EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON THE GROWTH AND YIELD OF WHEAT (BARI Gom 26)

A THESIS

BY

NUSRAT JAHAN

Student No. 1605036

Semester: January-June, 2017

Session: 2016-2017

MASTER OF SCIENCE (MS)

IN

SOIL SCIENCE

DEPARTMENT OF SOIL SCIENCE

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

DECEMBER, 2017

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Submitted to the Department of Soil Science
Hajee Mohammad Danesh Science and Technology University, Dinajpur
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DECEMBER, 2017

Dedicated

To

My Beloved

Parents

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The Author

ABSTRACT

An experiment was conducted at the Soil Science research field of Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period of December 2016 to April 2017 in order to evaluate the effects of organic and inorganic fertilizers on the growth and yield of wheat (BARI Gom 26). The experiment was laid out in a Randomized Complete Block Design (RCBD) having eight treatments with three replications. The treatments were as follows; T_0= Control, T_1= 100% recommended doses of inorganic fertilizers (RDIF), T_2= 100% recommended doses of organic fertilizers (RDOF), T_3= 50% RDIF+50% RDOF, T_4= 67% RDIF+33% RDOF, T_5= 33% RDIF+67% RDOF, T_6= 25% RDIF+75% RDOF, T_7= 75% RDIF+25% RDOF. The experimental soil belongs to the Old Himalayan Piedmont Plain (AEZ-1). The soil was sandy loam in texture having pH 5.13, organic matter content 1.64%, total N 0.07%, available P 55.59 ppm, exchangeable K 0.21 meq 100 g^{-1} soil and available S 19.75 ppm. Application of organic and inorganic fertilizers resulted in a considerable influence on the properties of the post-harvest soils such as pH, organic matter content, total N, available P, exchangeable K and available S. The results revealed that the yield components such as, plant height, spike length, no. of tillers $hill^{-1}$, spikelets $spike^{-1}$, grains $spike^{-1}$, 1000-grains weight of wheat (BARI Gom 26) responded significantly due to application of organic and inorganic fertilizers. The highest plant height (91cm) was observed in T_7 treatment and the lowest (48.73 cm) was found in the T_0 (control). The maximum number of tillers $hill^{-1}$ (4.66) was recorded in the treatment T_7 and the lowest (3.04) was observed from the controlled treatment T_0. The highest spike length (9.46 cm), highest spikelets $spike^{-1}$ (15.89), maximum number of grains $spike^{-1}$ (51.63), highest 1000-grains weight (35.93g) was noticed at T_7 treatment and the lowest performance of those treatments was noticed at T_0 (control). Application of organic and inorganic fertilizers significantly increased the yield component of grain and straw of wheat (BARI Gom 26). The treatment T_7 receiving 75% inorganic fertilizers with 25% organic fertilizers showed the highest grain yield (4.75 t ha^{-1}) and straw yield (5.56 t ha^{-1}).The lowest grain yield (2.34 t ha^{-1}) and straw yield (2.71 t ha^{-1}) were found in the treatment T_0 (control). The findings of the study showed that the performance of the treatment T_7 was the best among all treatments. Therefore, 75% inorganic fertilizer and 25% organic fertilizer is recommended for wheat cultivation.

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ABBREVIATIONS AND ACRONYMS

AEZ	:	Agro Ecological Zone
ANOVA	:	Analysis of Variance
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
DAP	:	Diammonium Phosphate
et al.	:	And others
FAO	:	Food and Agricultural Organization
Fig.	:	Figure
ha	:	Hectare
K	:	Potassium
MOP	:	Muriate of Potash
N	:	Nitrogen
P	:	Phosphorous
PPM	:	Parts Per Million
S	:	Sulphur
SOP	:	Sulphate of Potash
TSP	:	Triple Super Phosphate
t ha^{-1}	:	Ton per hectare
UNDP	:	United Nations Development Programme
Viz.	:	Namely

CHAPTER I

INTRODUCTION

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is commonly cultivated cereal crop in the world. It is a staple food for more than one third of the world population (Anonymous, 2007-08). In Bangladesh, it is the second major cereal crop after rice. Cereal crops contribute about 80% to the total food coming from plants. It contributes largest part among all cereals. Cereals are an important dietary protein source throughout the world, because they constitute the main protein and energy supply in most countries (Bos *et al.,* 2005). It is second after rice as a source of calories in the diets of consumers in developing countries and is first as a source of protein which is consumed by humans and is grown in diverse environments around the world (Braun *et al.,* 2010).

Wheat was cultivated in ancient Greece and Egypt in pre-historic times. The central Asia, Near East, Mediterranean and Ethiopian regions are the world's most important centers of diversity of wheat and its related species (Kundu and Nagarajan, 1996; Porrino and Porcedu, 1990). In Bangladesh, the climatic and edaphic conditions are suitable for wheat cultivation except some coastal districts. It is more widely cultivated than any other crop after rice. In Bangladesh, the total area under wheat crop has been estimated 10,99,158 acres (4,44,805 hectares) compared to 10,79,411 acres (4,36,814 hectares) of the last year (BBS, 2016). With rapidly increasing population, the demand of food is increasing. So there is a great need to increase the productivity of wheat. Average yield of wheat in Bangladesh has been estimated 3 metric tons per hectare whereas the highest production of wheat in China was 126 million metric tons (BBS, 2016).

The average yield of wheat is very low due to rapid change of climate, substandard methods of cultivation, nutrient deficiency, late sowing, imbalanced use of fertilizers, reduced use of organic matter, lack of high yielding varieties and socio-economic condition of farmers. However, increasing human population has led to intensive cultivation without adequately replenishing soil nutrients. The result has been the decline in crop yields and depletion of the resource base.

Fertilizers are usually applied to soil for increasing or maintaining crop yields to meet the increasing demand of food (Haynes and Naidu, 1998). Although inorganic fertilizers improve the growth of plants and increase the yields in a relatively short period of time, there are certain disadvantages of using inorganic fertilizers as opposed to organic fertilizers derived from natural sources. Continuous application of chemical fertilizers causes soil health problems even if applied in balanced proportion (Zia *et al.,* 2000). One of the possible options to reduce the use of chemical fertilizers could be using of organic matter.

Organic matter plays an important role in maintaining soil fertility. A good soil have at least 2.5% organic matter, but in Bangladesh most of have less than 1.5% and some soils even less than 1% organic matter (Anonymous, 2005). Intensive cultivation, continuous and unbalanced use of inorganic fertilizers accompanied by restricted use of organic manures has led to server degradation of the soil resulting in a reduction of soil organic matter, soil fertility and productivity. The role of organic matter for sustaining soil fertility and productivity is now attracting the attention of soil scientist and agriculturists throughout the world. It undergoes mineralization with the release of substantial quantities of N, P, K, S and smaller amount of micronutrients. The general effects of organic matter on soil are the improvement of the physical, chemical and biological properties. It contributes to soil aggregation and reduces susceptibility to erosion in sandy soils.

It is now essential to increase organic matter content through combined application of organic and inorganic fertilizers. Integration of organic and inorganic fertilizers has shown commitment not only in sustaining the productivity and soil health but also in meeting a part of costly inorganic fertilizers requirement of crops (Rabindra *et al.,* 1990; Hegde and Dwievedi, 1993). Only the solution is to combined use these materials for agricultural lands. But organic nutrients alone could not be a perfect substitute for chemical fertilizers as these are not as much quick nutrient supplier as chemical fertilizers, so integrated use of organic nutrients along with chemical fertilizers has proved more beneficial (Nasir and Qureshi, 1999; Alam *et al.,* 2005).

Therefore, suitable combination of organic and inorganic fertilizers needs to be developed for particular crop in particular cropping system and soil. Keeping the above stated in view, the present study was undertaken to find out the effects of different combination of organic and inorganic fertilizers on the growth and yield performance of wheat (BARI Gom 26) with following specific objectives:

i. To study the effects of organic and inorganic fertilizers on the growth and yield of wheat (BARI Gom 26).
ii. To study the effects of organic and inorganic fertilizers on the post-harvest fertility status of the experimental soil.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

A number of research works relating to the application of organic and inorganic fertilizers to wheat crops have been carried out in different wheat growing countries of the world including Bangladesh. A better understanding of the effects of the nutrients supplied from organic and inorganic fertilizers on wheat will be helped to literature forms a bridge between the past and present research works related to problem, which helps a researcher to draw a satisfactory conclusion, an effort was thus made to present some research works related to the present study in this section.

2.1 Effect of inorganic fertilizers on the growth and yield of wheat

Jogi *et al.* (2017) conducted a field experiment in Pakistan to study the effect of balanced fertilizer for enhancing wheat growth and yield. They used seven different fertilizer doses includes, 0:80, 60:80, 120:0, 120:40, 120:80, 120:120 and 180:80 kg NP ha^{-1} were tested The results revealed that NP doses had significant ($p<0.05$) influence on all the growth and yield constituents of wheat. The maximum 78.0 cm height of plant, 412.0 tillers m^{-2}, 11.2 cm spike length, 21.2 spikelets spike^{-1}, 43.0 grains spike^{-1}, 18.0 grams grain weight plant^{-1}, 10373 kg biological yield and 4820 kg grain yield ha^{-1} were recorded at 180:80 kg NP ha^{-1} followed by 120:120 kg NP ha^{-1} which positioned 2nd with 77.3 cm plant height, 411.3 tillers m^{2}, 11.2 cm spike length, 21.3 spikelets spike^{-1}, 42.9 grains spike^{-1}, 17.7 grams grain weight plant^{-1}, 10366 kg ha^{-1} biological yield and 4811 kg ha^{-1} grain yield. While, 120:80 kg NP ha^{-1} ranked 3rd and resulted 76.0 cm plant height, 410.7 tillers m^{-2}, 11.2 cm spike length, 21.2 spikelets spike^{-1}, 42.1 grains spike^{-1}, 17.3 grams grain weight plant^{-1}, 10354 kg biological yield and 4807 kg grain yield ha^{-1}.

Mandic *et al.* (2015) carried out an experiment at Serbia to study the nitrogen fertilizer influence on wheat yield and use efficiency under different environmental conditions. They estimate the effects of different N fertilization levels (0, 75, and 150 kg N ha^{-1}) on some quantitative traits, rain-use efficiency (RUE), N agronomic efficiency (NAE), and N use efficiency (NUE) in two Serbian winter wheat (*Triticum aestivum* L.) cultivars 'Pobeda' and 'Renesansa'. 'Pobeda' had higher grain yield (4437 kg ha^{-1}) and RUE (8.32 kg ha^{-1} mm^{-1}) than 'Renesansa' (4265 kg ha^{-1} and 8 kg ha^{-1} mm^{-1}, respectively). Grain yield (4652 kg ha^{-1}) and NUE (31.46 kg kg^{-1} N) were higher in the 2010-2011 season (favorable weather conditions) than in the 2011-2012 (4050 kg ha^{-1} and 27.59 kg kg^{1} N, respectively). The highly significant effect on grain yield (4396 and 4494 kg ha^{-1}), RUE (8.24 and 8.45 kg ha^{-1} mm^{-1}), NAE (3.11 and 2.21 kg kg^{-1} N) and NUE (58.62 and 29.96 kg kg^{-1} N) had levels of 75 and 150 kg Nha^{-1}.

Ali *et al.* (2015) set up a field experiment at Pakistan to evaluate the effect of different doses of nitrogen fertilizer on the yield of wheat .The response of wheat to N fertilizer levels viz. 84, 128, 150, 175 and 200 kg ha^{-1} was studied. Two years data during Rabi 2000–2001 and 2001–2002 indicated that number of productive tillers m^{-2}, 1000-grains weight and grain yield of wheat increased with the application of 150 kg N ha^{-1}. Whereas nitrogen @ 175 kg ha^{-1} resulted in the highest number of grains spike^{-1} and maximum plant height was observed at the nitrogen rate of 200 kg ha^{-1}.

Mumtaz *et al*. (2014) conducted an experiment in Pakistan to study the effect of different phosphorus levels on growth and yield of wheat under water stress conditions. They observed that water stress and low phosphorus availability are the limiting factors for growth and yield of wheat. They used five different phosphorus levels (P = 0, 30, 60, 90, 120 kg ha^{-1}) with three water stress levels (I_1 = well-irrigated, I_2 = water stress at reproductive stage and I_3 = water stress both at vegetative + reproductive stages) were applied to check their effects on growth and yield of wheat. They observed that higher application of phosphorus with optimum irrigation showed significant effect on growth of wheat. Higher phosphorus application rate compensate the effect of water stress conditions both at vegetative and reproductive stages. Drought stress at vegetative + reproductive stages was more drastically affected as compared to stress at reproductive stage. Lower phosphorus application rate with water stress caused maximum reduction in plant height, number of tillers, spike length, number of grains spike^{-1}, 1000 grains weight, grain yield and straw yield. It was concluded that application of phosphorus at higher rate could compensate drastic effect of water stress. On overall performance, application of phosphorus at the rate of 120 kg ha^{-1} showed better results under water stress conditions as compared to other phosphorus levels.

Khan *et al.* (2014) carried out a two years field experiment to study the influence of various nitrogen & potassium stages and application method on wheat yield and qualities of grain yield. The experimental contained the following elements i.e. wheat SIRAN-

2010, four stages having Nitrogen 90, Nitrogen 120, Nitrogen 150 and Nitrogen 180 kg ha^{-1}), 3 stages containing N 30, N 60, N 90 kg ha^{-1}) followed by four application methods vis-à-vis, (i) soil application, 95% soil + 5% foliar application, (ii) 90% soil + 10% foliar application (iii) 85% soil + 15% foliar application with three replications of RCBD. Half nitrogen amount was applied to soil and K was applied as a full dose on seeding period and remained half was applied with first irrigation around about 21 days after sowing. This step accompanied with foliar spray. Urea (46% N or 46-0-0) was applied in form of N and soil was applied by K in the form of Sulfate of Potash (50% K_2O or 0-0-50). Application of Foliar K necessary to apply in the form of foliar Solo Potash (50% K_2O) containing its quantity 0.57 Molar K solution. He applied a basal dose of P that was at 90 kilogram P_2O_5 ha^{-1} in the usage of TSP (0-46-0). The experiment showed an average of two years crop production grain yield that increased by 7.6% with 15% foliar application of nutrients with comparison of applied soil. It resulted in yield improvement increasing N and K levels. On the basis of two years experiment that found high average, Nitrogen at 180 kg ha^{-1} with stimulating K 90 kg ha^{-1}. Improved grain yield by 47.4%, biological yield 28.5%, 1000 grain weight 29.2% and grains $spike^{-1}$ 24.6% as matched with control. On the conclusion of the results observed from the experiment, it is recommended that N at 180 and K at 90 kg ha^{-1} in arrangement should be applied for higher grain yield of wheat. Nitrogen at 180 kg ha^{-1} with 10% foliar application is recommended for higher production.

Ali *et al.* (2012) conducted a field experiment in Pakistan to evaluate the effect of different levels of sulfur on the productivity of wheat in a saline sodic soil. They used different S levels (0, 25, 50 and 75 kg S ha^{-1}) on growth of wheat variety directly sown in a saline sodic soil (ECe=4.92 dSm-1, pH=8.22 and SAR=16.15 dSm^{-1}) at Zaidi Farm, Sheikhupura during winter 2009. They found that tillering, number of grains $spike^{-1}$, 1000 grain weight, grain yield significantly ($p \leq 0.05$) increased by enhancing the rate of S application. Wheat grain yield was the maximum (4040 kg ha^{-1}) at the application of 50 kg S ha^{-1} and 26% more than control treatment. The maximum number of tillers 5 $plants^{-1}$ (110), number of grains $spike^{-1}$ (63.6) and 1000 grain weight (47g) were recorded with S application at 50 kg ha^{-1}.

Mojid *et al.* (2012) tested an experiment to check “the requisite of N, P and K fertilizers for cultivation of wheat” on the basis of irrigation by municipal waste water. The experimental action contained wheat CV Shatabdi; recommended five different doses and the other two of each, viz-a-vis. 0-80-100-120, 140 kg ha^{-1} for Nitrogen; 0-10-20-30, 40 kg ha^{-1} for phosphorus, 0- 40-60-80, 100 kg ha^{-1} for potash. Each of the experiment was provided with an equal amount of irrigation by wastewater with 3 repetitions of RCBD. The usages had 4 doses of one of the major nutrients of each experiment, S, Zn and B and the other two major nutrients were positioned at suggested quantities. Plots were fertilized through Gypsum, TSP, MOP, Zinc sulfate and borax fertilizer. As a result, the spike length, spikelet's spike^{-1}, yield of grain and harvest index noticed to be improved with the nitrogen increase dose, simultaneously reduced by use of extra dose. It was noticed in the experiment that major growth and yield qualities improved significantly at $p=0.05$ by provision of increased Phosphorus amount up to 20 kg ha^{-1}. On the other hand, the phosphorus used into undesirable but found unimportant results on the crop qualities. The effect of Nitrogen and Phosphorus seemed to be decreased significantly on the makings of wheat yield. It was the increase in application rather than the suggested amount of potash. The wheat crop generally has more enhanced utilization of the nutrients after applied at the somewhat lesser amounts. Finally, the finding of this experiment shows that the oversight of Nitrogen, Phosphorus or potash slightly decreases the weight of grain per thousand grain yield.

Laghari *et al.* (2010) organized an experiment on different wheat cultivars to assess the yield, growth, and nutrient uptake under different fertilizers. The experimental method consisted of three wheat varieties viz-a-viz. TD-1, T.J-83 and Mehran-89: nine levels of fertilizer (0-0-0, 60-60-00, 60-60-30, 120-60-00, 12060-60, 18060-00, 180-60-90, 240-60-00 and 240-60-120 NPK kg ha^{-1}) with RCDB with 3 replications in factorial arrangement. Different levels of NPK were applied in the form of DAP, urea, and SOP respectively. All P, K in amalgamation of half Nitrogen were practiced during land preparation. The remaining half N was split applied with 2nd, 3rd and 4th irrigations. The results showed that fertilizer application significantly enhanced growth, yield and nutrient application traits of wheat. Request of 120-60-60 NPK kg ha^{-1} to TD^{-1} recorded the following all at maximum level, including these are; tillers, spike length, grains spike^{-1}, biological yield, grain yield, harvest index, dry matter, leaf area index, crop growth rate and NPK uptake. Further increase in NPK rate had a non-significant response on these traits. However, application of 180-60-60 NPK kg ha^{-1} or higher fertilizer regimes produced tall plants, maximum nodes per stem, internode length, grain weight spike^{-1}, seed index, prolonged maturity days and higher lodging tendency in Mehran-89 and TJ-83.

Malghani *et al.* (2010) conducted a field experiment in Pakistan to investigate the combined effect of NPK (Nitrogen, Phosphorus and Potash) on the growth and yield of wheat cultivars Sahar-2006. The objective of study was to determine optimum rate of NPK for wheat variety. The thrice replicated treatments F0: 0-0-0 (NPK), F_1:75-50-25(NPK), F_2:100-75-50 (NPK), F_3: 125-100-75 (NPK), F_4: 150-125-100 (NPK), F_5: 175-150-125 (NPK) and F_6: 200-150-125 (NPK) Kg ha^{-1} were tested in Randomized Complete Block Design (RCBD).The results revealed that maximum growth parameters responded significantly to NPK fertilizers. It was reported that highest grain yield of 5168 Kg ha^{-1} was recorded with the application of 175-150-125 NPK Kg ha^{-1}. The increase in yield was 51.58% higher as compared to control (2502 Kg ha^{-1}) where no fertilizer was used.

Sharma and Prassad (2003) studied the effect of phosphate rock (PR) and TSP in three cycles of rice-wheat cropping system. Application of TSP had significant effect on grain and straw yields and P uptake by rice and wheat. They stated that the efficiency of PR + TSP was better than of PR alone in rice-wheat cropping system.

Hussain *et al.* (2002) set up an experiment regarding growth, yield and excellence reaction of three wheat (*Triticum aestivum* L.) varieties. This consist the following 3 different stages of Nitrogen, Phosphorus and potash. The experimental apparatus consisted of three wheat varieties i.e. Inqulab-91, Kharchia and Parwaz-94. Three fertilizer levels low (35-25-25), medium (70-50-50) and high (105-75-75) kg NPK ha^{-1} with RCBD taking split plot plan, and replicated thrice. Nitrogen, phosphorus and potassium were applied in the usage of potassium sulphate, urea, diammonium phosphate (DAP), respectively. Whole of Phosphorus and potash and half of Nitrogen was practiced at sowing time and remaining nitrogen was top-dressed with first irrigation. The results showed that the use of different NPK levels significantly affected plant height, no. of fertile tillers, thousand grain weight, and grain yield and grain protein content of wheat. The highest grain yield (4.99 t ha^{-1}) was recorded in Inqulab-91 with the application of 105-75-75 kg NPK ha^{-1}.

Cheema *et al.* (2001) reported that application of phosphorus fertilizer produces taller plants.

Singh and Sale (2000) observed that the application of phosphorus enhances drought tolerance in plant. It also stimulates root growth and photosynthesis.

Patel *et al.* (1997) reported in a trial of rice and wheat grown in rotation using 0, 50 or 100% of the recommended P rates of 50 kg P_2O_5 ha^{-1} for rice and 60 kg P_2O_5 ha^{-1} for wheat and stated that rice responded up to 100% of the recommended P rates while wheat responded up to 50% of the recommended P.

2.2 Effect of organic fertilizers on the growth and yield of wheat

Al Amin *et al.* (2017) conducted an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh in Rabiseason (dry season) of 2014 to study the effect of mulching and organic manure on growth and yield performance of wheat. They used five mulching practices viz. M_1=1 irrigation at 17-21 days after sowing (DAS), M_2=2 irrigations at 17-21 and 55-60 DAS, M_3=3 irrigations at 17-21, 55-60 and 75-80 DAS, M_4=control, M_5=straw mulch (6 t ha^{-1}) and five organic manure managements viz. O_1=recommended chemical fertilizer (NPKS @ 100-23-20-16 kg ha^{-1}, O_2= poultry manure @ 6 t ha^{-1} (100% PM), O_3=vermicompost @ 8 t ha^{-1} (100% VC), O_4=50% chemical fertilizer + 50% VC and O_5=50% chemical fertilizer + 50% PM were used as experimental variables. The experiment was conducted in split-plot design with three replications. The results found that mulching had significant influence on all attributes. The highest values of all attributes were found in straw mulch treatment. It was observed that organic manure had significant influences on all characters. The highest values of yield and yield attributes were found in O_5 (50% chemical fertilizer + 50% PM) treatment. It was observed that effective tillers $hill^{-1}$, grain yield and straw yield were significantly affected by combined effect of mulching and organic manure. The highest values obtained from mulching and O_5 (50% chemical fertilizer + 50% PM) treatment. Therefore, it can be inferred from the results of the study that highest production could be obtained from mulching and O_5 (50% chemical fertilizer + 50% PM) treatment.

Bijay-Singh *et al.* (2013) viewed that incorporation of 3-7.9 t ha^{-1} rice residue 10-40 days before planting wheat significantly increased yield of wheat.

Kamal *et al.* (2012) stated that organic fertilizer is effective in restoring the productivity of degraded soil.

Namvar *et al*. (2012) investigated that the inoculation with bio-fertilization had significant effect on plant height, grain weight spike^{-1}, number of spikes m^{-2}, number of grains spike^{-1}, 1000 grain weight, grain and straw yields and crude protein percentage in wheat plants.

Sharma and Behera (2010) observed that air-dried Leukaemia leaves applied as surface mulch at 2 t ha^{-1} and incorporated into the soil 30 days after harvest of maize significantly increased wheat grain yield. They also showed that 3.14 t ha^{-1} green Leucaena leaves containing 3% N on dry weight basis when incorporated into the soil 15 days before planting wheat increased grain yield at par with 100 kg N ha^{-1} applied through urea.

Mostafa and Abo-Baker (2010) viewed that phosphor compost was found to be comparable to superphosphate in increasing grain yield of wheat.

Hossam EL-Din (2007) observed that the application of farmyard manure at different rates significantly increased yield and its components. He added that organic fertilization reduce soil pollution and sustain soil fertility through their effect on physical, chemical and biological properties of soil.

Tayebeh *et al.* (2007) reported a positive effect of organic fertilizer on soil structure that lead to better root development and more nutrients uptake. They also concluded that compost not only slowly releases nutrients but also prevent the loss of chemical fertilizers through desertification, volatilization and leaching by binding to nutrients and releasing with the passage of time.

Channabasanagowda *et al*. (2007) studied that vermicompost @ 3.8 t ha^{-1} + poultry manure @ 2.45 t ha^{-1} recorded significantly higher plant height (86.30 cm), number of leaves (40.50) and higher number of tillers (94.60) at 90 DAS and it also recorded higher number of ear heads m^{-2} (160.10), 1000-grains weight (42.73 g) and grain yield (3043 kg ha^{-1}), vigour index (3223), seedling dry weight (311.27 mg) and protein content (13.41%) of wheat compared to other treatments.

FAO (2006) showed that biofertilizers are used on farms at a limited scale which contributes only <2.0% of the total fertilizers used by the farmers for crop production.

Sarwar (2005) found that grain yield and yield components of wheat were significantly increased with the application of different organic materials in the form of compost.

Huang *et al.* (2005) reported that straw mulch increased wheat (*Triticum aestivum* L.) yields significantly during both dry (1997) and wet (1998) years. It increased biomass and grain yield of spring wheat by 37 and 52%, respectively, in 1997, and by 20 and 26%, respectively, in 1998. Straw mulch also significantly decreased evapotranspiration ($P < 0.05$), soil water depletion ($P < 0.01$), and increased water-use efficiency ($P < 0.001$).

Dixit & Gupta (2000) stated that crop growth may be improved by the use of organic materials.

Zhang *et al.* (1998) concluded that organic manures increased labile, moderately stable and stable organic P contents in soil.

Xu *et al.* (1997) observed that application of organic matters affected soil pH value as well as nutrient level and yield.

Sarkar and Singh (1997) found that organic fertilizer alone or in combination with inorganic fertilizer increased the level of organic carbon in the soil as well as the total N, P and K content in the soil.

Beri *et al.* (1995) reported that greater declines in wheat yield at a low rate of N application (0.5 t ha^{-1} declines at 60 kg N ha^{-1}) than at a high rate of N application (0.08 t ha^{-1} declines at 180 kg N ha^{-1}).

2.3 Combined effects of organic and inorganic fertilizers on the growth and yield of wheat

Islam *et al.* (2014) conducted an experiment in at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during November 2011 to March 2012 to study yield and nutrient uptake by wheat as influenced by integrated use of manures and fertilizers. They evaluated that the effect of integrated use of manures and fertilizers on the growth, yield and nutrient uptake by wheat. They observed that integrated use of manures and fertilizers significantly influenced the yield attributes as well as grain and straw yields of wheat.

Zahoor (2014) examined in the experimental research farm agricultural university, Peshawar during December 2009 to May 2010 to study the effects of integrated use of urea and farm yard manure (FYM) on nitrogen uptake and yield of wheat (*Triticum aestivum* L). They used organic and inorganic fertilizers for crop productivity and sustainability. The result of those experiment showed that application of 10 tons FYM ha^{-1} before sowing increased the number spike m^{-2}, grain yield, grains $spike^{-1}$, 1000 grain yield compared with control. It was proved from the experimental results that the uses of FYM with urea before sowing have the potential to enhance the yield of wheat.

Akhtar *et al.* (2011) observed that combined application of organic manure and fertilizers significantly increased the straw yield of wheat.

Devi *et al.* (2011) carried out a field experiment during 2005-06 and 2006-07 on clay loam soil to assess the effect of integrated nutrient management practices on growth and yield of wheat (*Triticum aestivum* L.) The results revealed that the application of 100% recommended dose of fertilizers (RDF) i.e. 120:26:4:50 N:P:K kg ha^{-1} + vermicompost @ 1 t ha^{-1} + phosphate solubilizing bacteria (PSB) and 75% RDF + vermicompost @ 1 t ha^{-1} + PSB produced higher yield attributes and grain yield than the other treatments. The higher yield led to higher NPK uptake by wheat. Further, the available NPK content of soil also increased in above NM treatment over control. The highest benefit: cost ratio (2.73) was obtained from the application of 75% RDF + vermicompost @1t ha^{-1} + PSB.

Abedi *et al.* (2010) conducted an experiment in Iran to study the effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. They used different levels of inorganic (0, 80, 160 and 240 kg Nitrogen ha^{-1}) and organic (0, 30 and 60 Mg municipal waste compost ha^{-1}) fertilizers on wheat grain yield, gluten content, protein variability and protein banding pattern on polyacrylamide gel in different growth stages of irrigated wheat, a field experiment was conducted at research station of the School of Agriculture, Shiraz University at Bajgah in 2007. Results indicated that the highest wheat grain yield was achieved when the plants were fertilized with 160 kg N ha^{-1} and 30 Mg compost ha^{-1}. Among yield components, spikes $plant^{-1}$, seeds $spike^{-1}$ and 1000 grains weight were significantly increased with increasing the level of nitrogen.

Bhattacharyya *et al.* (2010) observed that 27% higher wheat yield in NPK (120 kg N ha^{-1}, 26 kg P ha^{-1}, 33 kg K ha^{-1}) and FYM (10 t ha^{-1}) treated plots than in NPK plots (2.4 t ha^{-1}).

Meisner and Sadat (2010) recorded that application of 10 t FYM ha^{-1} along with 75% of the local fertilizer recommendation produced grain yield of wheat equivalent to 100% of the inorganic fertilizer treatment (100 kg N ha^{-1}, 26 kg P ha^{-1}, 33 kg K ha^{-1}). The application of 10 t ha^{-1} FYM along with 100% local recommendation of NPK (120 kg N ha^{-1}, 26 kg P ha^{-1}, 25 kg K ha^{-1}) produced wheat grain yield as high as produced by 150% NPK.

Shah *et al.* (2010) evaluated in a field experiment at Nuclear Institute for Food and Agriculture (NIFA), Peshawar during December 2004 to May 2005 to integrated use of organic and inorganic fertilizers on the yield of wheat. The organic sources used were farmyard manure, poultry manure and city waste. These were integrated in different proportions with mineral nitrogenous fertilizer to supply 120 kg N ha^{-1}. All the organic fertilizers were applied at sowing time and mineral fertilizer (urea) was applied in three splitters sowing, tillering and booting stages in equal amount. The results showed that integrated use in different proportion increased the plant height, spike length, grain $spike^{-1}$ and 1000-grains weight. Maximum grain yield of 3.5 t ha^{-1} was obtained from treatments where 25% N was applied from FYM 25% N from poultry manure or city waste and 50% from mineral source and in treatment where 25% N was applied from FYM, 25% from city waste and 50% from mineral fertilizer. Application of half N from urea with 25% N from either FYM and 25% poultry manure or city waste proved beneficial and reduced 50% fertilizer cost.

Yakub *et al.* (2010) found that 6% increase of grain yield by applying urea-N and manures.

Toor *et al.* (2009) carried out an experiment on the effect of application of poultry manure, farm yard manure and urea on available nutrient status of soil in wheat and observed that poultry manure was more effective than farm yard manure for available N and P.

Rehman *et al.* (2008) conducted an experiment during 2003-04 and 2004-05 under rainfed conditions at Cereal Crops Research Institute Pirsabaq, Pakistan. They used nine different combinations of NPK (control, 40-30-30, 40-30-60, 40-60-30, 40-60-60, 80-30-30, 80-30-60, 80-60-30 and 80-60-60 kg ha^{-1} and four different levels of FYM (control, 15, 30 and 45 t ha^{-1}) and a wheat variety (Haider-2000). Experiment was laid out in randomized complete block (RCB) design with split plot arrangement replicated four times. FYM was allotted to main plots while combinations of NPK were applied to subplots. Different levels of NPK and FYM alone or in combination had significant effect on emergence m^{-2}, spikes m^{-2}, grains $spike^{-1}$, biological yield (kg ha^{-1}) and thousand grain weight. Maximum emergence m^{-2} (83.5), grains $spike^{-1}$ (55.8) thousand grain weight (35.16) and biological yield (10008 kg ha^{-1}) were recorded at 80-60-60 NPK ha^{-1}. Maximum spikes m^{-2} (201.6) were recorded at 80-60-30 kg NPK ha^{-1}. Farmyard manure at 45 t ha^{-1} produce the maximum spikes m^{-2} (191.2), grains $spike^{-1}$ (54.4), thousand grain weight (34.69) and biological yield (10000 kg ha^{-1}), while no significance difference was recorded for these parameters between 30 and 45 t FYM ha^{-1}. It was concluded that 80-60-60 kg NPK ha^{-1} and 30 t FYM ha^{-1} have produced maximum wheat yield components and biomass under rainfed condition.

Shah and Ahmad (2006) set up a field experiment in Peshawar valley of North West Frontier Province, Pakistan during 2001-2002 to effect of integrated use of urea and Farm Yard Manure (FYM) on yield and N uptake of Wheat. Urea and FYM were combined in a way to supply N at 120 kg ha^{-1} from both sources in 0:0, 100:0, 75:25, 50:50, 25:75 and 0:100 ratios arranged in a RCB design with four replications. The results indicated that maximum biological (10952 kg ha^{-1}), straw (7710 kg ha^{-1}) and grain (3242 kg ha^{-1}) yields of wheat were obtained in treatment receiving N from urea and FYM in 75:25 ratio. The next higher yield was obtained in treatment receiving N from the two sources in 50:50 ratio. Comparing with other fertilizer treatments, the yields were significantly lower in treatments where N from urea source was below 50%. Similarly, the N uptake in grain (47.66 kg ha^{-1}) and straw (19.28 kg ha^{-1}) was also significantly ($P < 0.05$) greater in treatments receiving 75 or 50 % N from urea and 25 or 50% from FYM. The data on crop yields and N uptake in response to integrated use of urea and FYM supported each other. The residual soil organic fertility after crop harvest was proportional to the level of FYM used. They suggested that integrated use of urea and FYM at 75:25 or 50:50 ratios (N basis) has produced maximum yields and recommended for profitable wheat yield and sustainable soil fertility.

Singh (2006) conducted a field experiment to study the influence of integrated nutrient supply system comprising inorganic fertilizers and organics (FYM, GM and rice straw) on rice-wheat cropping system. He found that the total uptake of N, P and K by both crops increased significantly with combined use of organic and inorganic fertilizers.

Kaur *et al.* (2005) compared the change of chemical and biological 21 properties in soils receiving FYM, poultry manure and sugarcane filter cake alone or in combination with chemical fertilizers for seven years under a cropping sequence of pearl millet and wheat. Results showed that all treatments except chemical fertilizer application improved the soil organic C, total N, P and K status. Increase in microbial biomass C and N was observed in soils receiving organic manures only or with the combined application of organic manures and chemical fertilizers compared to soils receiving chemical fertilizers. This study showed that balanced fertilization using both organic and chemical fertilizers is important for maintenance of soil organic matter (OM) content and long-term soil productivity in the tropics where soil OM content is low.

Yadav *et al.* (2003) stated that application of 10 t ha^{-1} FYM alone or in combination with inorganic fertilizer improved the N and P uptake by wheat compared with application of inorganic fertilizers alone.

Haque *et al.* (2001) reported that increased grain yield with the application of manures and fertilizers in an integrated way.

Nambiar (2000) viewed that integrated use of manure and fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining higher soil fertility status.

Verma and Bhagat (1992) observed that 25% of the recommended fertilizer N to wheat through FYM and recorded yield of wheat equivalent to that produced by 100% inorganic fertilizers.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

A field experiment was conducted at the Soil Science research field, Department of Soil Science in HSTU, Dinajpur. This chapter contains a brief description under the following points: experimental site, soil, climate, crops, treatments, experimental designing, land preparation, fertilizer application, seed sowing, intercultural operation, harvesting, data collection, soil analysis and statistical analysis.

3.1 Experimental site

A field experiment was set up at the research field of the Department of Soil Science at Hajee Mohammad Danesh Science and Technology University (HSTU) during December, 2016 to April, 2017 to investigate the effect of organic and inorganic fertilizers on the growth and yield of wheat (BARI Gom 26). The field is located at $25^0 37' 16''$N latitude and $88^0 38' 4''$E longitude and 37m above the mean sea level (Fig. 3.1).

3.2 Experimental soil

The experimental soil belongs to the Old Himalayan Piedmont Plain (AEZ 1), which falls into Non Calcareous Brown Floodplain soils (UNDP and FAO, 1988). The general characteristics of the soil are presented in table 3.1 and 3.2.

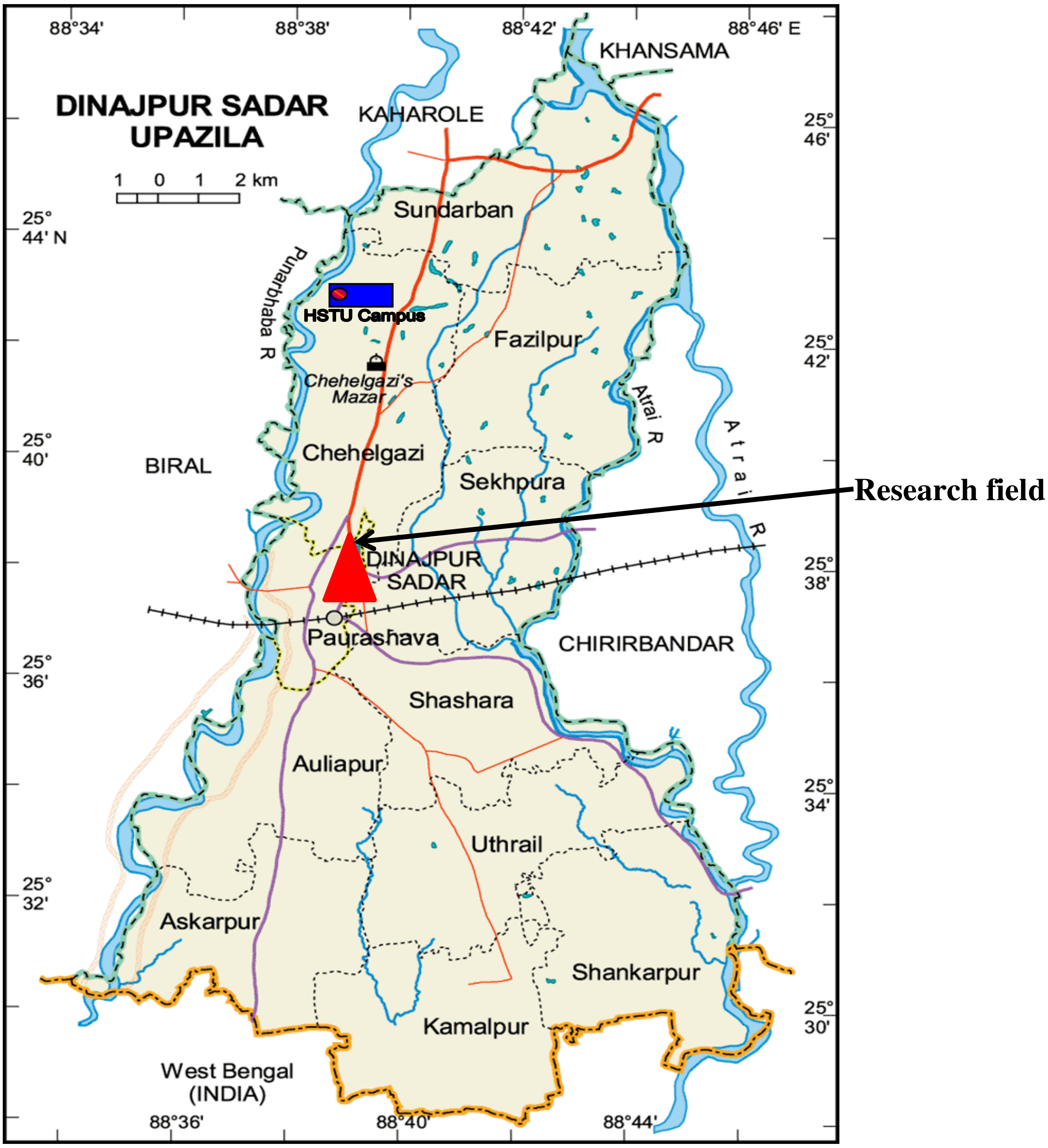

Fig. 3.1: Location of the experimental site

(Map of Dinajpur Sadar Upazila showing the research field)

Table 3.1 Morphological characteristics of the soils of HSTU research field

Location	HSTU research field
Agro-Ecological Zone (AEZ)	Old Himalayan Piedmont Plain
General soil type	Non Calcareous Brown Floodplain Soil
Topography	Medium high
Textural class	land Sandy loam
Drainage	Well drained

Table 3.2 Physical and chemical properties of the initial soil sample of the research field

Physical characteristics of the initial soil sample

Sand %	60
Silt %	29
Clay %	13
Textural class	Sandy loam

Chemical characteristic of the initial soil sample

pH (soil: water = 1:2.5)	5.13
Organic matter (%)	1.64
Total N (%)	0.07
Available P (ppm)	55.59
Exchangeable K (meq 100 g $^{-1}$ soil)	0.21
Available S (ppm)	19.75

3.3 Crop

The crop of the experiment was BARI Gom 26. This variety is high yielding and heat tolerant, commonly known as Hashi, semi dwarf in height, early maturing with high yield potential released in 2010 and can be grown successfully throughout the country for commercial cultivation. Grains are amber in colour, bright and larger in size its high yield potential. Healthy, vigorous, and well-matured seeds were selected for sowing.

3.4 Climate

In the experimental area, usually the rainfall was heavy during summer season (April to September) and winter (October to March) season. Winter season starts with low temperature and plenty sunshine. The atmospheric temperature increases from February as the season proceeds towards summer.

3.5 Soil texture

Mechanical analysis of soil was done by hydrometer method (Bouyoucos, 1926). The particle was separated according to the USDA size limits and the textural classes (% sand, % silt and % clay) of soil were determined using Marshall's triangular coordinate's diagram.

3.6 Experimental design and treatment

The experiment was laid out in Randomized Completely Block Design (RCBD) with 3 replications and 8 treatments. The experimental plot was divided into 24 plots according to the treatments and replications. The treatments were randomly distributed to unit plots in each blocks.

Treatments were as follow –

T_0= Control (no fertilizer application)

T_1= 100% recommended doses of inorganic fertilizers

T_2= 100% recommended doses of organic fertilizers

T_3= 50% recommended doses of inorganic fertilizers + 50% recommended doses of organic fertilizers

T_4 = 67% recommended doses of inorganic fertilizers + 33% recommended doses of organic fertilizers

T_5= 33% recommended doses of inorganic fertilizers + 67% recommended doses of organic fertilizers

T_6= 25% recommended doses of inorganic fertilizers + 75% recommended doses of organic fertilizers

T_7= 75% recommended doses of inorganic fertilizers + 25% recommended doses of organic fertilizers

3.7 Layout of the experimental plots

Total number of plots	:	24
Individual plot size = 2 m x 2.5 m	:	$5m^2$
Space between block to block	:	1m
Space between plot to plot	:	0.5m
Treatment	:	8
Replication	:	3

The layout of the experimental field has shown in Fig. 3.2.

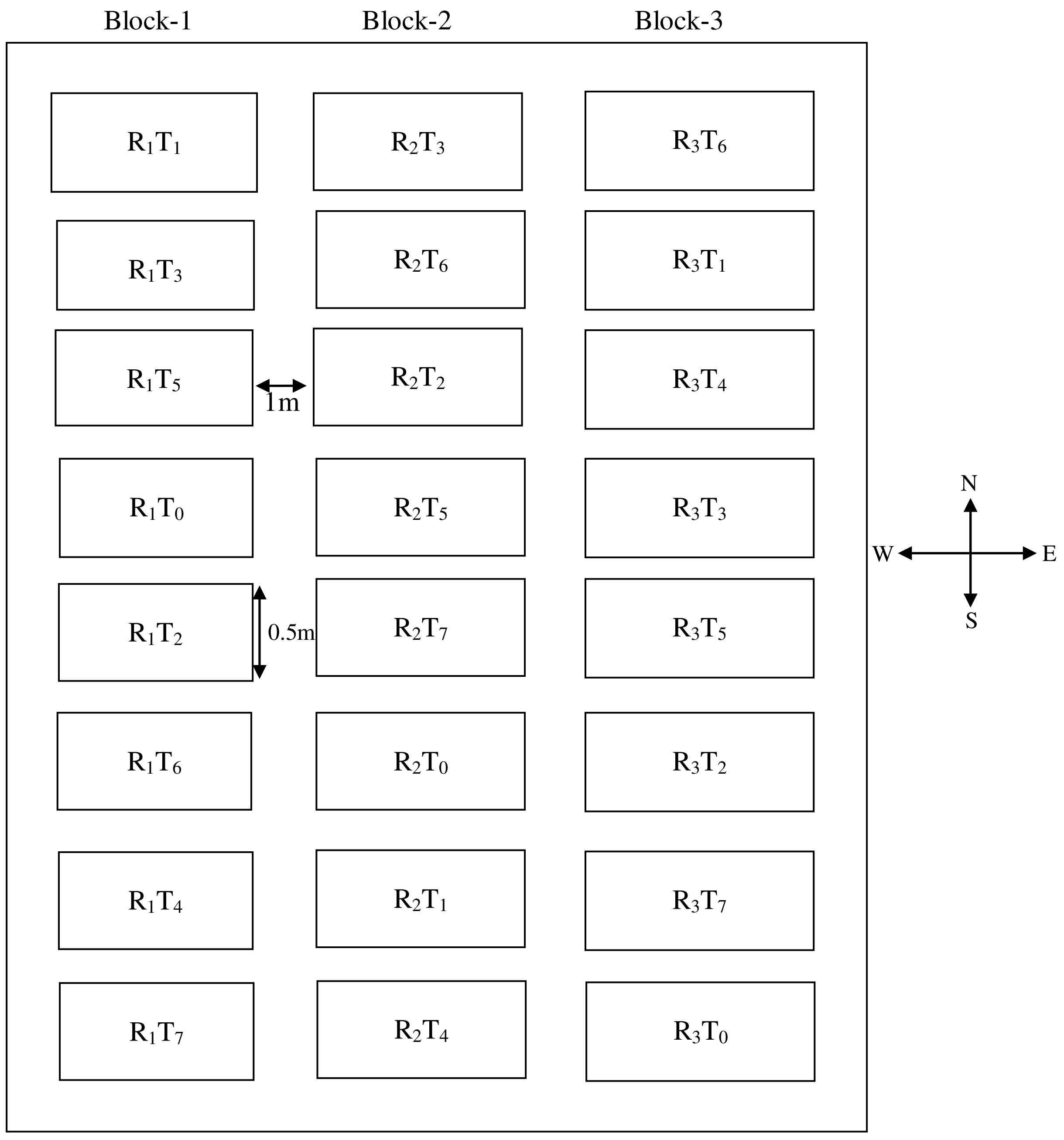

Fig. 3.2: Layout of the experiment

3.8 Land preparation

Land preparation was started 7 days before seed sowing. The land was first opened by a tractor and the land was prepared thoroughly by ploughing and cross ploughing with a power tiller. Every ploughing was followed by laddering to obtain a good tilth. Weeds and stubbles were collected and removed from the field. Field lay out was done on 3th December 2016, according to the design adopted. Finally, individual plots were prepared with spade on 7th December 2016.

3.9 Fertilizer application

Recommended doses of inorganic fertilizers (160 kg ha^{-1} urea, 140 kg ha^{-1} TSP, 105 kg ha^{-1} MOP, 117 kg ha^{-1} Gypsum) and organic fertilizers (G.T.S. Joibo Sar) (3.90 kg ha^{-1}) were applied respectively (on the soil test basis). Two thirds of urea and the full amount of the other fertilizers were applied as a basal amount during final land preparation. Another one third of urea was applied at first irrigation.

3.10 Sowing of seeds

Seeds of BARI Gom 26 were collected from Wheat Research Center, Dinajpur and seeds were sterilized with 0.4% vaitavax. Seeds were sown in the plots 11 December, 2016. Sowing was made continuously in lines and seeds were covered by soil. The spacing between lines was 10 cm.

3.11 Germination of seeds

Germination of seeds started from 4th day of sowing. On the 6th to 7th day all the seeds were germinated.

3.12 Intercultural operation

Intercultural operations were done to ensure normal growth of crops. The following intercultural operations were done as and whenever necessary.

3.12.1 Irrigation

All the seedlings of the crop emerged out within 6-8 days after sowing. Irrigation was given three on 3th January 2017 and 20th January and 9th February 2017 in order to maintain enough suitable moisture in the field.

3.12.2 Weeding

The experimental plots were infested with some weeds which were controlled by uprooting and removing them from the field at two times.

3.12.3 Pest and insect control

The plots were infested by birds, rats and different kinds of insects (pink borer insects and cereal aphids) during the growing period. Net was used over the whole plots to protect the wheat grain from birds especially crows and pigeons until 12 days from seed sowing. Bistop was used to protect rats and Carbofuran (5G) was used for pink borer insect. The experimental plots were sprayed at 35 days with appropriate insecticides to control the insects. Insecticide was applied to the plots after irrigation at afternoon.

3.13 Harvesting and threshing

The crop was harvested at maturity on 5 April, 2017. The sample plants from each unit plot were uprooted at random prior to harvest, which were dried properly for collecting data on yield components. Per plot yields of grain and straw were recorded after drying the plants in the sun followed by threshing and cleaning.

3.14 Data collection

The data as per objectives of the study were collected as follows:

i. Plant height
ii. Spike length
iii. Number of tillers hill^{-1}
iv. Number of spikelets spike^{-1}
v. Number of grains spike^{-1}
vi. 1000-grains weight
vii. Grain yield
viii. Straw yield

3.14.1 Plant height

The plant height was measured from the ground level to the top of the panicle. From each plot, plants of 10 hills were measured and average height was taken.

3.14.2 Panicle length

The panicle length was measured at harvest from the selected 10 hills of each plot.

3.14.3 Number of tillers hill^{-1}

Number of tillers hill^{-1} was counted from the selected 10 hills of each plot and total number of tillers hill^{-1} was recorded.

3.14.4 1000-grains weight

1000-grains weight was recorded from each plot after harvest.

3.14.5 Grain and straw yield

Grain and straw yield was recorded after harvest.

3.15 Analysis of soil sample

The soil samples were collected from the each plot after harvesting the crop. From each plot 3 samples were taken at 15 cm depth randomly. Then the soil was air dried, crushed and sieved with 60 mesh sieve separately. The samples were then stored in plastic container with tag for subsequent analysis.

3.15.1 Soil pH

Soil pH was determined using a glass electrode pH meter at 1:2.5, soil:water ratio. The suspension was allowed to stand for one hour with occasional shaking before determination (Jackson, 1967).

3.15.2 Organic matter content

Soil organic carbon content was determined volumetrically by wet oxidation method using $K_2Cr_2O_7$ and H_2SO_4 mixture and FeSO4 solution was used for titration as outlined by (Jackson, 1967). The organic matter content was calculated by multiplying the percent organic carbon with the Benmmelen factor of 1.724 (Piper, 1950).

3.15.3 Total nitrogen

Soil nitrogen was determined by Micro-Kjeldahl method (Bremner and Mulvancey, 1982). The soil sample (1.0g) was digested with 3ml concentrated H_2S0_4 and 1.1g catalyst mixture (K_2SO_4:$CuSO_4.5H_2O$: Se powder in the ratio of 100:10:1). Nitrogen was estimated by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01 N H_2SO_4 (Page *et al.,* 1989).

3.15.4 Available phosphorus

Available phosphorus was extracted from the soil with 0.5 M sodium bicarbonate solution, pH 8.5 (Olsen *et al.* 1954). Phosphorus in the extract was then determined by developing blue color with $SnCl_2$ reduction of phosphomolybdate complex and the color intensity was measured colorimetrically at 660 nm wave lengths (Page *et al.,* 1989).

3.15.5 Exchangeable potassium

Exchangeable potassium was determined from the ammonium acetate extraction method using flame photometer (Page *et al.,* 1989).

3.15.6 Available sulphur

Available sulphur was determined by extracting the soil sample with 0.01M Ca $(H_2P0_4)_2$. The S content in the extract was estimated turbid metrically and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

3.16 Statistical analysis

The data for different parameters were compiled and tabulated in proper form. All the collected data were subjected to statistical analysis following the ANOVA technique and the mean differences among the treatments were compared by Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to determine the effects of organic and inorganic fertilizers on yield and yield contributing characters of wheat (BARI Gom 26). The result has been presented in various tables, figures and possible explanations have been given under the following headings.

4.1 Yield and yield contributing characters of wheat

Yield contributing characters such as plant height, spike length, number of tillers hill^{-1}, spikelets spike^{-1}, grains spike^{-1}, 1000-grains weight, grain yield and straw yield were recorded in every trial.

4.1.1 Plant height

Plant height of wheat (BARI Gom 26) responded significantly due to application of organic and inorganic fertilizers (Fig. 4.1 and Appendix III). All the treatments gave significantly higher plant height over the T_0 (control). Plant height ranged from 48.73 to 91.00 cm. The tallest plant height was recorded in the treatment T_7 which was closely followed by the treatment T_4 and T_1. The shortest plant height was recorded from the controlled treatment T_0 (Fig. 4.1). Treatments may be ranked in the order of $T_7 > T_4 > T_1 > T_3 > T_5 > T_6 > T_2 > T_0$. Khan *et al.* (2007) and Delden (2001) reported that combined application of organic and inorganic fertilizers increased the plant height of wheat.

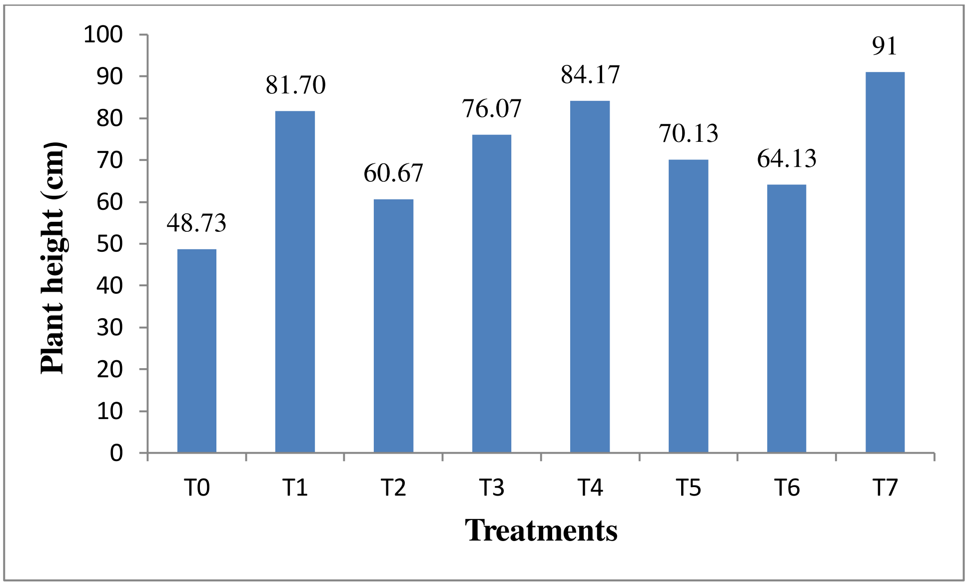

Fig. 4.1: Effects of organic and inorganic fertilizers on plant height of wheat (BARI Gom 26)

T_0= Control
T_1= 100% RIFD
T_2= 100% ROFD
T_3= 50% RIFD + 50% ROFD
T_4 = 67% RIFD + 33% ROFD
T_5= 33% RIFD + 67% ROFD
T_6= 25% RIFD + 75% ROFD
T_7= 75% RIFD + 25% ROFD

- RIFD = Recommended inorganic fertilizers doses
- ROFD = Recommended organic fertilizers doses

4.1.2 Spike length

Spike length of wheat (BARI Gom 26) significantly influenced due to application of organic and inorganic fertilizers (Table 4.1). The spike length varied from 6.48 to 9.46 cm. The highest spike length was recorded in the treatment T_7 which was statistically identical with all treatments. On the other hand the lowest spike length was found in the T_0 (control). Singh *et al.* (2002) also observed that combined application of organic and inorganic fertilizers increased the spike length of wheat.

4.1.3 Number of tillers hill^{-1}

Application of organic and inorganic fertilizers responded significantly the number of effective tillers hill^{-1} BARI Gom 26 (Table 4.1). The maximum tillers hill^{-1} (4.66) was found in the treatment T_7 which was statistically identical all the treatments. The minimum tillers hill^{-1} (3.04) was observed from the controlled treatment T_0. Uddin (2009) found that increased number of effective tillers hill^{-1} of wheat with the integrated use of organic and inorganic fertilizers.

4.1.4 Number of spikelets spike^{-1}

Results in Table 4.1 indicated that number of spikelets spike^{-1} of wheat varied significantly due to application of organic and inorganic fertilizers. The highest spikelets spike^{-1} (15.89) was recorded in the treatment T_7 which were statistically identical with all the treatments. On the other hand the lowest spikelets spike^{-1} (13.51) obtained in the T_0 (control).

4.1.5 Number of grains spike^{-1}

Combined applications of organic and inorganic fertilizers ensure favorable growth of wheat and ultimate result was the maximum number of grains spike^{-1} (Fig. 4.2 and Appendix III). The effect of different levels of organic and inorganic fertilizers was significant as observed on number of grains spike^{-1}. The highest number of grains spike^{-1} (51.63) was noticed at T_7 treatment which was statistically identical with the treatment T_1. The lowest number of grains spike^{-1} (23.41) was found in T_0 (control). Treatments may be ranked in the order of T_7> T_1> T_4> T_3> T_6> T_5> T_2> T_0. Satyannarayana *et al.* (2002) stated that grains spike^{-1} was increased with the combined application of organic and inorganic fertilizers.

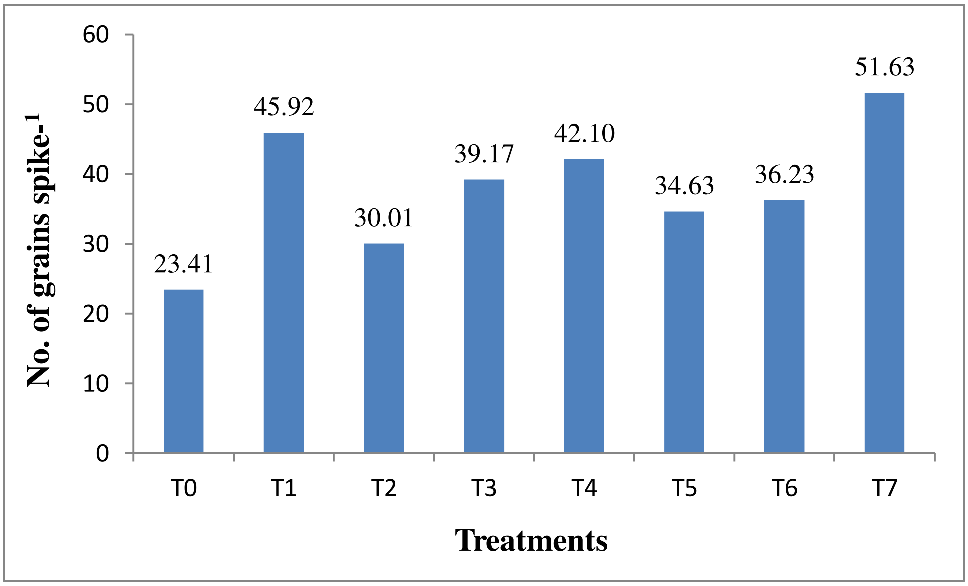

Fig. 4.2: Effects of organic and inorganic fertilizers on grains spike^{-1} of wheat (BARI Gom 26)

T_0= Control
T_1= 100% RIFD
T_2= 100% ROFD
T_3= 50% RIFD + 50% ROFD
T_4 = 67% RIFD + 33% ROFD
T_5= 33% RIFD + 67% ROFD
T_6= 25% RIFD + 75% ROFD
T_7= 75% RIFD + 25% ROFD

- RIFD = Recommended inorganic fertilizers doses
- ROFD = Recommended organic fertilizers doses

4.1.6 1000-grains weight

Variation in 1000-grains weight was observed with the application of organic and inorganic fertilizers (Table 4.1). The highest 1000-grains weight (35.93g) was recorded from the treatment T_7 which was similar to the other treatments T_1 and T_4. The lowest weight (19.67g) was recorded under T_0 (control). Treatments may be ranked in the order of $T_7 > T_4 > T_1 > T_3 > T_5 > T_6 > T_2 > T_0$. Goudreddy *et al.* (1989) viewed that organic fertilizers along with inorganic fertilizers improved 1000-grains weight in wheat.

Table 4.1 Effects of organic and inorganic fertilizers on the spike length, number of tillers hill^{-1}, spikelets spike^{-1} and 1000-grains weight of wheat (BARI Gom 26)

Treatments	Spike length (cm)	Number of tillers hill^{-1}	Number of spikelets spike^{-1}	1000-grains weight (g)
T_0	6.48	3.04	13.51	19.67 c
T_1	7.29	3.13	14.63	30.10 ab
T_2	6.53	3.27	13.70	25.80 b
T_3	6.66	4.11	14.40	29.70 b
T_4	7.63	3.82	15.60	31.83 ab
T_5	6.68	3.49	14.26	28.63 b
T_6	6.97	3.63	14.10	27.60 b
T_7	9.46	4.66	15.89	35.93 a
LSD	2.70	2.60	3.05	5.62
CV %	20.76	39.28	11.73	10.56
Level of significance	NS	NS	NS	*

In a column having common letters do not differ significantly at 5% level of significance.

CV% = Coefficient of variation

LSD = Level of Significance

NS = Not Significant

* = Significant

4.2 Grain and straw yield of wheat

4.2.1 Grain yield

The grain yield of wheat (BARI Gom 26) was significantly influenced by the different treatments. Application of different levels of organic and inorganic fertilizers showed variation in between the treatments due to the variation for grain yield (Fig. 4.3 and Appendix IV). The grain yield varied from 2.34 to 4.75 t ha^{-1}. The highest grain yield was recorded in the treatment T_7 which was closely followed by T_4 treatment and the lowest grain yield was recorded in the T_0 (control). Treatments may be ranked in the order of $T_7 > T_4 > T_1 > T_3 > T_5 > T_6 > T_2 > T_0$. Bodruzzaman *et al.* (2010) and Asit *et al.* (2007) also found almost the similar results.

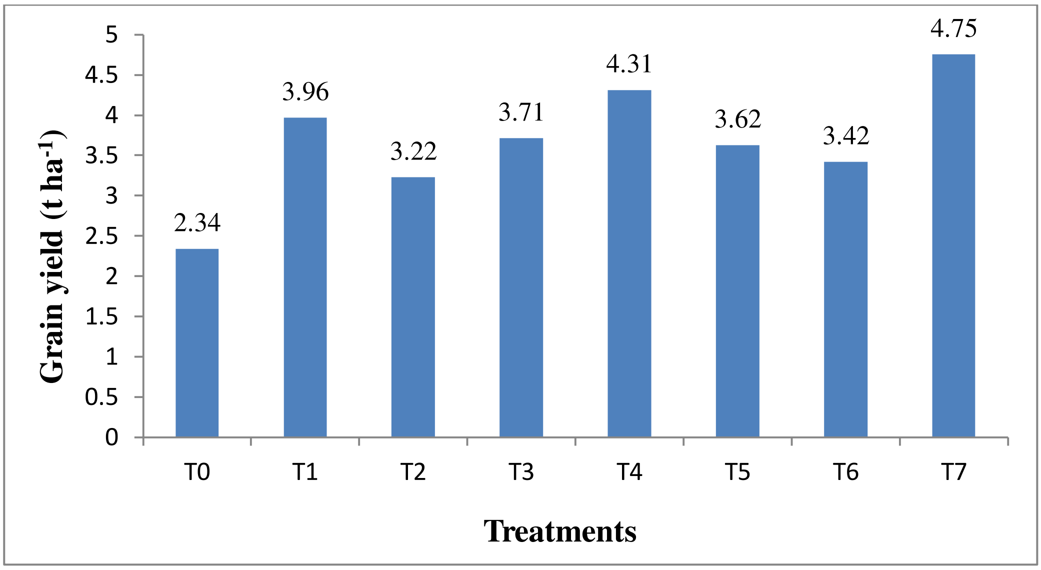

Fig. 4.3: Performance of grain yield on wheat (BARI Gom 26)

T_0= Control
T_1= 100% RIFD
T_2= 100% ROFD
T_3= 50% RIFD + 50% ROFD
T_4 = 67% RIFD + 33% ROFD
T_5= 33% RIFD + 67% ROFD
T_6= 25% RIFD + 75% ROFD
T_7= 75% RIFD + 25% ROFD

- RIFD = Recommended inorganic fertilizers doses
- ROFD = Recommended organic fertilizers doses

4.2.2 Straw yield

Application of organic and inorganic fertilizers at different levels showed the variation for straw yield per hectare (Fig. 4.4 and Appendix IV). The increased straw yield might be accounted for the superior growth of plant as well as increased number of tillers hill^{-1}. The highest and statistically straw yield (5.56 t ha^{-1}) was recorded in the treatment T_7. On the other hand the lowest straw yield (2.71 t ha^{-1}) obtained from the controlled treatment T_0. Akhtar *et al.* (2011) observed that combined application of organic and inorganic fertilizers significantly increased the straw yield of wheat.

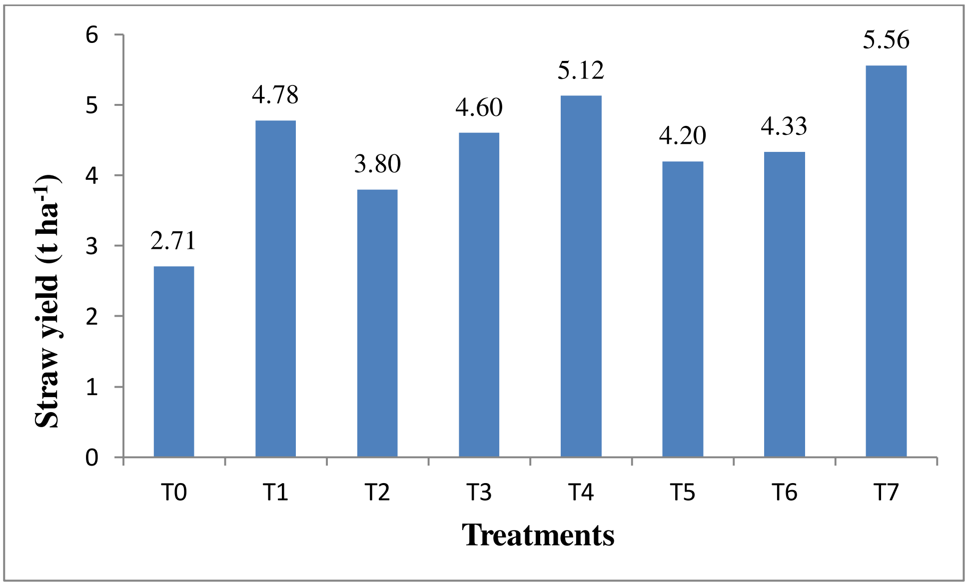

Fig. 4.4: Performance of straw yield on wheat (BARI Gom 26)

T_0= Control
T_1= 100% RIFD
T_2= 100% ROFD
T_3= 50% RIFD + 50% ROFD
T_4 = 67% RIFD + 33% ROFD
T_5= 33% RIFD + 67% ROFD
T_6= 25% RIFD + 75% ROFD
T_7= 75% RIFD + 25% ROFD

- RIFD = Recommended inorganic fertilizers doses
- ROFD = Recommended organic fertilizers doses

4.3 Chemical properties of the collected soil after harvesting

4.3.1 Soil pH

The post-harvest soil was acidic where soil pH ranged from 5.13 to 5.65 (Table 4.2). Soil pH was slightly increased in all the treatments. There was no significant difference among the treatments of the post-harvest soil. The study proved that soil reaction remained more or less same in the post-harvest soils compared to initial soil.

4.3.2 Organic matter content

The application of inorganic and organic fertilizers has a significant effect on organic matter in soil. Organic and inorganic fertilizers increased the soil organic matter in different treatments (Table 4.2). Soil organic matter content of the post-harvest soil was higher than the initial soil. The highest soil organic matter content 2.77 % was found in the T_7 treatment. The lowest soil organic matter 1.69 % was found in the T_0 (control).

4.3.3 Total nitrogen in soil

The total nitrogen (N) content of the post-harvest soil varied considerably by different treatments (Table 4.2). Soil nitrogen of the post-harvest soil was higher than the initial soil. The post-harvest soil has more or less same nitrogen percent. The total N content of the post-harvest soil ranged from 0.08 to 0.15% as compared to the initial soil was noted. The highest soil nitrogen was found both in T_7 and T_4 treatments. The lowest soil nitrogen was found from the controlled treatment T_0. Sreelatha *et al.* (2006) also reported that organic manures had a positive influence on total and available N content of soil.

Table 4.2 Effects of organic and inorganic fertilizers on the soil pH, organic matter content, total N of the post-harvest soil

Treatments	Soil pH	Organic matter content (%)	Total N (%)
T_0	5.13	1.69 e	0.08 c
T_1	5.53	2.42 c	0.13 ab
T_2	5.50	2.21 d	0.10 ab
T_3	5.57	2.35 cd	0.14 ab
T_4	5.59	2.60 b	0.15 a
T_5	5.51	2.28 cd	0.11 ab
T_6	5.43	2.26 cd	0.12 ab
T_7	5.65	2.77 a	0.15 a
LSD	0.62	0.58	0.05
CV (%)	6.43	13.56	11.17
Level of significance	NS	*	*

In a column having common letters do not differ significantly at 5% level of significance.

CV% = Coefficient of variation

LSD = Level of Significance

NS = Not Significant

* = Significant

4.3.4 Available phosphorus in soil

The available phosphorus content of the post-harvest soil varied significantly by different treatments (Table 4.3). Available phosphorus varied from 55.62 to 66.78 ppm. The maximum phosphorus content was observed in the treatment T_7 which was closely followed by T_1 treatment. The lowest phosphorus content was observed in the T_0 (control).

4.3.5 Exchangeable potassium in soil

The exchangeable potassium (K) content of the post-harvest soil was influenced considerably due to the application of organic and inorganic fertilizers (Table 4.3). The exchangeable K content of initial soil was 0.21 meq 100 g^{-1} soil and the values of post-harvest soil ranged from 0.23 to 0.35 meq 100 g^{-1} soil. The highest exchangeable K was found in the treatment T_7 and the lowest value was found in the T_0 (control).

4.3.6 Available Sulphur

Results in Table 4.3 indicated that the post-harvest soil which content available sulphur (S) was different for the different treatments. The available S content in the studied soil ranged from 19.80 to 53.83 ppm. The highest sulphur content soil was found in the treatment T_7 which was statistically similar to those in T_1 and T_4 treatments. The lowest sulphur content soil was observed from the controlled treatment T_0.

Table 4.3 Effects of organic and inorganic fertilizers on the available P, S and exchangeable K of the post-harvest soil.

Treatments	Available P (ppm)	Exchangeable K (meq 100 g^{-1} soil)	Available S (ppm)
T_0	55.62 d	0.23	19.80 e
T_1	66.17 a	0.34	52.74 a
T_2	58.41 bc	0.31	36.54 cd
T_3	64.67 ab	0.33	40.75 bc
T_4	65.09 ab	0.34	52.98 a
T_5	62.87 ab	0.32	41.47 b
T_6	62.19 ab	0.32	35.95 d
T_7	66.78 a	0.35	53.83 a
LSD	6.210	0.056	4.487
CV %	5.52	4.96	6.04
Level of significance	*	NS	*

In a column having common letters do not differ significantly at 5% level of significance.

CV% = Coefficient of variation

LSD = Level of Significance

NS = Not Significant

* = Significant

CHAPTER V

SUMMARY AND CONCLUSIONS

CHAPTER V

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Summary

The experiment was conducted at Soil Science research field, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of December 2016 to April 2017 with a view to evaluate the effects of organic and inorganic fertilizers on the growth and yield of wheat (BARI Gom 26). The experimental soil belongs to the Old Himalayan Piedmont Plain (AEZ 1). The soil was sandy loam in texture having pH 5.13, organic matter content 1.64%, total N 0.07%, available P 55.59 ppm, exchangeable K 0.21 meq 100 g^{-1} soil and available S 19.75 ppm. The experiment was laid out in a Randomized Complete Block Design (RCBD). There were eight treatments with three replications in the experiment. So the total numbers of plots were 24. The unit plot size was $5m^2$ (2 m×2.5 m). Different levels of inorganic and organic fertilizers were used as treatment viz. T_0= Control, T_1=100% recommended doses of inorganic fertilizers, T_2=100% recommended doses of organic fertilizers, T_3=50% recommended doses of inorganic fertilizers + 50% recommended doses of organic fertilizers, T_4=67% recommended doses of inorganic fertilizers + 33% recommended doses of organic fertilizers, T_5=33% recommended doses of inorganic fertilizers + 67% recommended doses of organic fertilizers, T_6=25% recommended doses of inorganic fertilizers + 75% recommended doses of organic fertilizers, T_7=75% recommended doses of inorganic fertilizers + 25% recommended doses of organic fertilizers.

Recommended doses of 160 kg ha^{-1} urea, 140 kg ha^{-1} TSP, 105 kg ha^{-1} MOP, 117 kg ha^{-1} Gypsum and 3.90 kg ha^{-1} organic fertilizers (G.T.S. Joibo Sar) were applied respectively. Two thirds of urea and the full amount of the other inorganic and organic fertilizers were applied as basal doses during final land preparation. Rest urea was applied at first irrigation. Seeds were sown on the 11 December, 2016. The crop was allowed to grow until maturity and intercultural operations such as weeding and irrigation were done whenever required in order to support normal growth of the plant. At maturity, the crop was harvested on 5 April, 2017. Plot wise yield and yield components were recorded.

Soil samples were collected before fertilizers application and after harvest. Initial and post-harvest soil samples were analyzed for physical and chemical properties of soil

using the standard methods. All the data were statistically analyzed by F-test and the mean differences were judged by Duncan's Multiple Range Test (DMRT).

The results revealed that the yield components such as, plant height, spike length, no. of tillers hill^{-1}, spikelets spike^{-1}, grains spike^{-1}, 1000-grains weight of wheat (BARI Gom 26) responded significantly due to application organic and inorganic fertilizers.

The tallest plant height (91 cm) was found in the treatment T_7 which was statistically identical with T_4 and T_1. The shortest plant height (48.73cm) was observed in T_0 (control). The maximum tillers hill^{-1} (4.66) was recorded in the treatment T_7. The minimum tillers hill^{-1} (3.04) was observed in the T_0 (control). The treatment T_7 produced the highest spike length (9.46 cm) and spikelets spike^{-1} (15.89) which was statistically identical with all treatments. The lowest spike length (6.48 cm) and spikelets spike^{-1} (13.51) were obtained from the controlled treatment T_0. The maximum number of grains spike^{-1} (51.63) was recorded from the treatment T_7 and the minimum grains spike^{-1} (23.41) was observed in the T_0 (control). The highest 1000-grains weight (35.93g) was noticed at T_7 treatment and the lowest (19.67) was observed in the T_0 (control), so the treatments may be ranked in the order of $T_7 > T_4 > T_1 > T_3 > T_5 > T_6 > T_2 > T_0$. The application of recommended doses of inorganic fertilizers in combination with organic fertilizers remarkably increased the grain and straw yields of wheat (BARI Gom 26). The maximum grain yield of 4.75 t ha^{-1} was found in T_7 treatment which was closely followed by T_4 treatment and the minimum grain yield (2.34 t ha^{-1}) was recorded in the T_0 (control). The treatment T_7 gave the highest straw yield 5.56 t ha^{-1} while the T_0 (control) gave the lowest value 2.71 t ha^{-1}.

Application of organic and inorganic fertilizers resulted in a considerable influence on the properties of the post-harvest soils such as pH, organic matter content, total N, available P, exchangeable K and available S. Finally it can be concluded from the present study with the recommended doses of inorganic fertilizers showed better performance in respect of grain yield and yield contributing characters. On the other hand, organic fertilizers mineralized slowly thereby better performance was not found in grain yield and yield contributing characters than other treatments. So, inorganic fertilizers will be profitable for wheat cultivation.

So the combined application of organic fertilizers with inorganic fertilizers will be beneficial for wheat cultivation.

Conclusions

From the results of the study it may be concluded that:

i. Combined application of organic and inorganic fertilizers can significantly increase the yield and yield contributing components of wheat and 75% inorganic fertilizers with 25% organic fertilizers also produced the maximum yield of wheat.
ii. Application of 75% inorganic fertilizers and 25% organic fertilizers can increase the amount of organic matter content, total N, available P, exchangeable K and available S in soil to some extent.

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APPENDICES

APPENDICES

Appendix I: Monthly recorded air temperature, relative humidity and rainfall during December, 2016 to April, 2017

Year	Month	** Air temperature (^oC)			**Humidity (%)	**Rainfall (mm)
		Maximum (0^oC)	Minimum (0^oC)	Average (0^oC)		
2016	December	26.4	12.1	19.25	85	7
2017	January	25	9.7	17.35	81	4
	February	28.1	12.5	20.3	77	0
	March	28.7	15.1	21.9	78	97
	April	31.4	19.5	25.45	83	207

**Monthly average

Source: Wheat Research Centre, Nashipur, Dinajpur.

Appendix II: Schedule of cultural operations in the experimental plots

Serial No.	Cultural operations	Date
1	Opening of the land	01.12.2016
2	Ploughing and cross ploughing	01.12.2016
3	Breaking of clods, laddering and weeding	03.12.2016
4	Layout of the experiment	03.12.2016
5	Application of the 2/3 rd doses of urea and entire of other fertilizers	08.12.2016
6	Sowing of seeds	11.12.2016
7	Netting	11.12.2016
8	1stweeding, thinning and irrigation	03.01.2017
9	Application of the 1/3rd doses of urea	03.01.2017
10	2nd weeding	20.01.2017
11	2nd irrigation	20.01.2017
12	3rd irrigation	09.02.2017
13	Application of insecticide	21.02.2017
14	Application of pesticide	10.03.2017
15	Harvesting	05.04.2017
16	Threshing	09.04.2017
17	Cleaning	09.04.2017
18	Weighting	09.04.2017

Appendix III: Effects of organic and inorganic fertilizers on the plant height and grains spike^{-1} of wheat (BARI Gom 26)

Treatments	Plant height (cm)	Number of grains spike^{-1}
T_0	48.73 e	23.41 e
T_1	81.70 ab	45.92 ab
T_2	60.67 d	30.01 d
T_3	76.07 bc	39.17 bcd
T_4	84.17 ab	42.10 bc
T_5	70.13 cd	34.63 cd
T_6	64.13 d	36.23 cd
T_7	91.00 a	51.63 a
LSD	9.52	8.95
CV %	7.10	12.60
Level of significance	*	*

In a column having common letters do not differ significantly at 5% level of significance.

CV% = Coefficient of variation

LSD = Level of Significance

* = Significant

Appendix IV: Effects of organic and inorganic fertilizers on the grain yield (t ha^{-1}) and straw yield (t ha^{-1}) of wheat (BARI Gom 26)

Treatment	**Grain Yield (t ha^{-1})**	**Straw yield (t ha^{-1})**
T_0	2.34 d	2.71 c
T_1	3.96 abc	4.78 ab
T_2	3.22 c	3.80 b
T_3	3.71 bc	4.60 ab
T_4	4.31 ab	5.12 ab
T_5	3.62 bc	4.20 ab
T_6	3.42 bc	4.33 ab
T_7	4.75 a	5.56 a
LSD	0.82	1.28
CV %	11.95	15.63
Level of significance	*	*

In a column having common letters do not differ significantly at 5% level of significance.

CV% = Coefficient of variation

LSD = Level of Significance

* = Significant

Appendix V: Showing some photographs of research plots and operational activities during conducting experiment

(a)

(b)

(c)

(d)

(e)

(f)