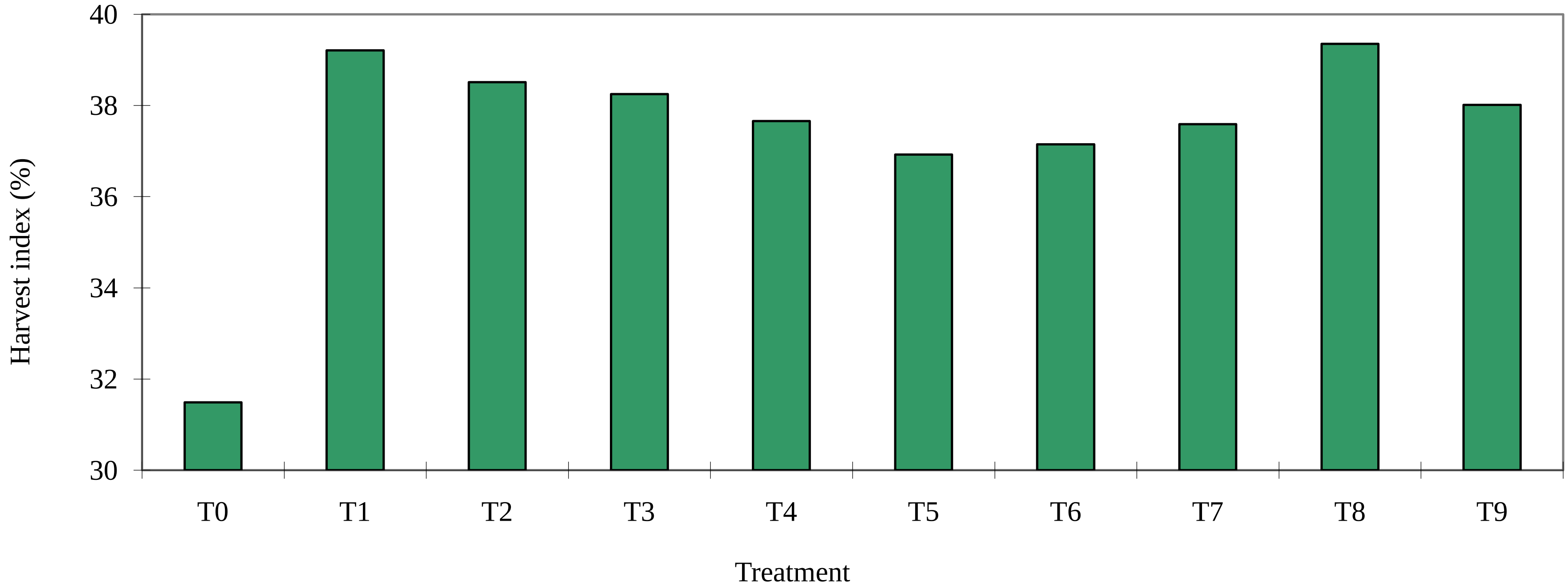
T_0: Control (without manure and fertilizer)
T_1: All chemical fertilizer as recommended dose
T_2: Cowdung as recommended dose
T_3: Compost as recommended dose
T_4: ½ Cowdung + ½ Compost
T_5: Cowdung + Compost
T_6: Cowdung + ½ Chemical fertilizer
T_7: Compost + ½ Chemical fertilizer
T_8: Cowdung + Compost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

4.14. Biological yield (t ha^{-1})

Significant variation was recorded in biological yield of wheat for different chemical and organic fertilizer and their combinations (Appendix X). The highest biological yield was found in T_1 (9.49 t ha^{-1}), which was statistically similar with T_8, T_9 and T_7 (9.31 t ha^{-1}, 9.23 t ha^{-1} and 8.99 t ha^{-1}, respectively) and was closely followed by T_6 (8.67 t ha^{-1}) and that of the lowest 6.54 t ha^{-1} from T_0 (Table 8). Application of all chemical fertilizer in recommended doses ensured the essential macro and micro nutrients for the vegetative and reproductive growth of wheat and the ultimate results were the highest grain and straw yield as well as maximum biological yield. Combination of cowdung, compost and chemical fertilizers half in recommended doses also created a favorable condition for the growth and development of wheat plant for that combination of cowdung, compost and half chemical fertilizers also gave the similar results.

4.15. Harvest index (%)

Harvest index for different chemical and organic fertilizer showed significant differences (Appendix X). The highest harvest index was recorded from T_8 (39.35%), which was similar with T_1, T_2, T_3, T_9, T_4, T_7, T_6 and T_5 (39.21%, 38.51%, 38.25%, 38.01%, 37.66%, 37.59%, 37.15% and 36.92%, respectively) and the lowest harvest index was recorded from T_0 (31.49%) (Figure 5).



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: Cowdung + Compost
T_6: Cowdung + ½ Chemical fertilizer
T_7: Compost + ½ Chemical fertilizer
T_8: Cowdung + 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 harvest index (Sx=1.283

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2010 to March 2011 to study the feasibility of replacing chemical fertilizer by using organic fertilizer in wheat. The experiment comprised with the following 10 treatments, such as 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: Cowdung + Compost; T_6: Cowdung + ½ Chemical fertilizer; T_7: Compost + ½ Chemical fertilizer; T_8: Cowdung + Compost +½ Chemical fertilizer and T_9: ½ Cowdung + ½ Compost + ½ Chemical fertilizer. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth characters and yield were recorded.

At 30 DAS, the longest plant was recorded from T_8 (27.93 cm), while the shortest plant was found in T_0 (23.13 cm). At 50 DAS, the longest plant was recorded from T_1 (52.13 cm), whereas the shortest plant was obtained from T_0 (41.14 cm). At 70 DAS, the longest plant was recorded from T_1 (82.13 cm) and the shortest plant was found in T_0 (65.84 cm). At 90 DAS, the longest plant was recorded from T_1 (85.93 cm), whereas the shortest plant was recorded from T_0 (70.77 cm). At harvest, the longest plant was attained from T_1 (95.21 cm) and the shortest plant was recorded from T_0 (76.00 cm). At 30 DAS, the maximum number of tillers hill^{-1} was recorded from T_1 (2.00), whereas the minimum number was found in T_0 (1.33). At 50 DAS, the maximum number of tillers hill^{-1} was recorded from T_1 (5.64) while the minimum number was recorded from T_0 (2.87). At 70 DAS, the maximum number of tillers hill^{-1} was recorded from T_1 (6.93) again the minimum number was found from T_0 (4.20). At 90 DAS, the maximum number of tillers hill^{-1} was recorded from T_1 (6.15), while the minimum number was observed from T_0 (3.94). At harvest, the maximum number of tillers hill^{-1} was obtained from T_1 (5.78) and the minimum number was recorded from T_0 (3.72). At 30 DAS, the highest dry matter content plant^{-1} was recorded from T_1 (0.30 g), whereas the lowest weight was found from T_0 (0.18 g). At 50 DAS, the highest dry matter content plant^{-1} was observed from T_1 (3.87 g), whereas the lowest weight was recorded from T_0 (2.49 g). At 70 DAS, the highest dry matter plant^{-1} was obtained from T_1 (8.84 g), while the lowest weight was found from T_0 (6.50 g). At 90 DAS, the highest dry matter content plant^{-1} was recorded from T_1 (19.58 g), while the lowest weight was recorded from T_0 (11.80 g). At harvest, the highest dry matter content plant^{-1} was attained from T_1 (30.18 g), again the lowest weight from T_0 (18.08 g). At 30-50 DAS, the highest CGR was found from T_1 (5.35 g m^{-2}day^{-1}), while the lowest CGR was recorded from T_0 (3.46 g m^{-2}day^{-1}). At 50-70 DAS, the highest CGR was found from T_7 (8.34 g m^{-2}day^{-1}), while the lowest CGR was recorded from T_0 (6.70 g m^{-2}day^{-1}). At 70-90 DAS, the highest CGR was found from T_1 (17.89 g m^{-2}day^{-1}), while the lowest CGR was recorded from T_0 (8.83 g m^{-2}day^{-1}). At 90-110 DAS, the highest CGR was found from T_8 (18.69 g m^{-2}day^{-1}), while the lowest CGR from T_0 (10.47 g m^{-2}day^{-1}). At 30-50 DAS, the highest

RGR was found from T_3 (0.134 g g^{-1} day^{-1}) and the lowest RGR was recorded from T_5 and T_8 (0.127 g g^{-1} day^{-1}). At 50-70 DAS, the highest RGR was found from T_3 (0.049 g g^{-1} day^{-1}) and the lowest RGR was recorded from T_9 (0.041 g g^{-1} day^{-1}). At 70-90 DAS, the highest RGR was found from T_3 (0.040 g g^{-1} day^{-1}) and the lowest RGR was recorded from T_0 (0.030 g g^{-1} day^{-1}). At 90-110 DAS, the highest RGR was found from T_3 (0.026 g g^{-1} day^{-1}) and the lowest RGR was recorded from T_0 (0.021 g g^{-1} day^{-1}).

The maximum number of plants m^{-2} was found from T_1 (45.33), whereas the minimum number was recorded from T_0 (32.67). The maximum number of spikes $plant^{-1}$ was found from T_1 (4.61), while the minimum number was recorded from T_0 (3.73). The longest spike was observed from T_1 (19.86 cm), again the shortest spike was recorded from T_0 (14.33 cm). The maximum number of spikelets $spike^{-1}$ was recorded from T_1 (20.33), whereas the minimum number was found from T_0 (14.18). The maximum number of spikes m^{-2} was obtained from T_1 (204.67), while the minimum number was recorded from T_0 (121.33). The highest weight of 1000 seed was recorded from T_1 (49.06 g) and the lowest weight was recorded from T_0 (39.48 g). The highest grain yield was obtained from T_1 (3.71 t ha^{-1}) and the lowest yield was found from T_0 (2.06 t ha^{-1}). The highest straw yield was observed from T_1 (5.78 t ha^{-1}) again the lowest yield was recorded from T_0 (4.49 t ha^{-1}). The highest biological yield was found from T_1 (9.49 t ha^{-1}) and the lowest yield from T_0 (6.54 t ha^{-1}). The highest harvest index was recorded from T_8 (39.35%) and the lowest harvest index was observed from T_0 (31.49%).

Conclusion

Among the treatments all chemical fertilizers with recommended doses (T_1) showed the highest yield as well as yield contributing characters of wheat. But the treatments T_8 (Cowdung + Compost +½ Chemical fertilizer), T_9 (½ Cowdung + ½ Compost + ½ Chemical fertilizer) and T_7 (Compost + ½ Chemical fertilizer) showed statistically similar results in yield and yield attributes of wheat as T_1. In these treatments chemical fertilizers were reduced with organic fertilizers. So, considering the results of the present experiment, we have option to choice treatment T_8 consisting of cowdung + compost +½ chemical fertilizer or T_9 (1/2 cowdung + ½ compost +½ chemical fertilizer) without significant yield loss.

Recommendations

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study needs to be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability;

2. Other inorganic and organic fertilizer as sole or different combinations may be included in the future study.

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APPENDICES

Appendix I. Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
pH	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October 2010 to March 2011

Month	*Air temperature (^{o}C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
October, 2010	26.11	18.05	77	19
November, 2010	25.82	16.04	78	00
December, 2010	22.4	13.5	74	00
January, 2011	24.5	12.4	68	00
February, 2011	27.1	16.7	67	30
March, 2011	31.4	19.6	54	11

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix III. Anlysis of variance of the data on plant height as influenced by chemical and organic fertilizers and their combination on wheat

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAS	50 DAS	70 DAS	90 DAS	Harvest
Replication	2	0.614	3.526	1.004	5.865	6.122
Treatment	9	5.788*	31.506*	60.361*	58.643*	89.431*
Error	18	2.248	11.493	22.604	21.313	34.581

*: Significant at 0.05 level of probability

Appendix IV. Anlysis of variance of the data on number of tillers hill^{-1} as influenced by chemical and organic fertilizers and their combinations on wheat

Source of variation	Degrees of freedom	Mean square				
		Number of tillers hill^{-1} at				
		30 DAS	50 DAS	70 DAS	90 DAS	Harvest
Replication	2	0.011	0.014	0.050	0.001	0.031
Treatment	9	0.152**	2.416**	2.887**	1.382**	1.219**
Error	18	0.044	0.061	0.081	0.104	0.051

**: Significant at 0.01 level of probability

Appendix V. Anlysis of variance of the data on dry matter content plant^{-1} as influenced by chemical and organic fertilizers and their combinations on wheat

Source of variation	Degrees of freedom	Mean square				
		Dry matter content plant^{-1} (g) at				
		30 DAS	50 DAS	70 DAS	90 DAS	110 DAS
Replication	2	0.0001	0.009	0.022	0.340	1.070
Treatment	9	0.005**	0.532**	1.328**	12.577**	32.069**
Error	18	0.001	0.052	0.254	1.140	2.348

**: Significant at 0.01 level of probability

Appendix VI. Anlysis of variance of the data on Crop Growth Rate as influenced by chemical and organic fertilizers and their combinations on wheat

Source of variation	Degrees of freedom	Mean square			
		Crop Growth Rate (g $m^{-2}day^{-1}$) at			
		30-50 DAS	50-70 DAS	70-90 DAS	90-110 DAS
Replication	2	0.017	0.265	0.372	2.003
Treatment	9	0.985**	0.773**	16.491**	16.125**
Error	18	0.116	0.177	2.213	2.106

**: Significant at 0.01 level of probability

Appendix VII. Anlysis of variance of the data on Relative Growth Rate as influenced by chemical and organic fertilizers and their combinations on wheat

Source of variation	Degrees of freedom	Mean square			
		Relative growth rate (g g^{-1} day^{-1}) at			
		30-50 DAS	50-70 DAS	70-90 DAS	90-110 DAS
Replication	2	0.0001	0.0001	0.0001	0.0001
Treatment	9	0.0005**	0.0009**	0.0011*	0.0007**
Error	18	0.0001	0.0001	0.0001	0.0001

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix VIII. Anlysis of variance of the data on number of plants m^{-2}, number of spikes $plant^{-1}$ and number of spikelets $spike^{-1}$ as influenced by chemical and organic fertilizers and their combinations on wheat

Source of variation	Degrees of freedom	Mean square		
		Number of plant m^{-2}	Number of spikes $plant^{-1}$	Number of spikelets $spike^{-1}$
Replication	2	0.433	0.012	1.689
Treatment	9	43.911*	0.325**	12.182**
Error	18	14.878	0.097	3.771

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix IX. Anlysis of variance of the data on spike length, number of spikes m^{-2} and weight of 1000 seed as influenced by chemical and organic fertilizers and their combinations on wheat

Source of variation	Degrees of freedom	Mean square		
		Spike length	Number of spikes m^{-2}	Weight of 1000 seed (g)
Replication	2	1.024	372.400	1.232
Treatment	9	9.054*	2432.670**	24.652*
Error	18	3.457	576.659	9.851

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability

Appendix X. Anlysis of variance of the data on grain, straw & biological yield and harvest index as influenced by chemical and organic fertilizers and their combinations on wheat

Source of variation	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.002	0.060	0.041	3.054
Treatment	9	0.657**	0.573**	2.346**	14.893*
Error	18	0.068	0.127	0.145	4.936

**: Significant at 0.01 level of probability: *: Significant at 0.05 level of probability