RESPONSE OF HEAT TOLERANT WHEAT VARIETIES TO INORGANIC AND ORGANIC FERTILIZER MANAGEMENT

MUSARRAT JAHAN

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

June, 2018

RESPONSE OF HEAT TOLERANT WHEAT VARIETIES TO INORGANIC AND ORGANIC FERTILIZER MANAGEMENT

By

MUSARRAT JAHAN

REGISTRATION NO. 12-04949

A Thesis
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 (MS)

IN

AGRONOMY

SEMESTER: JANUARY-JUNE, 2018

Approved by:

(Prof. Dr. Md. Fazlul Karim)
Supervisor

(Prof. Dr. Md. Jafar Ullah)
Co-Supervisor

(Prof. Dr. Md. Shahidul Islam)
Chairman
Examination Committee

DEDICATED TO

MY

BELOVED PARENTS

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
PABX: 9110351 & 9144270-79

CERTIFICATE

This is to certify that the thesis entitled " ***RESPONSE OF HEAT TOLERANT WHEAT VARIETIES TO INORGANIC AND ORGANIC FERTILIZER MANAGEMENT*** *" 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 (MS)*** *in* ***AGRONOMY,*** *embodies the results of a piece of bona fide research work carried out by* ***MUSARRAT JAHAN,*** *Registration. No.* **12-04949** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated:

Dhaka, Bangladesh

(Prof. Dr. Md. Fazlul Karim)
Supervisor

ACKNOWLEDGEMENTS

All praises to the almighty **Allah** for His gracious kindness and infinite mercy in all the endeavors the author to let her successfully complete the research work and this scientific document.

The author would like to express her heartiest respect, deep sense of gratitude and sincere, profound appreciation to her supervisor, **Prof. Dr. Md. Fazlul Karim**, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism, constant inspiration and unforgettable help throughout the course and in preparation of the manuscript as thesis. Likewise grateful appreciation is conveyed to co-supervisor, **Prof. Dr. Md. Jafar Ullah**, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his constant encouragement, cordial suggestions, constructive criticisms and valuable advice to conduct the research work as well as preparation of the thesis.

The author would like to express her deepest respect and boundless gratitude to all the respected teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for their scholarly suggestions, constructive criticism, support, encouragement and sympathetic consideration during the course of studies.

The author appreciates the assistance rendered by the staff of Agronomy Department and labors, staff of Sher-e-Bangla Agricultural University farm, for their sincere help in carrying out the research work.

The author wishes to give special thanks to Science & Technology Ministry for giving National Science & Technology (NST) fellowship.

The author wishes to extend her special thanks to her husband, **Rafiul Islam** and all other friends and all well wishers for their help during experimentation, active encouragement and inspiration to complete this journey.

Finally the author is very glad to express her gratefulness and deepest appreciation to her parents, brothers and other relatives for their great sacrifices, endless prayers, blessings and support to reach her at this level of higher education.

RESPONSE OF HEAT TOLERANT WHEAT VARIETIES TO INORGANIC AND ORGANIC FERTILIZER MANAGEMENT

ABSTRACT

A field experiment was conducted to evaluate the response of heat tolerant wheat varieties to inorganic and organic fertilizer management at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November, 2017 to March, 2018. The experiment consisted of two factors; as Factor A: Varieties (2) *viz.*, V_1= BARI Gom -29 and V_2= BARI Gom -30, and factor B: Fertilizer managements (7) *viz.*, F_1= Recommended fertilizer doses (RF) (100%), F_2= Compost + 75% RF, F_3= Compost + 50% RF, F_4= Compost + 25% RF, F_5= Poultry manure + 75% RF, F_6= Poultry manure + 50% RF and F_7= Poultry manure + 25% RF. The experiment was laid out following split-plot design with three replications where main plot was for variety and sub plot was for fertilizer treatment. The results of the investigation revealed that BARI Gom -29 (V_1) produced higher grain yield (2.04 t ha^{-1}) which was 13.33 % higher than BARI Gom -30 (V_2) (1.80 t ha^{-1}) as minimum. Integration of organic and inorganic fertilizers produced higher grain yield than only inorganic application. The highest grain yield (2.71 t ha^{-1}) was produced by 100% Poultry manure + 75% RF (F_5) treatment which was 94.96% higher than poultry manure + 25% RF (F_7) treatment (1.39 t ha^{-1}) as minimum and 80.67% more than sole application of inorganic fertilizer (100% RF) (F_1) (1.50 t ha^{-1}) as the second highest. Combined effect of BARI Gom-29 along with 100% poultry manure + 75% RF (V_1F_5) gave the highest grain yield (2.90 t ha^{-1}) and the lowest grain yield (1.23 t ha^{-1}) was produced by BARI Gom-30 in combination with 100 % poultry manure + 25 % RF (V_2F_7) which was 135.77 % lower than V_1F_5. Irrespective of varietal difference 100% poultry manure + 75% RF was the suggestive fertiizer management for cultivation of heat tolerant wheat variety with the advantage of 25 % cut of chemical feetilizers.

LIST OF CONTENTS

LIST OF CONTENTS (contd.)

LIST OF CONTENTS (contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
%	=	Percent
µg	=	Micro gram
^0C	=	Degree Celsius
BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
et al.	=	And others
g	=	Gram (g)
ha^{-1}	=	Per hectare
HI	=	Harvest Index
Hr	=	Hour
kg	=	Kilogram
LSD	=	Least significant difference
mm	=	Millimeter
MP	=	Muriate of potash
N	=	Nitrogen
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Non-significant
ppm	=	Parts per million
q	=	Quintal
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
T	=	Ton
TSP	=	Triple super phosphate
viz.	=	Videlicet (namely)
Wt.	=	Weight

CHAPTER 1

INTRODUCTION

Cereals are an important dietary carbohydrate source throughout the world, because they constitute the main CHO and energy supply in most countries (Bos *et al.,* 2005). Wheat (*Triticum aestivum* L.) belongs to family *Poaceae* is one of the major cereal crops, which is consumed by humans and is grown around the world in diverse environments. Among the world's most important food grains, it ranks 1st position. It is considerably grown under larger area than any other commercial food. Wheat has got higher taste and nutritive value over corn and rice thus it has become the major staple food of different regions of the world (Slafer *et al.,* 1994). Millions of farmer in developing countries need adequate resource for augmenting crop productivity and sustainability of soil to meet the demand of ever growing people of the world. The world total area under wheat is approximately 215 million hectares. Wheat is providing 1/ 5th on an average of total calorific input to the world, by producing 621 million tons of grain to the world's population (Reynolds *et al.,* 2006). Even it meets about 73% protein and calories of the average diet (Hossain *et al.,* 2003).

The average yield of wheat in Bangladesh is low comparing with the developed countries of the world which is due to substandard methods of cultivation, imbalanced nutrition, poor plant protection measures and lack of high yielding varieties.

After green revolution, scenario of agriculture has faced many problems such as stagnation or even decrease in production and productivity of major crops under deterioration of soil fertility and increasing cost of production. These constraints have cropped-up partially as a result of continuous cropping without proper nutrient management and indiscriminate use of agrochemicals on soil and crops (Sharma and Subehia, 2014; Thind *et al.,* 2016). Beside this, the increased temperature and reduced winter period in Bangladesh put pressure on wheat cultivation reducing its potential yield (IPCC, 2014). Faisal and Parveen (2004), and Hossain and Teixeira da Silva (2013) projected that wheat production in Bangladesh might drop by 32% by 2050 due to an increase in temperature. Hence heat tolerant variety would be an option to keep wheat in cropping system (Farooq *et al.,* 2011; Hossain and Teixeira da Silva, 2012).

Use of chemical fertilizers in combination with organic manure is essential to improve the soil health (Prasad *et al.,* 2010). Moreover, mineral fertilizer requirement cannot be completely fulfilled by the fertilizer industry due to wide margin between production capacity and crop demand. A large quantity of mineral fertilizers, especially micronutrients is currently being imported. The high cost of mineral fertilizers, low use efficiency and less availability makes it difficult to manage crop production (NFDC, 2008). The continued use of chemical fertilizers causes health and environmental hazards such as ground and surface water pollution by nitrate leaching (Pimentel 1996). So, reducing the amount of NPK fertilizers applied to the field without NPK deficiency will be the main challenge in field management. Therefore to maintain fertility and productivity of soil at sustainable level for long duration, there is need to adopt the concept of integrated nutrient management (INM). Integrated nutrient management can be the best alternate approach for better crop production and sustainable soil health (Kumar *et al.,* 2013; Subehia and Sepehya, 2012). Integrated nutrient management involves the integrated use of mineral fertilizers together with organic manure in suitable combination compliments each other to optimize input use and maximize production and sustain the same without impairing the crop quality or soil health, help in improving soil properties and reduce nutrient leaching, thereby increase the efficacy of mineral fertilizers (Tadesse *et al.,* 2013; Bodruzzaman *et al.,* 2010; Lamps, 2000). It enables gainful utilization of organic wastes (Dhaka *et al.,* 2012).

Compost or poultry manure can be a valuable and inexpensive fertilizer and source of plant nutrients. Positive effects of organic manure on soil structure, aggregate stability and water-holding capacity were reported in several studies (Odlare *et al.,* 2008; Jedidi *et al.,* 2004; Shen and Shen, 2001; Wells *et al.,* 2000). Previous studies showed that the combination of compost with chemical fertilizer improve grain yield of crops while reducing chemical production (Sarwar *et al.,* 2008: Sarwar *et al.,* 2007: Cheuk *et al.,* 2003).

Ibrahim *et al.* (2000) reported that integration of farmyard manure and compost with mineral fertilizers in wheat rice-wheat cropping pattern enhanced yield of both crops

Similarly, another study reported significant increase in wheat harvest with the integration of farmyard manure and mineral fertilizers (Shah *et al.*, 2013). Hence this investigation was carried out with organic and inorganic fertilizers on heat tolerant varieties with following objectives:

i. To compare the growth and yield performance of heat tolerant varieties of wheat.
ii. To study the combined effect of inorganic and organic fertilizers on the growth and yield of heat tolerant wheat varieties.

CHAPTER 2

REVIEW OF LITERATURE

Integration of organic and inorganic fertilizers bear great significance for sustaining the soil productivity. Inorganic sources mainly include chemical fertilizers, while major organic sources are crop residues, FYM, compost, poultry manure, green manure, oil cakes, bio-fertilizers, vermicompost, bio-gas slurry etc. to improve soil health. An attempt was made in this section to collect and study relevant information available regarding the use of inorganic and organic fertilizers on wheat to justify the implementation of the present research work and the findings would come out from experimentation.

2.1 Plant height

Experiment investigated by Singh *et al.* (2018) at the experimental Farm of the Department of Agriculture, Lovely Professional University, Jalandhar, Punjab (India) during 2017-18. The treatments were *viz.*, T_0: Control, T_1: 75% RDF, T_2: 50% RDF + 6 t FYM ha^{-1} + 1 t Poultry Manure ha^{-1}, T_3: 50% RDF + 0.4 t Sewage Sludge ha^{-1} + 0.25 t Bone Meal ha^{-1}, T_4: 50% RDF + 6 t FYM ha^{-1} + 1.5 t Vermicompost ha^{-1}, T_5: 25% RDF + 6 t FYM ha^{-1} + 1.5 t Vermicompost ha^{-1} + 25% Bone meal, T_6: 25% RDF + 1.5 t Vermicompost ha^{-1} + 0.4 t Sewage Sludge ha^{-1} + 1 t Poultry Manure ha^{-1} and T_7: 6 t FYM ha^{-1} + 1 t Poultry Manure ha^{-1} + 0.4 t Sewage Sludge ha^{-1} + 0.25 t Bone Meal ha^{-1}. The result of the experiment expressed that the plant height ranged from 54.22 to 67.67 cm at 90 DAS. The highest plant height (67.67 cm) was recorded in T_3 (50% RDF + 0.4 t sewage sludge ha^{-1} + 0.25 t bone meal ha^{-1}) followed by T_1 (75% RDF) *i.e.* 66.30 cm while the lowest value (54.22 cm) was recorded in T_0 (control). As compared to T_0, T_3 showed 24.81% increase in plant height at 90 DAS.

Experiment were carried out by Subhan *et al.* (2017) at Arid Zone Research Centre (AZRC) to investigate the water use efficiency and response of winter wheat (*Triticum aestivum* L.) crop to organic and inorganic fertilizers on a heavy textured soil. The treatments used in the experiment include compost @ 5 t ha^{-1}, cattle manure @ 5 t ha^{-1}, compost + cattle manure each @ 2.5 t ha^{-1}, NPK @ 150:120:90 and control (without amendments), replicated four times. The results revealed that significantly the tallest plant of 95.5 cm recorded where inorganic fertilizer was applied @

150:120:90 kg NPK ha^{-1}. The shortest plants with height of 64 cm were found in the control.

Yadav *et al.* (2017) carried out an investigation during winter season of 2014-15 on wheat at Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (UP). The experiment was consisted of 8 treatments *viz*. T_1 (control), T_2 (100 % RDF), T_3 (75% RDF), T_4 (75% RDF + 25% N-FYM), T_5 (75% RDF + *Azotobacter*), T_6 (50% RDF + 50% N-FYM) T_7 (50% RDF + 50% N-FYM + PSB) and T_8 (50% RDF + *Azotobacter* + PSB). The result exposed that various levels of nutrients applied through fertilizers alone and their combination with FYM and bio-fertilizers influenced the plant height significantly. The highest plant height (93.2 cm) was recorded under the treatment T_7 (50 % RDF + 50 % N-FYM + PSB) and minimum (60.4 cm) in T_1 (control) at harvest stage.

A field experiment was conducted by Chopra *et al.* (2016) at Agronomy Farm, Rajasthan College of Agriculture, Udaipur during *rabi* season in 2013-14 and 2014-15. The experiment was laid out in a split plot design with 27 treatment combinations which consisted of 3 organic manures (FYM @ 10 t ha^{-1}, Vermicompost @ 4 t ha^{-1} and Poultry manure @ 5 t ha^{-1}), 3 levels of inorganic fertilizers (50% RDF, 75% RDF and 100% RDF) and 3 levels of biofertilizers (*Azotobacter*, PSB and *Azotobacter* + PSB) were replicated three times. The results of the study showed that an application of poultry manure @ 5 t ha^{-1} significantly increased higher plant height (88.60 cm) over FYM @ 10 t ha^{-1} (82.57 cm) and statistically at par with vermicompost @ 4 t ha^{-1} (85.84 cm).

2.2 Above ground dry matter weight plant^{-1}

An experiment was carried out by Phullan *et al.* (2017) under semi-arid subtropical environment located at an altitude of 14 m of marine level in Sindh province of Pakistan. The experiment was laid out in a split plot design with four organic manures (control, farmyard manure, sesbania and cluster bean) as main split and mineral fertilizer rates (control, 40-30, 60-45, 80-60, 90-70 and 120-90 kg N-P_2O_5 ha^{-1}) as sub-split replicated four times. The results of the investigation revealed that Shoot dry weight was significantly influenced with the incorporation of organic manures and rates of mineral fertilizers. In case of organic manures, maximum shoot dry weight of 0.263 g plant^{-1} (8% over mineral fertilizer) was noted in plots fertilized with farmyard manure. The heaviest shoot dry weight of 0.278 g $plant^{-1}$ (26% over control) was noted in plots fertilized with recommended rate of mineral fertilizer (120-90 kg N-P_2O_5 ha^{-1}). In case of interactive effects of organic manures and mineral fertilizer, the highest shoot dry weight of 0.288 g $plant^{-1}$ (4.3% over recommended rate of mineral fertilizer and 38% over control) was noticed, where farmyard manure was integrated with recommended rate of mineral fertilizer.

A field experiment was conducted by Chopra *et al.* (2016) at Agronomy Farm, Rajasthan College of Agriculture, Udaipur during *rabi* season in 2013-14 and 2014-15. The results of the study showed that application of poultry manure @ 5 t ha^{-1} recorded significantly higher dry matter accumulation $plant^{-1}$(196.84 g) than both the treatments *i.e.* FYM @ 10 t ha^{-1} (178.66 g) and vermicompost @ 4t ha^{-1} (186.91 g) ,respectively.

2.3 Leaf area

Experiment investigated by Singh *et al.* (2018) at the experimental Farm of the Department of Agriculture, Lovely Professional University, Jalandhar, Punjab (India) during 2017-18.The result of the experiment expressed that the leaf area per plant ranged from 196.62 to 227.34 cm^2 at 90 DAS. The highest value of leaf area per plant (227.34 cm^2) was recorded in T_3 (50% RDF + 0.4 t sewage sludge ha^{-1} + 0.25 t bone meal ha^{-1}) followed by T_1 (75% RDF) of 222.86 cm^2 while the lowest value (196.62 cm^2) was recorded in T_0 (control). T_3 showed 15.62% increase in leaf area per plant as compared to T_0 at 90 DAS.

2.4 Spikelets $spike^{-1}$

A field experiment was conducted by Chopra *et al.* (2016) at Agronomy Farm, Rajasthan College of Agriculture, Udaipur during *rabi* season in 2013-14 and 2014-15. The results of the study showed that the highest grains $spike^{-1}$ (42.40) was recorded from poultry manure @ 5 t ha^{-1} whereas the lowest one (39.50) was recorded from FYM @ 10 t ha^{-1}.

A research was conducted by Rasul *et al.* (2015) at Bakrajow Agricultural Research Farm during winter growing season of 2013-2014. The experiment comprised of four treatments; T_1= control, T_2= 20 t ha^{-1} sheep manure, T_3= 20 t ha^{-1} cow manure and

T_4= 20 t ha^{-1} poultry manure. They reported that, the tallest plant (86.90 cm) was recorded from 20 t ha^{-1} poultry manure and the shortest plant (78.50 cm) was recorded from control (no fertilizer) treatment.

A study was conducted by Tahir *et al.* (2011) at the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during *rabi* season 2007-08 to check the effect of different organic matters along with recommended dose of synthetic fertilizers on the growth and yield components of wheat (*Triticum aestivum* L.). The experiment comprised of six treatments; T_1= [control (only Basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})], T_2= [Humic acid 12.50 % + Fulvic acid 0.35 % @ 5 l ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1}), T_3= [Humic acid 55 % (dry basis) + K_2O 8 % (dry basis) @ 10 kg ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})], T_4= [Humic acid 8.25 % + Fulvic acid 0.25 % @ 2.5 l ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})], T_5= [Humic acid 55 % + K_2O 8 % @ 10 kg ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})], and T_6= Fe 3 % + Zn 2 % + Ca 20 % + S 12 % + O.M 10 % @ 250 kg ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1}). They reported that the maximum spikelets $spike^{-1}$ (18.40) was recorded from treatment T_3 and the minimum spikelets $spike^{-1}$ (13.13) was recorded from treatment T_1.

2.5 Grains $spike^{-1}$

Experiment investigated by Singh *et al.* (2018) at the experimental Farm of the Department of Agriculture, Lovely Professional University, Jalandhar, Punjab (India) during 2017-18. The result of the experiment expressed that the number of grains $spike^{-1}$ ranged from 46.42 to 72.02. The highest value (72.02) of number of grains $spike^{-1}$ was recorded in T_3 (50% RDF + 0.4 t sewage sludge ha^{-1} + 0.25 t bone meal ha^{-1}) followed by T_1 (75% RDF) of 70.32 while the lowest value (46.42) was recorded in T_0 (control). As compared to T_0, T_3 showed 25.8% increase in the number of grains $spike^{-1}$.

Experiment was carried out by Subhan *et al.* (2017) at Arid Zone Research Centre (AZRC), D. I. Khan during year 2014-2015 and 2015–16 to investigate the water use efficiency and response of winter wheat (*Triticum aestivum* L.) crop to organic and inorganic fertilizers on a heavy textured soil. The results revealed that the organic amendments showed significant effect on the number of grains spike^{-1} of wheat grown during the two consecutive years. The number of grains spike^{-1} was found greater (44.5) in the plots receiving inorganic fertilizer (NPK) over the control (33 grains spike^{-1}). The commercial fertilizer gave the similar higher number of grain spike^{-1} during the second year and it was followed by the organic amendment of compost applied @ 5 t ha^{-1}.

Yadav *et al.* (2017) carried out an investigation during winter season of 2014-15 on wheat at Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (UP). The result exposed that the maximum grains spike^{-1} (61.6) was recorded from T_7 (50% RDF + 50% N-FYM + PSB) which was statistically at par with T_2 (100 % RDF), T_4 (75% RDF + 25% N-FYM) and T_6 (50% RDF + 50% N-FYM), and the least (34.00) was found in T_1 (control).

A research was conducted by Rasul *et al.* (2015) at Bakrajow Agricultural Research Farm during winter season of 2013-2014. They reported that, the maximum grains spike^{-1} (54.00) was recorded from 20 t ha^{-1} cow manure and the minimum grains spike^{-1} (49.00) was recorded from control (no fertilizer) treatment.

A study was conducted by Tahir *et al.* (2011) at the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during *rabi* season 2007-08 to check the effect of different organic matters along with recommended dose of synthetic fertilizers on the growth and yield components of wheat (*Triticum aestivum* L.). They reported that, the maximum grains spike^{-1} (48.80) was recorded from treatment T_3 [Humic acid 55% (dry basis) + K_2O 8% (dry basis) @ 10 kg ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})], and the minimum grains spike^{-1} (38.90) was recorded from treatment T_1 [control (only basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})].

In order to evaluate the effects of 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 by Abedi *et al*. (2010) at research station of the School of Agriculture, Shiraz University at Bajgah in 2007. Results indicated that the highest grains spike^{-1}

(19.96) was attained by 60 mg municipal waste compost ha^{-1}, and the lowest grains spike^{-1} (19.96) was attained by control treatment (0 mg municipal waste compost ha^{-1}).

Field trials were carried out by Rehman *et al.* (2008) aiming to determine whether modification to currently recommended inorganic fertilizers application (NPK) in combination with organic fertilizers in the form of farmyard manure (FYM) can improve wheat yield components and biomass under rain fed condition during 2003-04 and 2004-05 at Cereal Crops Research Institute Pirsabaq, NWFP, Pakistan. 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}) using a wheat variety (Haider-2000) were studied. 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. Grains spike^{-1} of wheat was affected by the levels of FYM, N, P and K in the two growing season. NPK, FYM and FYM x NPK significantly affected grains spike^{-1}. Grains spike^{-1} were significantly increased with each increment of NPK and the maximum grains spike^{-1} (55.8) were recorded in plots which received the highest level of 80-60-60 kg NPK ha^{-1} while the minimum grains spike^{-1} (50.2) were recorded in control plots. FYM significantly increased grains spike^{-1} and the maximum grains spike^{-1} (54.4) were recorded at highest level of 45 t FYM ha^{-1} while the minimum grains spike^{-1} (52.4) were recorded in control plots. Interaction of FYM and NPK showed that the maximum number of grain spike^{-1} (56.8) were recorded in plots which received 45 t FYM ha^{-1} and 80-60-60 kg NPK ha^{-1}, while the minimum grains spike^{-1} (48.8) were recorded from control.

2.6 1000 grain weight

Experiment were carried out by Subhan *et al.* (2017) at Arid Zone Research Centre (AZRC), D. I. Khan during year 2014-2015 and 2015-16 to investigate the water use efficiency and response of winter wheat (*Triticum aestivum* L.) crop to organic and inorganic fertilizers in a heavy textured soil. The results revealed that the thousand grain weight in the study significantly affected by cattle manure and compost. Maximum grain weirht (36.5 g) in the plots that were receiving cattle manure +

compost each @ 2.5 t ha^{-1}, the minimum weight (34.5 g) was received from the control treatment.

Yadav *et al.* (2017) carried out an investigation during winter season of 2014-15 on wheat at Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad, India). The result exposed that the 1000 grain weight (36.6 g) were recorded under treatment T_7 (50% RDF + 50% N-FYM + PSB) which was statistically at par with T_2 (100% RDF), T_4 (75 % RDF + 25% N-FYM and T_6 (50% RDF + 50% N-FYM) while least (35.7 g) was found in T_1 (control).

A field experiment was conducted by Chopra *et al.* (2016) at Agronomy Farm, Rajasthan College of Agriculture, Udaipur during *rabi* season in 2013-14 and 2014-15. The results of the study showed that the highest 1000 grain weight (43.42 g) was recorded from poultry manure @ 5 t ha^{-1} whereas the lowest one (40.01 g) was recorded from FYM @ 10 t ha^{-1}.

A research was conducted by Rasul *et al.* (2015) at Bakrajow Agricultural Research Farm during winter growing season of 2013-2014. They reported that, the maximum 1000 grain weight (46.85 g) was recorded from 20 t ha^{-1} poulty manure and the minimum 1000 grain weight (42.66 g) was recorded from control (no fertilizer) treatment.

A study was carried out by Tahir *et al.* (2011) at the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during *rabi* season 2007-08 to check the effect of different organic matters along with recommended dose of synthetic fertilizers on the growth and yield components of wheat (*Triticum aestivum* L.). They reported that the maximum 1000 grain weight (43.83 g) was recorded from treatment T_3 [Humic acid 5 % (dry basis) + K_2O 8% (dry basis) @ 10 kg ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})], and the minimum 1000 grain weight (37.55 g) was recorded from treatment T_1 [control (only basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})].

A field experiment was conducted by Abedi *et al.* (2010) at research station of the School of Agriculture, Shiraz University at Bajgah in 2007. Results indicated that the highest 1000 grain weight (40.23 g) was attained by 60 Mg municipal waste compost ha^{-1} and the lowest 1000 grain weight (38.69 g) was attained by control treatment (0 Mg municipal waste compost ha^{-1}).

Field trials were carried out by Rehman *et al.* (2008) during 2003-04 and 2004-05 at Cereal Crops Research Institute Pirsabaq, NWFP, Pakistan. NPK and FYM significantly affected thousand grain weight. Two years average showed that thousand grain weight significantly increased with the application of NPK as compared to control plots. Thousand grain weight increased with increase in NPK levels and the maximum thousand grain weight (35.16 g) was recorded in plots which received 80-60-60 kg NPK ha^{-1}. Lowest thousand grain weight (32.22 g) was recorded in control. No significant difference was recorded for thousand grain weight between 80-60-60 kg NPK ha^{-1}, 80-60-30 kg NPK ha^{-1}, 80-30-60 kg NPK ha^{-1} and 80-30-30 kg NPK ha^{-1}. FYM also significantly increased thousand grain weight. The maximum thousand grain weight (34.69 g) was recorded in plots which received 45 t FYM ha^{-1} while the minimum thousand grain weight (33.69 g) was recorded in control plots. No significant difference was recorded among 15 and 30 t FYM ha^{-1} for thousand grain weight.

2.7 Grain yield

Experiment was investigated by Singh *et al.* (2018) at the experimental Farm of the Department of Agriculture, Lovely Professional University, Jalandhar, Punjab (India) during 2017-18. The result of the experiment expressed that grain yield varied from 3.62 to 6.0 t ha^{-1}. The highest grain yield (6.0 t ha^{-1}) was recorded in T_3 (50% RDF + 0.4 t sewage sludge ha^{-1} + 0.25 t bone meal ha^{-1}) followed by T_1 (75% RDF) *i.e.* 5.62 t ha^{-1}. The lowest value (3.62 t ha^{-1}) was recorded in T_0 (control). T_3 showed 12.86% increase in grain yield as compared to T_0.

Study on the integrated effect of organic and chemical fertilizer levels on bread wheat was conducted by Chekolle (2017) in 2013 cropping season at high lands of Adi-golo and Mekan districts of Tigray, Ethiopia with the objective of determining the optimum integration of organic and inorganic fertilization for bread wheat production. The field experiment consists four level of N/P_2O_5 (0/0, 23/23, 46/46 and 69/69 kg ha^{-1}) and five level of farmyard manure (0, 4, 6, 8 and 10 t ha^{-1}) arranged in factorial RCBD with three replications. The statistical analysis revealed significant ($p \leq 0.05$) main and combined effect of farmyard manure and NP fertilizers on grain yield of bread wheat. The maximum grain yield was obtained in treatment receiving combined application of 46/46 kg ha^{-1} N/ P_2O_5 + 6 tone ha^{-1} of farmyard manure for Adi-golo and 46/46 kg ha^{-1} N/ P_20_5 + 10 t ha^{-1} of farmyard manure for Mekan areas, respectively. However, the lowest grain yield was recorded on plots without any fertilizer application. Hence, this organic and inorganic fertilizing system integration generated 144% and 47% yield increment compared to the control treatment and the NP fertilizer recommendation, respectively at Adi-golo. Similarly, 162.5% and 12.8% yield increment was obtained from combined application of organic and inorganic fertilizer compared to the control treatment and NP fertilizer recommendation, respectively at Mekan areas.

Experiments were carried out by Subhan *et al.* (2017) at Arid Zone Research Centre (AZRC), D. I. Khan during year 2014-2015 and 2015–16 to investigate the water use efficiency and response of winter wheat (*Triticum aestivum* L.) crop to organic and inorganic fertilizers in a heavy textured soil. The results revealed that the commercial fertilizer, organic manures and compost showed significant influence on grain yield of wheat during the two experimental years. Grain yield was found maximum 3887.5 kg ha^{-1} in plots receiving the stated dose of NPK. It was followed by the treatment of compost @ 5 t ha-1, cattle manure + compost each @ 2.5 t ha^{-1} and cattle manure @ 5 t ha^{-1}. The least quantity of grains was recorded in the plots receiving no amendments. In the next year, the similar trend was observed. The maximum yield of 3969.8 kg ha^{-1} was received from the plots where standard dose of NPK was applied. The least value of grain yield was found in control, with the value of 974.3 kg ha^{-1}.

The present study was demonstrated by Kumari *et al.* (2017) in 2013 at the Bihar Agricultural College Research Farm, Sabour, Bhagalpur, Bihar, India. The experiment consisted of 12 treatment combinations *viz*; control (T_1) (no fertilizer no organic manure); 50% recommended dose of fertilizers (RDF) to both rice and wheat (T_2); 50% RDF to rice and 100% RDF to wheat (T_3); 75% RDF to both rice and wheat (T_4); 100% RDF to both rice and wheat (T_5); 50% RDF + 50% N through farm yard manure (FYM) to rice and 100% RDF to wheat (T_6); 75% RDF + 25% N through FYM to rice and 75% RDF to wheat (T_7); 50% RDF + 50% N through wheat straw to rice and 100% RDF to wheat (T_8); 75% RDF + 25% N through wheat straw to rice and 75% RDF to wheat (T_9); 50% RDF + 50% N through green leaf manure (GLM) (*Sesbania aculeata*) to rice and 100% RDF to wheat (T_{10}); 75% RDF + 25% N through (GLM) to rice and 75% RDF to wheat (T_{11}); farmer's fertilizers practice to rice and wheat (70 kg N + 13.2 kg P + 8.3 kg K ha^{-1})(T_{12}). They revealed that the grain yield of wheat varied from a minimum of 7.71 q ha^{-1} under control (T_1) to a maximum of 46.83 q ha^{-1} with the treatment receiving 100% RDF through chemical fertilizers in wheat after 50% N substitution with FYM in rice (T_6). Treatments receiving 50% RDF + 50% N substituted through farm yard manure (FYM), green manure (GM) and wheat straw (WS) enhanced the productivity of wheat grain by 11.47, 9.55 and 6.31 %, respectively over 100% RDF whereas, treatments T_3, T_7, T_8, T_9 and T_{11} were at par with 100% RDF (T_5) and rest of the treatments were significantly ($P<0.01$) inferior to treatment T_5.

Yadav *et al.* (2017) carried out an investigation during winter season of 2014-15 on wheat at Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (UP). The result exposed that the maximum grain yield (4.19 t ha^{-1}) was recorded from T_7 (50% RDF + 50% N-FYM + PSB) which was statistically at par with T_2 (100% RDF), T_4 (75% RDF + 25% N-FYM), and T_6 (50% RDF + 50% N-FYM), and while the least (1.79 t ha^{-1}) was found in T_1 (control).

A field experiment was conducted by Chopra *et al.* (2016) at Agronomy Farm, Rajasthan College of Agriculture, Udaipur during *rabi* season in 2013-14 and 2014-15. The results of the study showed that the highest grain yield (5.04 t ha^{-1}) was recorded from poultry manure @ 5 t ha^{-1} whereas the lowest one (4.40 t ha^{-1}) was recorded from FYM @ 10 t ha^{-1}.

A research was conducted by Rasul *et al.* (2015) at Bakrajow Agricultural Research Farm during winter growing season of 2013-2014. They reported that the maximum grain yield (6.75 t ha^{-1}) was recorded from 20 t ha^{-1} poultry manure and the minimum grain yield (5.42 t ha^{-1}) was recorded from control (no fertilizer) treatment.

In order to Evaluation of different fertility systems and cultivars on wheat In Khuzestan conditions, a field experiment was conducted by Jala-Abadi *et al.* (2012) at the experimental field of Ramin Agriculture and Natural Resources University in Ahwaz, south-western of Iran, during 2008-2009 growing season. Four type of organic and inorganic treatments were used, which were as following: S_1= inorganic-1 (80 kg ha^{-1} N, 75kg ha^{-1} superphosphate (15.5% P_2O_5) and 75 kg ha^{-1} potash), S_2=

inorganic-2 (control) (140 kg ha^{-1} N, 150 kg ha^{-1} superphosphate (15.5% P_2O_5) and 150 kg ha^{-1} potash), S_3= chicken manure (8 t ha^{-1}) and S_4= chicken manure (8 t ha^{-1}) + Nitroxin (1lit ha^{-1}) + Barvar-2 (1 kg ha^{-1}). Nitroxin is a commercial product of bio fertilizer contains *Azotobacter* and *Azospirillum* produced by Asia Bio Technology Institute, Iran. Barvar-2 is a commercial product of biofertilizer contains *Pesudomonas putida* and *Bacilla lentus* produced by Green Biotech, Iran. Six genotypes with different growth durations were used. The genotypes included three bread wheat (Veenak, Chamran and Star) and three durum wheat (D-79-15, Karkheh and SP-50). The results revealed that the highest grain yield was in integrated chicken manure with bio-fertilizer (7042.5 kg ha^{-1}). But this treatment (S_4) did not vary significantly with chicken manure (S_3) (6486.9 kg ha^{-1}) and control (S_2) (6530.9 kg ha^{-1}). The lowest grain yield of 6142.9 kg ha^{-1} was obtained under inorganic-1 system (S_1).

A study was conducted by Tahir *et al.* (2011) at the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during *rabi* season 2007-08 to check the effect of different organic matters along with recommended dose of synthetic fertilizers on the growth and yield components of wheat (*Triticum aestivum* L.). They reported that the maximum seed yield (4.14 t ha^{-1}) was recorded from treatment T_3 [Humic acid 55 % (dry basis) + K_2O 8 % (dry basis) @ 10 kg ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})], and the minimum seed yield (3.67 t ha^{-1}) was recorded from treatment T_1 [control (only basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})].

A field experiment was conducted by Abedi *et al.* (2010) at research station of the School of Agriculture, Shiraz University at Bajgah in 2007. Results indicated that the highest seed yield (5360.90 kg ha^{-1}) was attained by 60 Mg municipal waste compost ha$^{-1,}$ and the lowest 1000 grain weight (3025.80 kg ha^{-1}) was attained by control treatment (0 Mg municipal waste compost ha^{-1}).

2.8 Straw yield

Experiment were carried out by Subhan *et al.* (2017) at Arid Zone Research Centre (AZRC), D. I. Khan during year 2014-2015 and 2015-16 to investigate the water use efficiency and response of winter wheat (*Triticum aestivum* L.) crop to organic and inorganic fertilizers on a heavy textured soil. The results revealed that the straw yield of wheat showed significant difference among the treatments in both of the study years. In the initial year, straw yield of 7769.25 kg ha^{-1} was observed in the plots where inorganic fertilizers were applied. The treatments receiving compost @ 5 t ha^{-1}, cattle manure + compost each @ 2.5 t ha^{-1} and cattle manure @ 5 t ha^{-1} gave significantly higher straw yield over the control. Similar trend was found in the subsequent year of experiment with the maximum straw yield of 3969.8 kg ha^{-1} through synthetic fertilizer application.

Yadav *et al.* (2017) carried out an investigation investigation during winter season of 2014-15 on wheat at Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (UP). The result exposed that the maximum straw yield (6.07 t ha^{-1}) was recorded from T_7 (50 % RDF + 50 % N-FYM + PSB) which was statistically at par with T_2 (100 % RDF), T_4 (75 % RDF + 25 % N-FYM), and T_6 (50 % RDF + 50 % N-FYM) and while the least (2.65 t ha^{-1}) was found in T_1 (control).

The present study was demonstrated by Kumari *et al.* (2017) in 2013 at the Bihar Agricultural College Research Farm, Sabour, Bhagalpur, Bihar, India and they revealed that the straw yield of wheat varied from a minimum of 11.45 q ha^{-1} under control (T_1) to a maximum of 59.44 q ha^{-1} with the treatment receiving 100% RDF through chemical fertilizers in wheat after 50% N substitution with FYM in rice (T_6).

A field experiment was conducted by Chopra *et al.* (2016) at Agronomy Farm, Rajasthan College of Agriculture, Udaipur during *rabi* season in 2013-14 and 2014-15. The results of the study showed that the highest straw yield (9.69 t ha^{-1}) was recorded from poultry manure @ 5 t ha^{-1} whereas the lowest one (8.23 t ha^{-1}) was recorded from FYM @ 10 t ha^{-1}.

A study was conducted by Tahir *et al.* (2011) at the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during *rabi* season 2007-08 to check the effect of different organic matters along with recommended dose of synthetic fertilizers on the growth and yield components of wheat (*Triticum aestivum* L.). They reported that the maximum straw yield (4.75 t ha^{-1}) was recorded from treatment T_3 [Humic acid 55 % (dry basis) + K_2O 8 % (dry basis) @ 10 kg ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})], and the minimum straw yield (3.94 t ha^{-1}) was recorded from treatment T_1 [control (only basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})].

2.9 Biological yield

Experiment were carried out by Subhan *et al.* (2017) at Arid Zone Research Centre (AZRC), D. I. Khan during year 2014-2015 and 2015-16 to investigate the water use efficiency and response of winter wheat (*Triticum aestivum* L.) crop to organic and inorganic fertilizers on a heavy textured soil. The results revealed that the TDM yield of wheat was significantly affected by the imposition of treatments during the two experimental years. In the initial year the highest TDM (11656.75 kg ha^{-1}) was found in the plots receiving synthetic fertilizer (NPK) and the lowest was in control (3520.5 kg $ha^{-1)}$. In the succeeding year of the experiment almost similar trend was found, with significantly maximum biomass of 12435 kg ha^{-1} in the treatment of NPK @ 150:120:90 kg ha^{-1}. It was followed by the treatments receiving compost @ 5 t ha^{-1}, cattle manure @ 5 t ha^{-1}, and cattle manure + compost each @ 2.5 t $ha^{-1.}$ The least quantity of biomass was found in control, with the value of 2325 kg ha^{-1}.

A field experiment was conducted by Chopra *et al.* (2016) at Agronomy Farm, Rajasthan College of Agriculture, Udaipur during *rabi* season in 2013-14 and 2014-15. The results of the study showed that the highest biological yield (14.73 t ha^{-1}) was recorded from poultry manure @ 5 t ha^{-1} whereas the lowest one (12.63 t ha^{-1}) was recorded from FYM @ 10 t ha^{-1}.

A research was conducted by Rasul *et al.* (2015) at Bakrajow Agricultural Research Farm during winter growing season of 2013-2014. They reported that the maximum biological yield (15.67 t ha^{-1}) was recorded from 20 t ha^{-1} poultry manure and the minimum biological yield (11.29 t ha^{-1}) was recorded from control (no fertilizer) treatment.

A field experiment was conducted Jala-Abadi *et al.* (2012) at the experimental field of Ramin Agriculture and Natural Resources University in Ahwaz, south-western of Iran, during 2008-2009 growing season. The results revealed that the inorganic system produced significantly lower biological yield (1631.94 kg ha^{-1}) than the other fertility treatments and the mixed organic treatment produced more biological yield (1900.69 kg ha^{-1}) than the control and chicken manure treatments.

A study was conducted by Tahir *et al.* (2011) at the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during *rabi* season 2007-08 to check the effect of different organic matters along with recommended dose of synthetic fertilizers on the growth and yield components of wheat (*Triticum aestivum* L.). They reported that the maximum biological yield (8.70 t ha^{-1}) was recorded from treatment T_3 [Humic acid 55 % (dry basis) + K_2O 8 % (dry basis) @ 10 kg ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})], and the minimum biological yield (7.77 t ha^{-1}) was recorded from treatment T_1 [control (only basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})].

Field trials were carried out by Rehman *et al.* (2008) during 2003-04 and 2004-05 at Cereal Crops Research Institute Pirsabaq, NWFP, Pakistan. Statistical analysis of the data showed that FYM, NPK and FYM x NPK significantly affected biological yield. Minimum biological yield (8813 kg ha^{-1}) was recorded in control plots. Biological yield increased as the NPK levels increased and the maximum biological yield (10008 kg ha^{-1}) was recorded in plots which received 80-60-60 kg NPK ha^{-1}. Significant increase in biological yield with different levels of FYM was recorded and the maximum biological yield (10000 kg ha^{-1}) was recorded at the highest level of 45 t FYM ha^{-1} while the minimum biological yield (9272 kg ha^{-1}) was recorded in control plots. Similarly interaction of FYM and NPK showed the maximum biological yield of 10340 kg ha^{-1} in plots where 45 t FYM ha^{-1} and 80-60-60 kg NPK ha^{-1} were used, while the minimum biological yield of (8468 kg ha^{-1}) was recorded in plots where no NPK and FYM were applied.

2.10 Harvest Index

Experiment were carried out by Subhan *et al.* (2017) at Arid Zone Research Centre (AZRC), D. I. Khan during year 2014-2015 and 2015-16 to investigate the water use efficiency and response of winter wheat (*Triticum aestivum* L.) crop to organic and inorganic fertilizers on a heavy textured soil. The inorganic amendments showed significant effect on harvest index (HI) of wheat during the first experimental year, while the cattle manure gave higher value of HI during the second year of the experiment. Comparing the results of two years. The treatment receiving inorganic fertilizer gave the highest HI (33.35%) over the rest of the treatments in year 2014-15. In the next year (2015-16) the result were completely inverse with the highest harvest index of 40.05 % in the treatment receiving cattle manure @ 5 t ha^{-1}, which was statistically at par with plots receiving compost @ 5 t ha^{-1}. The least quantity was recorded in the plots receiving inorganic fertilizer.

A field experiment was conducted by Chopra *et al.* (2016) at Agronomy Farm, Rajasthan College of Agriculture, Udaipur during *rabi* season in 2013-14 and 2014-15. The results of the study showed that the highest harvest index (35.06%) was recorded from poultry manure @ 5 t ha^{-1} whereas the lowest one (34.36%) was recorded from FYM @ 10 t ha^{-1}.

A field experiment was conducted Jala-Abadi *et al.* (2012)) at the experimental field of Ramin Agriculture and Natural Resources University in Ahwaz, south-western of Iran, during 2008-2009 growing season. The results revealed that the highest index (39.68%) was recorded with application chicken manure (S_3). The lowest harvest index (34.92%) was noted with control (S_2).

A study was conducted by Tahir *et al.* (2011) at the Department of Agronomy, University of Agriculture, Faisalabad, Pakistan during *rabi* season 2007-08. They reported that the maximum harvest index (49.48 %) was recorded from treatment T_3 [Humic acid 55 % (dry basis) + K_2O 8 % (dry basis) @ 10 kg ha^{-1} + basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})], and the minimum harvest index (47.62 %) was recorded from treatment T_1 [control (only basal dose of chemical fertilizers (Nitrogen + Phosphorous @ 108 + 57 kg ha^{-1})].

CHAPTER 3

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, intercultural operations, data collection and statistical analysis.

3.1 Location

The field experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2017 to March, 2018. The location of the experimental site has been shown in Appendix I.

3.2 Soil

The soil of the experimental area belonged to the Modhupur tract (AEZNo.28). It was a medium high land with non-calcarious dark grey soil. The pH value of the soil was 5.6. The physical and chemical properties of the experimental soil have been shown in Appendix II.

3.3 Climate

The experimental area was under the subtropical climate and characterized by high temperature, high humidity and heavy precipitation with occasional gusty winds during the period from April to September, but scanty rainfall associated with moderately low temperature prevailed during the period from October to March. The detailed meteorological data in respect of air temperature, relative humidity, rainfall and sunshine hour recorded by the meteorology center, Dhaka for the period of experimentation have been presented in Appendix III.

3.4 Treatments

The experiment consisted of two factors as mentioned below:

Factor A: Varieties (2)

- V_1 = BARI Gom -29
- V_2 = BARI Gom - 30

Factor B: Fertilizer management (7 levels)

- F_1= Recommended fertilizer doses (RF) (100 %)
- F_2= 100% Compost + 75% RF
- F_3= 100% Compost + 50% RF
- F_4=100 % Compost + 25% RF
- F_5= 100% Poultry manure + 75% RF
- F_6=100% Poultry manure + 50% RF
- F_7= 100% Poultry manure + 25% RF

3.5 Plant materials

Wheat variety BARI Gom -29 and BARI Gom -30 were used as plant materials for the present study. The varieties are heat tolerant and were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh.

3.6 Design and layout

The experiment was laid out in a split-plot design with three replications. The size of the individual plot was 2.20 m x 1.30 m and total numbers of plots were 42. Varieties were assigned to the main plots and fertilizer management to the sub-plots. There were 14 treatment combinations. The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively.

3.7 Land preparation

The experimental field was opened by a tractor driven rotavator 15 days before sowing. It was ploughed well to make the soil ready for sowing. Weeds and stubbles were removed and the field was leveled by repeated laddering. The experimental field was then divided into unit plots and prepared before line sowing of wheat.

3.8 Fertilizer application

The recommended fertilizer doses for wheat are Urea, TSP, MP, Gypsum, Compost and Poultry manure at the rate of 220, 180, 50, 120 kg ha^{-1}, 10 t ha^{-1} and 8 t ha^{-1} respectively. At first the compost and poultry manure were applied 3 days before sowing. The whole amount of all the fertilizers except urea were applied at the time of final land preparation as per treatment and thoroughly incorporated with soil with the help of a spade. Urea was splited into three equal portions, 1^{st} one was applied as basal during final land preparation, 2^{nd} was at 25 DAS and the 3^{rd} one at 46 DAS.

3.9 Seed sowing

After final land preparation, the seeds were sown in line on 18 November, 2017 and the lines were smoothly covered with soil.

3.10 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop.

3.10.1 Weeding

Two weeding were done at 12 DAS and 36 DAS to keep the crops free from weeds.

3.10.2 Irrigation

During final land preparation the line was irrigated for sowing seed then experimental plots required two irrigations at 46 DAS and 77 DAS during the crop growth season. Because of rainfall at CRI stage irrigation was not required.

3.10.3 Plant protection measures

There were negligible infestations of insect-pests during the crop growth period. Yet to keep the crop growth normal, fungicide Austin was applied at 25 DAS and 38 DAS to protect the crop from fungi and insects, respectively.

3.11 Harvest and post-harvest operation

The maturity of crop was determined when the crop plant along with spike turned into golden color. From the centre of each plot 1.5 m^2 area was harvested to determine yield of individual treatment and converted into t ha^{-1}. The harvested crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each plot were recorded after proper drying in sun. Before harvesting, 10 plants were selected randomly outside the sample area of each plot and cut at the ground level for collecting data on yield contributing characters.

3.12 Collection of data

i. Plant height (cm) at 20, 40, 60, 80 days after sowing (DAS) and harvest

ii. Above ground dry matter weight $plant^{-1}$ (g) at 20, 40, 60, 80 DAS and harvest

iii. Leaf Area (cm^2) at 20, 40, 60, 80 days after sowing (DAS) and harvest

iv. Length of spike (cm)

v. Spikelets $spike^{-1}$ (No.)

vi. Grains $spike^{-1}$ (No.)

vii. 1000 grain weight (g)

viii. Shelling percentage (%)

ix. Grain yield (t ha^{-1})

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

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

xii. Harvest index (%)

3.12.1 Procedure of sampling for growth study during the crop growth period

i. Plant height (cm)

The height of the wheat plants was recorded at 20, 40, 60, 80 DAS and harvest. From the ground level up to tip of the flag leaf was counted as height of the plant. The average height of 10 plants was considered as the height of the plant for each plot.

ii. Above ground dry matter weight plant^{-1} (g)

Five sample plants were cut at the ground level from each plot unbiasly and then dried them in an electric oven maintaining 80^0C for 72 hours. Then the plants were weighed in an electric balance and averaged them to have above ground dry matter weight plant^{-1}.

iii. Leaf area (cm^2)

Five sample plants were cut at the ground level from each plot unbiasly. Leaf area at 20 DAS was measured by destructing method using CL-202 Leaf Area Meter (USA). The length and breadth of the leaf was measured of the leaf at 40, 60, 80 DAS and harvest. Then area was calculated by multiplying length and breadth. Then the mean was calculated.

iv. Length of spike (cm)

Ten plants were randomly selected during harvesting and the spikes were measured with meter scale and then the average length was calculated and expressed as cm.

v. Spikelets spike^{-1} (No.)

Number of spikelets from randomly selected 10 spikes were counted and average of which gave the number of spikelets spike^{-1}.

vi. Grains spike^{-1} (No.)

Number of grains from randomly selected 10 spikes were counted and average of which gave the number of grains spike^{-1}.

vii. 1000 grain weight (g)

One thousand cleaned dried grains were randomly collected from the seed stock obtained from each plot and were sundried properly at 10% moisture content and weight by using an electric balance.

viii. Grain and straw yield (t ha^{-1})

An area of 1 m^2 harvested for yield measurement. The crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each plot were recorded after proper drying in sun.

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

Biological yield was calculated by using the following formula:

Biological yield = Grain yield + straw yield

x. Harvest index (%)

Harvest index is the relationship between grain yield and biological yield. It was calculated by using the following formula:

HI (%) = $(\text{Grain yield})/(\text{Biological yield}) \times 100$

3.13 Statistical analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance.

CHAPTER 4

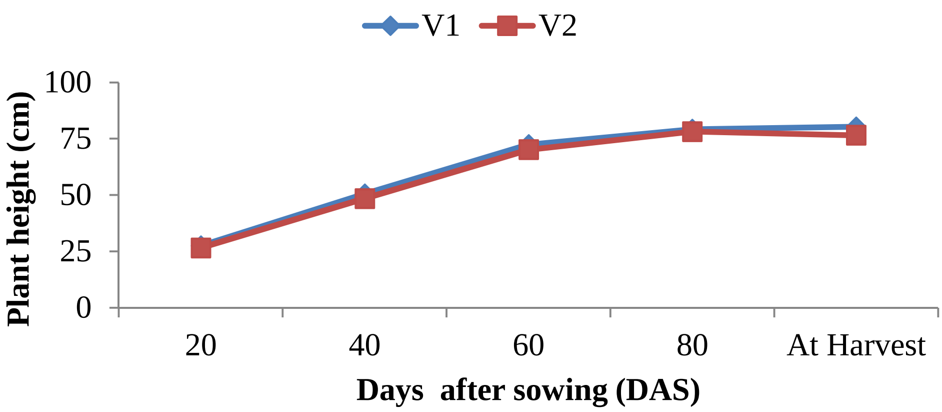
RESULTS AND DISCUSSION

Results obtained from the study "response of heat tolerant wheat varieties to inorganic and organic fertilizer management" have been presented and discussed in this chapter. Treatments effect of variety and fertilizer management on all the studied parameters have been presented in various tables and figures and discussed below under the following sub-headings.

4.1 Plant height

4.1.1 Effect of variety

Wheat varieties did not exhibit significant difference on plant height at different growth stages (Fig. 1 and Appendix iv). Between the varieties, BARI Gom-29 (V_1) produced the t numerically taller plant (27.46 cm, 50.53 cm, 72.37 cm, 79.20 cm and 80.27cm) at 20, 40, 60, 80 DAS and harvest, respectively. While the shortest plant (26.53 cm, 48.47 cm, 70.11 cm, 78.17 cm and 76.54 cm) were produced by BARI Gom -30 (V_2) at 20, 40, 60, 80 DAS and harvest, respectively. This might be due to genetic makeup of variety of wheat.

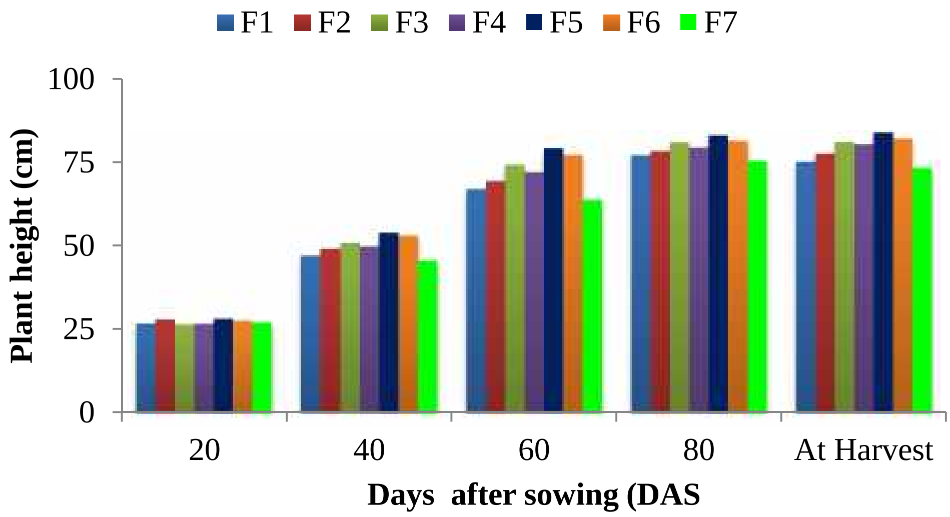


V_1: BARI Gom-29 and V_2: BARI Gom- 30

Figure 1. Effect of variety on the plant height of wheat at different days after sowing ($LSD_{0.05}$ = NS, NS, NS, NS and NS at 20, 40, 60, 80 DAS and harvest, respectively).

4.1.2 Effect of fertilizer management

Different fertilizer management exhibited significant difference on plant height of wheat at different growth stages except 20 and 80 DAS (Fig. 2 and Appendix iv). The results revealed that at 40, 60 DAS and harvest the tallest plant (53.37 cm, 78.51 cm and 83.26 cm respectively) were recorded from treatment F_5 [100% poultry manure + 75% RF (recommended fertilizer)] which was statistically similar with F_6, F_3, F_4 and F_2 at 40 DAS and harvest; with F_6, F_3 and F_4 at 60 DAS while the shortest plant (45.24 cm, 63.29 cm and 72.78 cm respectively) were recorded from treatment F_7 (100% Poultry Manure + 25% RF) which was statistically similar with F_1, F_2 and F_4 at 40 and 60 DAS and finally with F_1, F_2, F_3 and F_4 at harvest. The organic manures in addition with inorganic nutrients help in improving the metabolic activity and plant growth. Overall improvement in growth of plants under the application of inorganic fertilizers along with organic manure which are good source of essential nutrients specially NPK that could be ascribed to potential role of N, P and K fertilizer in modifying soil and plant environment conducive for better development of morphological components of the growth. Nitrogen plays a vital role in growth processes as it is an integral part of chlorophyll, protein and nucleic acid. It is viewed as the central element because of its role in substance synthesis. It constitutes 1.5 to 5 % of the dry weight of higher plant. Further, phosphorus drive from both organic and inorganic sources improves various metabolic and physiological processes, thus known as “Energy currency” which is subsequently used for vegetative and reproductive growth through phosphorylation (Brady, 1996 and Tisdale, 2002). An adequate supply of phosphorus early in the life of a plant is important in laying down the primordial for its reproductive parts. Phosphorus also increases the initiation of both first and second order rootlets and their development. The extensive root system helps in exploiting the maximum nutrients and water from soils (Tandon and Narayan, 1990). Potassium (K^+) is of unusual significance because of its live role in biochemical functions of the plant like activating various enzymes, improvement of protein, carbohydrates and fat concentration, developing tolerance against drought and resistance to frost, lodging, pests and disease attack. Potassium is one of the major essential plant nutrient required for normal growth and development of plants. The improvement in nutritional status of plant might have resulted in greater synthesis of amino acids and protein and other growth promoting substances which seems to have enhanced the meristematic activity and increased cell division and enlargement and their elongation resulting in higher plant height. Singh *et al.* (2018), Thakur *et al.* (2017) and Yadav *et al.* *(*2017) reported that the reason of the highest plant height recorded with RDF along with organic manure is having good amount of nitrogen and easily provided to plants which helps in good plant height. The results of present investigation were in close conformity with findings of several researchers Subhan *et al.* (2017); Chopra *et al.* (2016); Rasul *et al.* (2015); Muhammad *et al.* (2014); Soleiman zadeh and Gooshchi (2013); Singh *et al.* (2012); Tahir *et al.* (2011); Sarwar *et al.* (2007); Khan *et al.* (2007); Iqtidar *et al.* (2006); Jamil *et al.* (2004) and Song *et al.* (2000).



F_1: Recommended fertilizer dose (RF) for wheat (100%), F_2: Compost (100%) + RF (75%), F_3: Compost (100%) + RF (50%), F_4: Compost (100%) + RF (25%), F_5: Poultry manure (100%) + RF (75%), F_6: Poultry manure (100%) + RF (50%) and F_7: Poultry manure (100%) + RF (25%)

Figure 2. Effect of different fertilizers management on the plant height of wheat at different days after sowing ($LSD_{0.05}$=NS, 5.26, 8.35, NS and 8.27 at 20, 40, 60, 80 DAS and harvest, respectively).

4.1.3 Combined effect of variety and fertilizer management

Combined effect of variety and fertilizer management showed significant variation on plant height of wheat at different growth stages except 20 and 80 DAS (Table 1). The results exposed that, the tallest plant (54.05 cm, 79.07 cm and 84.81 cm) were found in treatment combination V_1F_5 at 40, 60 DAS and harvest, respectively which were statistically similar with rest of the treatment combinations except V_2F_1 and V_2F_7 at 40 DAS; with V_2F_7 at 60 DAS and harvest. On the other hand, the shortest plant

(43.54 cm, 61.62 cm and 71.08 cm) were found in treatment combination V_2F_7 at 40, 60 DAS and harvest, respectively which were statistically similar with rest of the treatment combinations except V_2F_6, V_2F_5, V_1F_6, V_1F_5 and V_1F_3 at 40 and 60 DAS; with V_1F_3, V_1F_5 and V_1F_6 at harvest.

Table 1. Combined effect of variety and different fertilizers management on the plant height of wheat at different days after sowing

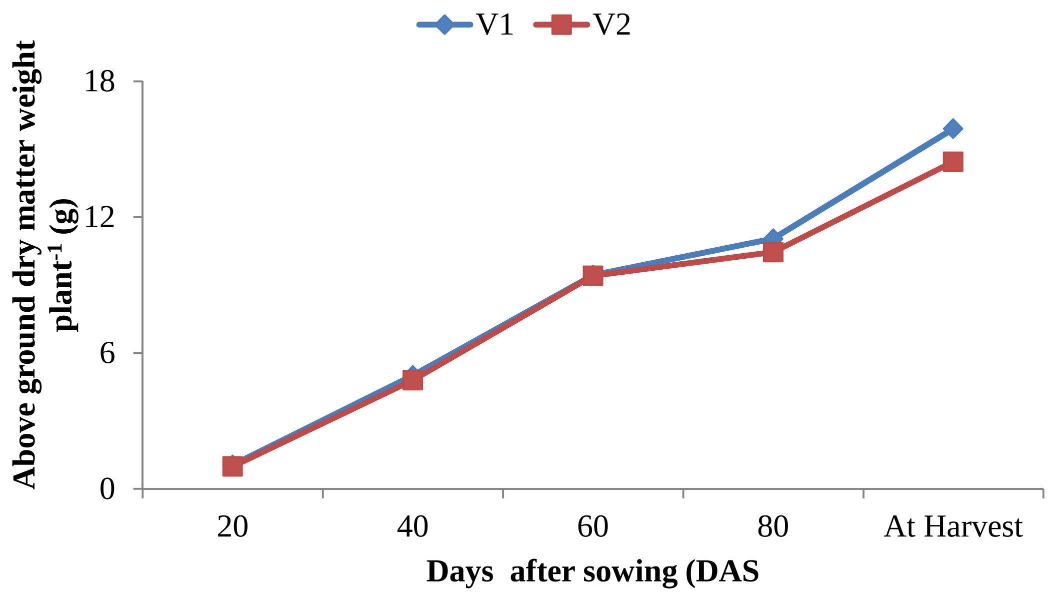
Treatment combinations	Plant height (cm) at different days after sowing (DAS)				
	20	40	60	80	At Harvest
V_1F_1	27.01	48.02 a-c	67.62 a-c	77.63	74.44 ab
V_1F_2	28.51	49.75 a-c	69.71 a-c	78.13	78.41 ab
V_1F_3	26.43	51.35 ab	74.16 ab	80.73	83.43 a
V_1F_4	25.97	50.49 a-c	72.93 a-c	79.20	82.55 ab
V_1F_5	28.24	54.05 a	79.07 a	81.70	84.81 a
V_1F_6	28.29	53.11 a	78.17 a	81.00	83.75 a
V_1F_7	27.77	46.95 a-c	64.95 bc	76.00	74.49 ab
V_2F_1	26.03	45.24 bc	65.33 bc	75.20	74.55 ab
V_2F_2	26.94	47.68 a-c	67.93 a-c	77.20	75.43 ab
V_2F_3	25.92	49.71 a-c	73.05 a-c	79.73	77.24 ab
V_2F_4	26.83	48.45 a-c	70.07 a-c	78.13	76.73 ab
V_2F_5	27.71	52.69 a	77.94 a	83.07	81.71 ab
V_2F_6	26.38	51.97 ab	74.81 ab	80.53	79.01 ab
V_2F_7	25.89	43.54 c	61.62 c	73.33	71.08 b
LSD $_{(0.05)}$	**NS**	**7.44**	**11.81**	**NS**	**11.70**
CV (%)	**9.22**	**8.92**	**9.83**	**8.39**	**8.85**

V_1: BARI Gom -29 and V_2: BARI Gom -30; F_1: Recommended fertilizer dose (RF) for wheat (100%),F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

4.2 Above ground dry matter weight plant^{-1}

4.2.1 Effect of variety

Insignificant variation was observed on above ground dry matter weight plant^{-1} at different growth stages of wheat varieties (Fig. 3 and Appendix v). Numerically V_1 showed the maximum above ground dry matter weight plant^{-1}(1.06 g, 5.01 g, 9.45 g, 11.05 g and 15.90 g at 20, 40, 60, 80 DAS and harvest, respectively); whereas numerically the minimum ones (1.00 g, 4.81 g, 9.41 g, 10.46 g and 14.45 g at 20, 40, 60, 80 DAS and harvest, respectively) was found in V_2.



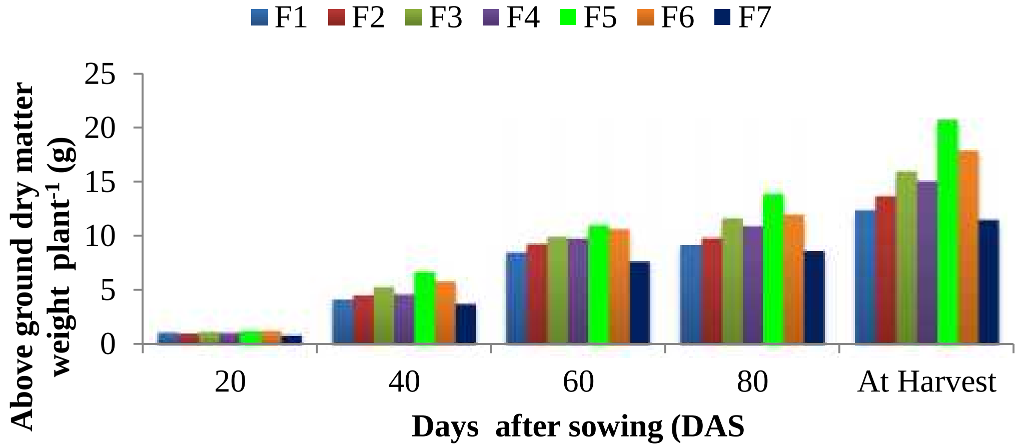
V_1: BARI Gom -29 and V_2: BARI Gom -30

Figure 3. Effect of variety on the above ground dry matter weight plant^{-1} of wheat at different days after sowing ($LSD_{0.05}$ = NS, NS, NS, NS and NS at 20, 40, 60, 80 DAS and harvest, respectively).

4.2.2 Effect of fertilizer management

Different fertilizer managements showed a significant variation on above ground dry matter weight plant^{-1} for all growth stages (Fig. 4 and Appendix v). The results of the investigation revealed that, at 20 DAS, the maximum above ground dry matter weight plant^{-1} (1.20 g) was recorded from F_6 treatment which was statistically similar with F_5 and F_3, while the minimum one (0.78 g) was recorded from F_7 treatment. At 40, 60, 80 DAS and harvest, the maximum above ground dry matter weight plant^{-1} (6.60 g, 10.85 g, 13.76 g and 20.55 g, respectively) were recorded from F_5 treatment which was statistically similar with F_6 and F_3 only at 60 DAS, while the minimum ones (3.67 g, 7.55 g, 8.53 g and 11.36 g, respectively) were recorded from F_7 Treatment which was statistically similar with F_1 at 40, 60 DAS and harvest; with F_1 and F_2 at 80 DAS. The organic manure has many attributes. It supplies a wide variety of nutrients along with organic matters that improved the physical properties of soil. Its beneficial effects some time is difficult to duplicate with other materials (Pong and Laty, 2000).

Organic matter is very important for the growth of many plants because it improves the growth of plants directly or indirectly. Large amount of macro nutrients and micro nutrients are present in the organic matter and humic is a substance which is produce in the soil by the decomposition of organic material and this material is very useful for the growth of the plant (Noreen and Noreen, 2014). Application of various organic manures stimulated the plant growth, activity of soil microorganisms and higher activity of soil enzymes (Knapp *et al.* 2010). The higher dry matter accumulation in organic manure along with mineral fertilizer may be due to the fact that in organic manure mineralization is rapid, large portion of nitrogen in organic manure is inorganic fractions, but 20 to 40% of the total is in organic (Channabasanagowda *et al.,* 2008). Thus plant growth vigorously and accumulate higher dry matter. Low organic matter content and nutrient application rates, not only hampers the yield targets but also adversely affect the properties of soil (Ahmad *et al.,* 1998). Phullan *et al*. (2017) reported that the soil amended with farmyard manure, cluster bean and *Sesbania* with different mineral fertilizer rates using IPNM approach. It improves the crop growth and soil properties. It also improves water use efficiency, eventually increases the biomass production (Ahmad *et al.,* 2008). Nyangani (2010) reported that incorporation of organic manures and rate of mineral fertilizers significantly influenced dry matter accumulation of wheat. Increases in fresh weight of wheat with the incorporation of organic fertilizers have also been reported by Chopra *et al.* (2016) and Sarwar *et al.* (2009).



F1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

Figure 4. Effect of different fertilizers management on the above ground dry matter weight plant^{-1} of wheat at different days after sowing ($LSD_{0.05}$=0.13, 0.53, 1.11, 1.40 and 2.08 at 20, 40, 60, 80 DAS and harvest, respectively).

4.2.3 Combined effect of variety and fertilizer management

Combined effect of variety and fertilizer management showed significant variation on above ground dry matter weight plant^{-1}for all growth stages (Table 2). At 20, 40, 80 DAS and harvest, the maximum above ground dry matter weight plant^{-1}(1.31 g, 6.73 g, 14.38 g and 21.51 g, respectively) was produced by treatment combination V_1F_5 which was statistically similar with V_1F_3 and V_1F_6 and V_2F_6 at 20 DAS and with V_2F_5 at 40 DAS, with V_2F_5 at 80 DAS and with V_2F_5 and V_1F_6 at harvest. At 60 DAS, the maximum above ground dry matter weight plant^{-1} (10.98 g) was produced by treatment combination V_2F_5 which was statistically similar with V_1F_5, V_1F_3, V_1F_6, V_2F_3, V_2F_4 and V_2F_6. On the other hand, the minimum ones (0.74 g, 3.52 g, 7.19 g, 8.15 g and 10.70 g) were produced by treatment combination V_2F_7 at 20,40,60,80 DAS and harvest respectively which was statistically similar with V_1F_7, V_2F_3 and V_1F_2 at 20 DAS; with V_1F_7 and V_2F_1 at 40 DAS; with V_2F_1 and V_1F_7 at 60 DAS; with V_2F_1, V_1F_7, V_2F_2 and V_1F_1 at 80 DAS and harvest.

Table 2. Combined effect of variety and different fertilizers management on the above ground dry weight plant^{-1} of wheat at different days after sowing

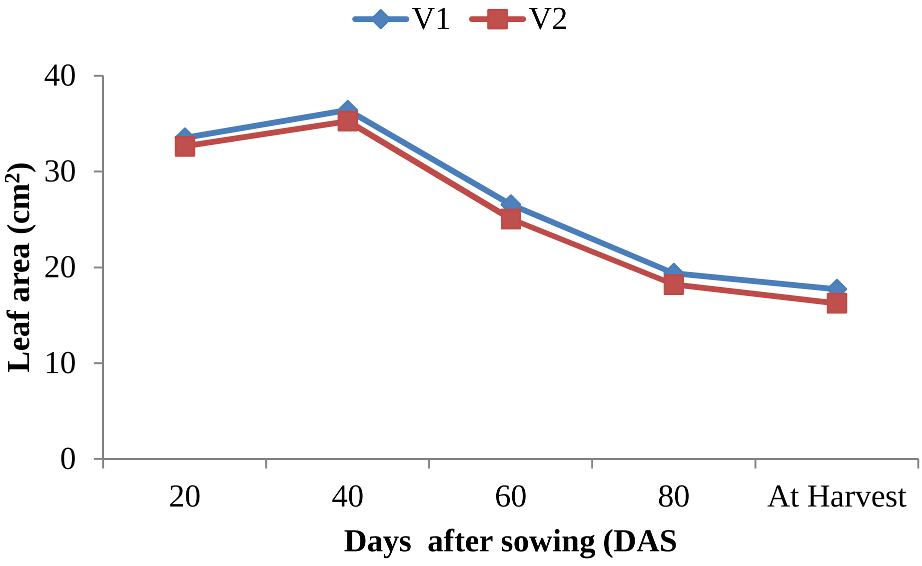
Treatment combinations	Above ground dry weight plant^{-1} (cm) at different days after sowing (DAS)				
	20	40	60	80	At Harvest
V_1F_1	1.02 c-e	4.34 fg	8.99 d-f	9.430 d-f	12.75 c-e
V_1F_2	0.88 e-g	4.49 e-g	9.13 c-f	10.17 cde	13.98 b-d
V_1F_3	1.26ab	5.26cd	9.50 a-d	11.64 bc	16.24 b
V_1F_4	0.94 d-f	4.66def	9.39b-e	10.65 c-e	15.47 bc
V_1F_5	1.31a	6.73a	10.71 ab	14.38 a	21.51 a
V_1F_6	1.19 a-c	5.74 bc	10.49 a-d	12.15 bc	19.34 a
V_1F_7	0.82 fg	3.82 gh	7.90 e-g	8.907 ef	12.02 de
V_2F_1	1.04 c-e	3.85 gh	7.82fg	8.750 ef	11.81 de
V_2F_2	1.04c-e	4.45 fg	9.25 b-f	9.287 def	13.17 c-e
V_2F_3	0.91e-g	5.21cde	10.10 a-d	11.44bc	15.41 bc
V_2F_4	1.11 b-d	4.46fg	9.98a-d	10.91 cd	14.32 b-d
V_2F_5	0.96 d-f	6.48 ab	10.98 a	13.15 ab	19.59 a
V_2F_6	1.20 a-c	5.68 c	10.57 a-c	11.57 bc	16.14 b
V_2F_7	0.74 g	3.52 h	7.19g	8.147 f	10.70 e
LSD $_{(0.05)}$	**0.18**	**0.75**	**1.57**	**1.99**	**2.94**
CV (%)	**10.84**	**9.02**	**9.87**	**10.96**	**11.48**

V_1: BARI Gom-29 and V_2: BARI Gom- 30;F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

4.3 Leaf area (cm^2)

4.3.1 Effect of variety

Significant variation was not observed on leaf area of wheat at different growth stages due to varietal variation (Fig. 5 and Appendix vi). Numerically the maximum leaf area (33.53, 36.40, 26.55, 19.39 and 17.73 cm^2) were produced by wheat variety V_1 at 20, 40, 60, 80 DAS and harvest, respectively and the minimum ones (32.64 cm^2, 35.25cm^2, 25.06cm^2, 18.21cm^2 and 16.25 cm^2) were produced by wheat variety V_2 at the same observation periods, respectively.

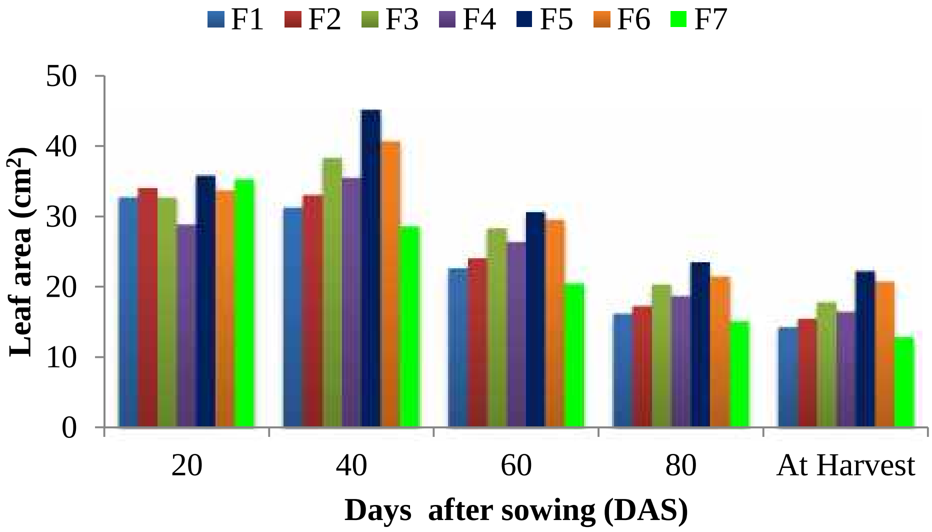


V_1: BARI Gom-29 and V_2: BARI Gom- 30

Figure 5. Effect of variety on the leaf area of wheat at different days after sowing ($LSD_{0.05}$= NS, NS, NS, NS and NS at 20, 40, 60, 80 DAS and harvest, respectively).

4.3.2 Effect of fertilizer management

Different fertilizer managements had significant influenced on leaf area of wheat at all the growth stages (Fig. 6 and Appendix vi). The result of the investigation revealed that, the maximum leaf area (35.59, 44.84, 30.40, 23.28 and 22.03 cm^2) were attained by F_5 treatment at 20, 40, 60, 80 DAS and harvest, respectively which was statistically at par with F_5, F_1, F_2, F_3, F_6 and F_7 at 20 DAS; with F_6 at 40, 80 DAS and harvest; with F_6 and F_3 at 40 DAS. At 20 DAS the minimum leaf area (28.63 cm^2) was attained by F_4 treatment. Again at 40, 60, 80 DAS and harvest the minimum leaf area (28.35, 20.32, 14.95 and 12.73 cm^2, respectively) were attained by F_7 treatment which was statistically at par with F_1 and F_2 at 40 and 80 DAS; with F_1 at 60 DAS and harvest. Similar findings were also reported by Singh *et al.* (2018) and Pietz *et al.* (1982) who reported that the recommended doses of fertilizer (RDF), along with organic manure helps to increase the leaf area of wheat.



F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

Figure 6. Effect of different fertilizers management on the leaf area of wheat at different days after sowing ($LSD_{0.05}$=3.39, 4.61, 3.28, 2.48 and 2.48 at 20, 40, 60, 80 DAS and harvest, respectively).

4.3.3 Combined effect of variety and fertilizer management

Combined effect of variety and fertilizer management showed significant variation on leaf area for all growth stages (Table 3). At 20 DAS, the maximum leaf area (36.95 cm^2) was attained by treatment combination V_2F_5 which was statistically similar with V_2F_7, V_1F_2, V_1F_1, V_1F_5, V_1F_6, V_1F_7, V_2F_3 and V_2F_6 and the minimum leaf area (30.52 cm^2) was attained by V_2F_1 which was statistically similar with V_2F_2, V_2F_3, V_2F_6, V_1F_7, V_1F_6, V_1F_5, V_1F_4 and V_1F_1. At 40, 60, 80 DAS and harvest, the maximum leaf area (46.42, 31.13, 23.86 and 22.58 cm^2, respectively) were attained by treatment combination V_1F_5 which was statistically similar with V_1F_6 and V_2F_5 at 40 DAS; with V_1F_6, V_2F_5, V_1F_3, V_2F_3 and V_2F_6 at 60 DAS; with V_2F_5, V_2F_6, V_1F_6 and V_1F_3 at 80 DAS and finally with V_1F_6, V_2F_5 and V_2F_6 at harvest. On the other hand at 40, 60, 80 DAS and harvest, the minimum leaf area (27.92, 19.80, 13.82 and 11.85cm^2, respectively) were attained by treatment combination V_2F_7 which was statistically similar withV_1F_7, V_2F_1, V_2F_2, V_1F_1 and V_1F_2 at 40 DAS; with V_1F_7, V_2F_1, V_2F_2 and V_1F_1 at 60, 80 DAS and harvest.

Table 3. Combined effect of variety and different fertilizers management on the leaf area of wheat at different days after sowing

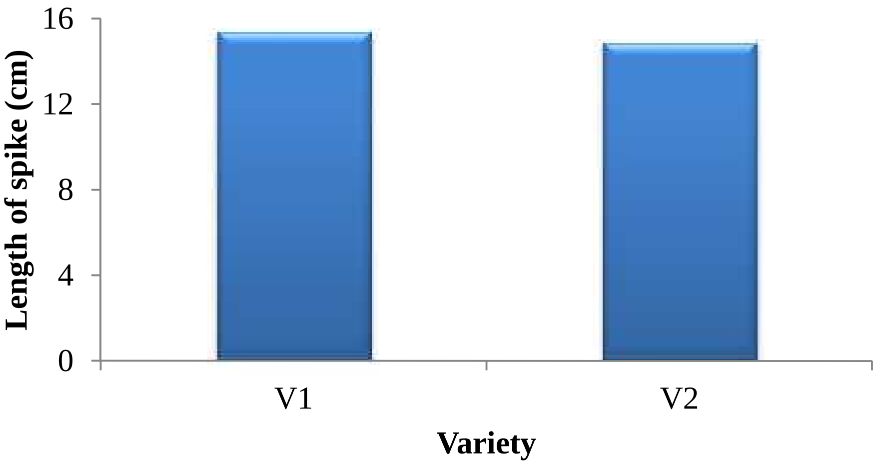
Treatment combinations	Leaf area (cm^2) at different days after sowing (DAS)				
	20	40	60	80	Harvest
V_1F_1	34.52 a-c	31.88 d-g	23.25 d-h	16.92 d-g	14.91 e-g
V_1F_2	35.70 ab	33.06 c-g	25.40 c-g	17.96 c-f	15.79 d-f
V_1F_3	31.25 bc	36.53 c-e	28.51 a-c	20.50 a-c	18.96 b-d
V_1F_4	31.95 bc	34.98c-f	26.38 b-e	19.10 c-e	17.15 c-e
V_1F_5	34.23 a-c	46.42 a	31.13 a	23.86 a	22.58 a
V_1F_6	33.84 a-c	43.15 ab	30.34 ab	21.32 a-c	21.08 ab
V_1F_7	33.19 a-c	28.78 fg	20.85 gh	16.08 e-g	13.60 fg
V_2F_1	30.52 c	30.21 e-g	21.63 f-h	15.23 fg	13.43 fg
V_2F_2	32.01 bc	32.64 d-g	22.28 e-h	16.38 e-g	14.87 e-g
V_2F_3	33.70 a-c	39.51 bc	27.69 a-d	19.91 b-d	16.47 d-f
V_2F_4	25.31 d	35.64 c-e	26.01 b-f	18.05 c-f	15.53 d-f
V_2F_5	36.95 a	43.25 ab	29.66 a-c	22.69 ab	21.48 ab
V_2F_6	33.08 a-c	37.61 b-d	28.31 a-c	21.42 a-c	20.15 a-c
V_2F_7	36.89 a	27.92 g	19.80 h	13.82 g	11.85 g
LSD $_{(0.05)}$	**4.79**	**6.51**	**4.64**	**3.51**	**3.51**
CV (%)	**8.60**	**10.79**	**10.67**	**11.08**	**12.26**

V_1: BARI Gom -29 and V_2: BARI Gom -30;F_1: Recommended fertilizer dose (RF) for wheat (100%),F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

4.4 Length of spike

4.4.1 Effect of variety

Significant variation was not observed on panicle length between the wheat varieties (Fig. 7 and Appendix vii). The figure showed that numerically the longer spike (15.35 cm) was found in V_1 and the shorter one (14.85 cm) was from V_2.

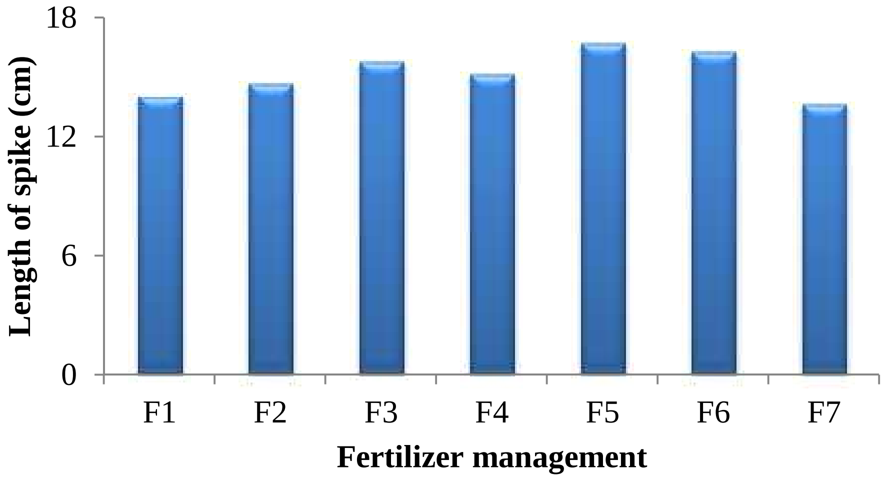


V_1: BARI Gom -29 and V_2: BARI Gom -30

Figure 7. Effect of variety on the length of spike of wheat ($LSD_{0.05}$=NS).

4.4.2 Effect of fertilizer management

Length of spike was significantly affected due to different fertilizer management (Fig. 8 and Appendix vii). The longest spike (16.63 cm) was obtained when the plot treated with 100% poultry manure along with 75% of RF (F_5) which was statistically similar with F_6, F_3 and F_4 while the shortest one (13.55 cm) was obtained when the plot treated with 100% poultry manure along with 25% of RF (F_7) which was statistically similar withF_1, F_2 and F_4.



F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

Figure 8. Effect of different fertilizers management on the length of spike of wheat ($LSD_{0.05}$=1.64)

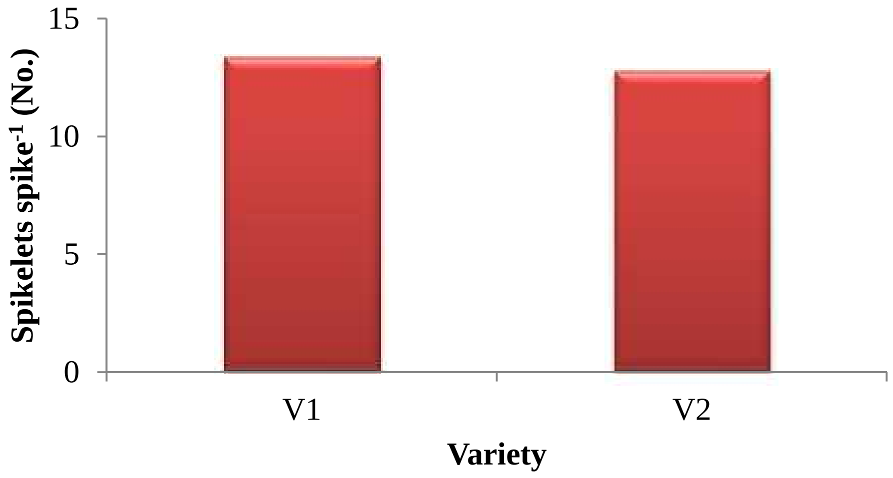
4.4.3 Combined effect of variety and fertilizer management

Length of spike was significantly affected due to combined effect of variety and different fertilizer management (Table 4). The longest spike (16.77 cm) was obtained when the plot treated with 100% poultry manure + 75% of RF (F_5) along with wheat variety BARI Gom -29 (V_1) which was statistically similar with all the treatment combinations except V_2F_7, V_2F_1, V_2F_2, V_1F_7 and V_1F_1 while the shortest spike (13.17 cm) was obtained when the plot treated with 100% poultry manure + 25% of RF along with BARI Gom -30 (V_2) which was statistically similar with all the treatment combinations except V_1F_5, V_1F_6, V_2F_5, V_2F_6 and V_1F_3.

4.5 Spikelets spike^{-1}

4.5.1 Effect of variety

Spikelets spike^{-1} was not significantly varied due to varietal variation (Fig. 9). The result showed that numerically the maximum spikelets spike^{-1} (13.32) was scored by V_1 and the minimum (12.72) was scored by V_2.

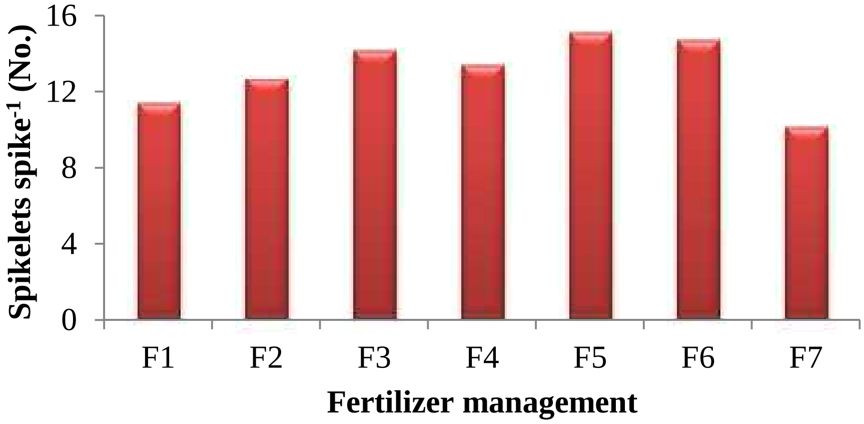


V_1: BARI Gom -29 and V_2: BARI Gom -30

Figure 9. Effect of variety on the spikelets spike^{-1}of wheat ($LSD_{0.05}$=NS).

4.5.2 Effect of fertilizer management

Spikelets spike^{-1} was significantly varied due to different fertilizer management (Fig. 10 and Appendix vii). The maximum spikelets spike^{-1} (15.05) was scored by F_5 which was statistically similar with F_6 and F_3 while the minimum spikelets spike^{-1} (10.07) was scored by F_7 which was statistically similar with F_1. The advantage of organic manures is quite obvious, as these provide a steady supply of nutrients leading better growth of plants. Moreover, the increased availability of P and K in addition to other plant nutrients released by the organic manures might have contributed in enhancing the yield-attributes (spikelets spike^{-1}). The positive impact of availability of individual plant nutrients and humic substances from manure and balanced supplement of NPK through inorganic fertilizers might have induced cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency and regulation of water intake into the cells, resulting in the increasing of yield parameters (Sharma *et al.*, 2013). Singh *et al.* (2018) reported that organic manure (sewage sludge and bone meal) can improve physical, chemical and biological properties of soil. It helps to reduce soil erosion and improves the soil quality as a plant growth medium which helped to trigger the production of spikelets of wheat. The results of our study were in close agreement with the results obtained by Chopra *et al.* (2016) and Tahir *et al.* (2011) who stated that the numbers of spikelets spike^{-1} increased by the application of organic matters along with synthetic fertilizers.



F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

Figure 10. Effect of different fertilizers management on the spikelets spike^{-1}of wheat ($LSD_{0.05}$=1.53).

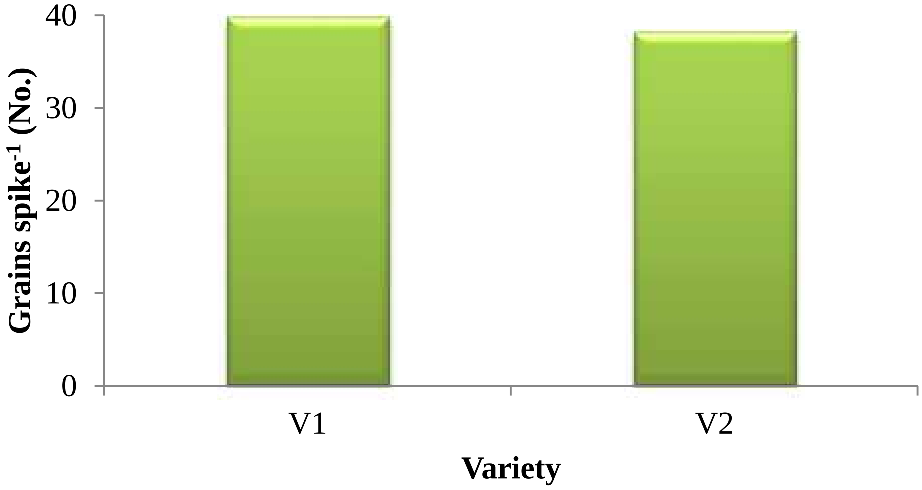
4.5.3 Combined effect of variety and fertilizer management

Spikelets spike^{-1} was significantly affected due to combined effect of variety and different fertilizer management (Table 4). The maximum spikelets spike^{-1} (15.17) was scored by the treatment combination V_1F_5 which was statistically similar with V_1F_6, V_2F_6, V_2F_5, V_1F_3, V_1F_4, V_2F_3 and V_2F_4 while the minimum spikelets spike^{-1} (9.56) was scored by treatment combination V_2F_7 which was statistically similar with V_1F_7 and V_2F_1.

4.6 Grains spike^{-1}

4.6.1 Effect of variety

Grains spike^{-1} was not significantly differed due to wheat varieties (Fig. 11 and Appendix vii). The result showed that numerically the maximum grains spike^{-1} (39.62) was given by V_1 and the minimum grains spike^{-1} (38.08) was given by V_2.

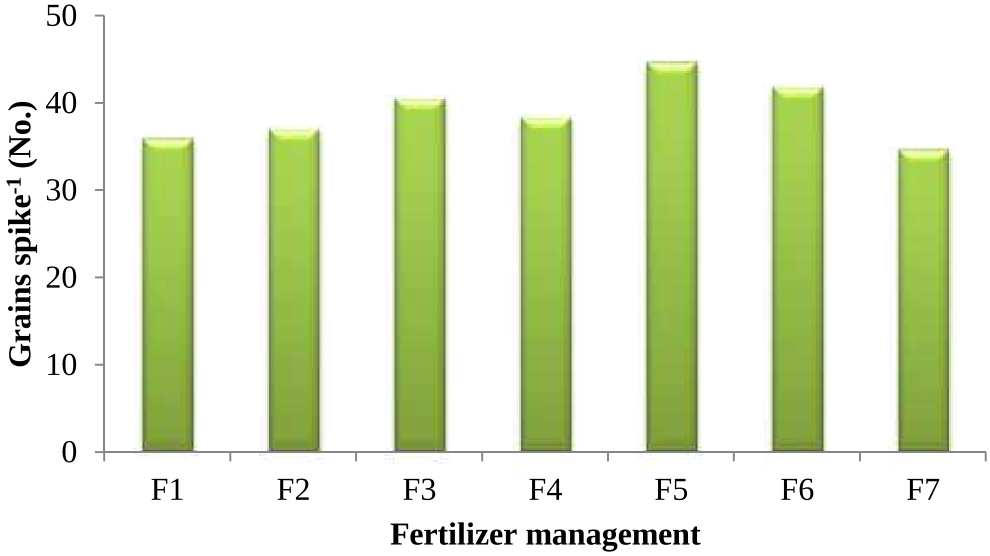


V_1: BARI Gom -29 and V_2: BARI Gom -30

Figure 11. Effect of variety on the grains spike^{-1}of wheat ($LSD_{0.05}$=NS).

4.6.2 Effect of fertilizer management

Grains spike^{-1} was significantly differed due to different fertilizer management (Fig. 12 and Appendix vii). The maximum grains spike^{-1} (44.55) was given by F_5 which was statistically similar with F_6 and F_3 while the minimum grains spike^{-1} (34.50) was given by F_7 which was statistically similar with F_1, F_2 and F_4. The increase in grains spike^{-1} may result from increase in the various components of grain set, the number of spikelets per spike, the frequency of spikelets bearing grains, the number of differentiated florets, the survival of florets, the frequency of grain setting by florets (Peltonen-Sainio *et al.*, 2007). The nutrient elements supplied by both organic and inorganic sources in balanced form that might have increased the production of fertile spikelets resulting increasing the number of grains spike^{-1}. The findings of present investigation were in line with the findings of Singh *et al.* (2018); Subhan *et al.* (2017); Rasul *et al.* (2015); Tahir *et al.* (2011); Abedi *et al.* (2010) and Khan and Hussain (2001) who found that the application of organic manure along with inorganic fertilizer significantly increased the number of grains per spike.



F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

Figure 12. Effect of different fertilizers management on the grains spike^{-1}of wheat ($LSD_{0.05}$=4.63).

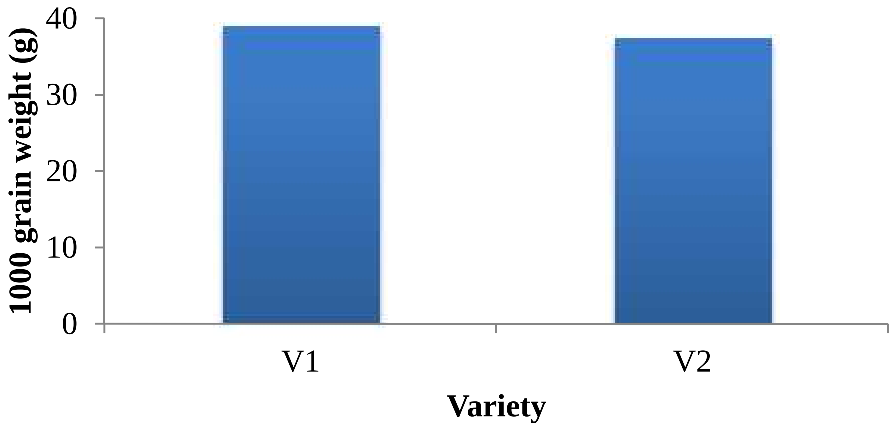
4.6.3 Combined effect of variety and fertilizer management

Grains spike^{-1} was significantly differed due to combined effect of variety and different fertilizer management (Table 4). The maximum grains spike^{-1} (45.27) was given by treatment combination V_1F_5which was statistically similar with V_2F_5, V_1F_6, V_1F_3, V_1F_4, V_2F_3 and V_2F_6 and the minimum grains spike^{-1} (33.37) was given by treatment combination V_2F_7 which was statistically similar with V_2F_1, V_1F_7, V_2F_2, V_2F_3, V_2F_4, V_1F_1, V_1F_2 and V_1F_4

4.7 1000 grain weight

4.7.1 Effect of variety

Variety had no significant effect on the 1000 grain weight of wheat shown in the fig. 13. Numerically the higher 1000 grain weight (39.93 g) was observed in V_1 and the lower 1000 grain weight (37.32 g) was observed in V_2.

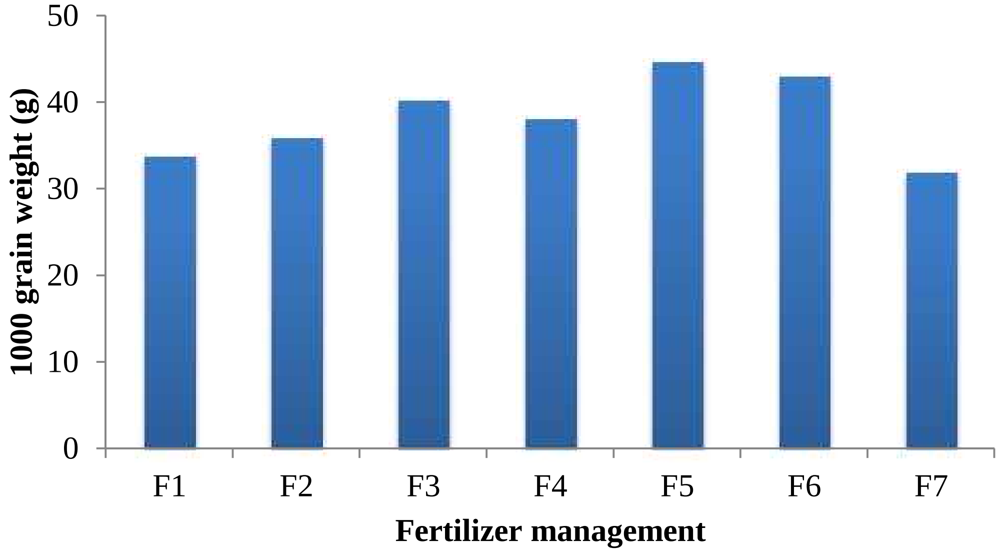


V_1: BARI Gom -29 and V_2: BARI Gom -30

Figure 13. Effect of variety on the 1000 grain weight of wheat ($LSD_{0.05}$=NS)

4.7.2 Effect of fertilizer management

Fertilizer management had significant effect on the 1000 grain weight of wheat shown in the fig. 14 and Appendix vii. The highest 1000 grain weight (44.55 g) was observed in F_5 followed by F_6 (42.91 g) and the lowest 1000 grain weight (31.80 g) was observed in F_7 followed by F_1 (33.67 g) and F_2 (35.81 g). Jala-Abadi *et al.* (2012), and Turk and Tawaha (2002) concluded that the higher 1000 grain weight could have been due to higher rates of photosynthesis and photosynthates partitioning from source to sink (to the grains). This higher photosynthesis rate and photosynthates partitioning might have resulting from the balanced supply of essential nutrients from both organic and inorganic sources. Subhan *et al.* (2017) and Rehman *et al.* (2008) also recorded highest thousand grain weight by the application of FYM along with chemical fertilizers. The results of the study strongly supported by Rasul *et al.* (2015); Devi *et al.* (2011); Tahir*et al.* (2011); Brown and Petrie (2006); Hossain *et al.* (2002) and Bakash *et al.* (1999) who reported that grain yield was significantly increased by the application of organic matter along with fertilizers.



F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

Figure 14. Effect of different fertilizers management on the 1000 grain weight of wheat ($LSD_{0.05}$=4.10).

4.7.3 Combined effect of variety and fertilizer management

A significant interaction between variety and fertilizer management was found on the 1000 grain weight (Table 4). The highest 1000 grain weight (45.01 g) was observed in the interaction of V_1F_5 that was statistically similar with the interaction of V_1F_6, V_1F_3, V_2F_5 and V_2F_6. The lowest 1000 grain weight (31.50 g) was observed in the interaction of V_2F_7 that was statistically similar with V_1F_7, V_2F_1, V_2F_2, V_2F_4, V_1F_1 and V_1F_2.

Table 4. Combined effect of variety and different fertilizers management on the yield contributing characteristics of wheat

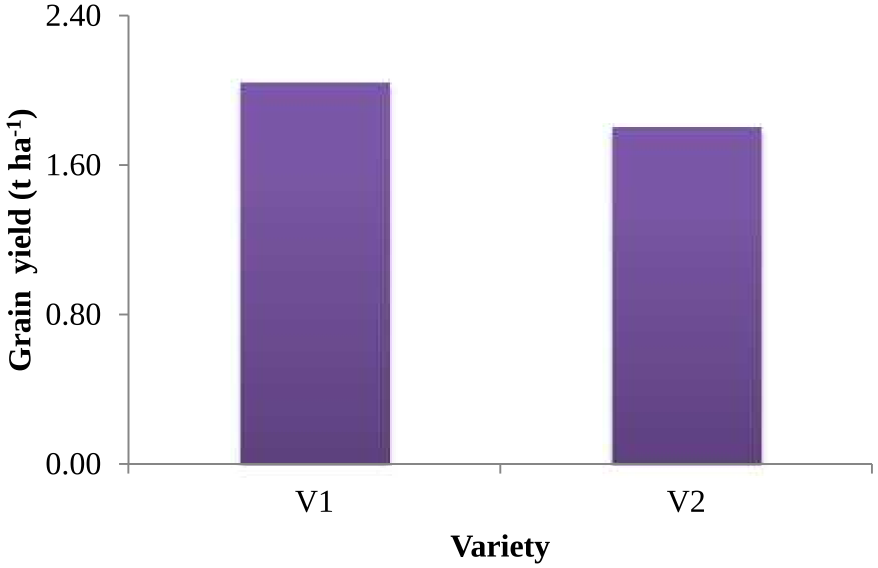
Treatment combinations	Spike length (cm)	Spikelets spike^{-1} (No.)	Grains spike^{-1} (No.)	1000 grain weight (g)
V_1F_1	14.23 b-e	11.83 d-f	36.49 c-e	34.21 de
V_1F_2	14.93 a-e	12.97 b-e	37.42 b-e	36.94 c-e
V_1F_3	16.00 a-d	14.33 a-c	41.42 a-d	41.58 a-c
V_1F_4	15.27 a-e	13.60 a-d	39.07 a-e	38.66 b-d
V_1F_5	16.77 a	15.17 a	45.27 a	45.01 a
V_1F_6	16.33 ab	14.77 ab	42.07 a-c	43.99 ab
V_1F_7	13.94 c-e	10.59 fg	35.63 c-e	32.10 e
V_2F_1	13.73 de	10.85 e-g	35.01 de	33.14 de
V_2F_2	14.23 b-e	12.30 c-f	36.31 c-e	34.67 de
V_2F_3	15.37 a-e	13.87 a-d	39.33 a-e	38.70 b-d
V_2F_4	14.87 a-e	13.05 a-d	37.40 b-e	37.26 c-e
V_2F_5	16.50 ab	14.93 ab	43.83 ab	44.10 ab
V_2F_6	16.07 a-c	14.50 ab	41.33 a-d	41.84 a-c
V_2F_7	13.17 e	9.56 g	33.37 e	31.50 e
LSD $_{(0.05)}$	**2.32**	**2.16**	**6.55**	**5.80**
CV (%)	**9.12**	**9.85**	**10.00**	**9.02**

V_1: BARI Gom-29 and V_2: BARI Gom -30;F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

4.8 Grain yield

4.8.1 Effect of variety

Varieties differed significantly in producing grain yield of wheat (Fig. 15 and Appendix viii). Between the varieties, BRRI Gom-29 showed its superiority in producing highest grain yield which was 13.33% higher than BARI Gom-30. However, BARI Gom -29 produced the higher grain yield (2.04 t ha^{-1}) compare to that of BARI Gom -30 (1.80 t ha^{-1}).

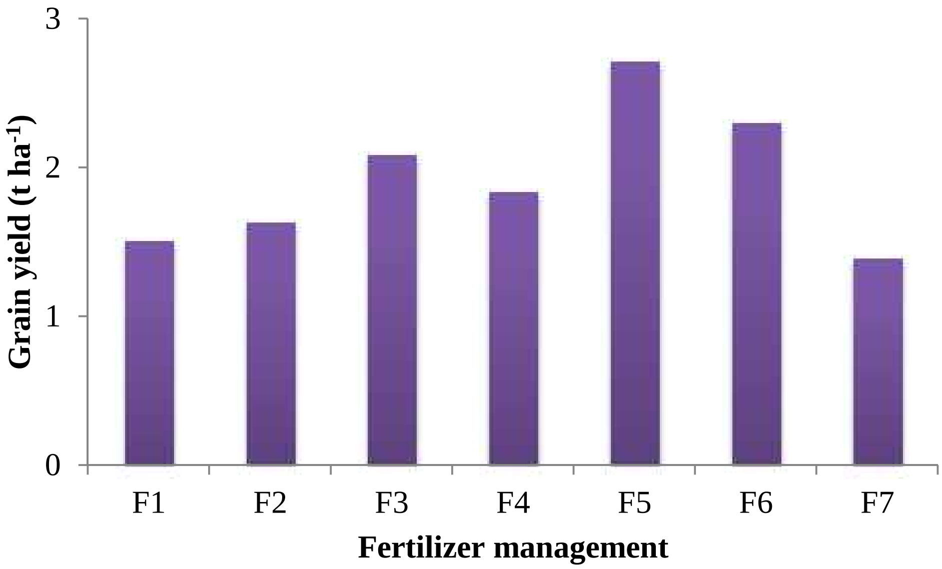


V_1: BARI Gom -29 and V_2: BARI Gom -30

Figure 15. Effect of variety on the grain yield of wheat ($LSD_{0.05}$=0.13).

4.8.2 Effect of fertilizer management

Grain yield was significantly influenced by different fertilizer managements (Fig. 16 and Appendix viii). The results of the experiment revealed that, the maximum grain yield (2.71 t ha^{-1}) was produced when the plot fertilized with 100% poultry manure + 75% RF (F_5) followed by treatment F_6 (2.30 t ha^{-1}). The minimum grain yield (1.39 t ha^{-1}) was produced when the plot fertilized with 100% poultry manure + 25% RF (F_7) followed by treatment F_1 (1.50 t ha^{-1}) and F_2 (1.63 t ha^{-1}). Among the different levels of fertilizer, F_5 produced 94.96% and 80.87% higher grain than F_7 and F_1 treatments respectively. Improvement of yield component such as number of effective tillers $hill^{-1}$ and number of grains $panicle^{-1}$ in these treatments ultimately resulted in high yield of grains. It is well recognized that crop productivity depends on adequate plant nutrient and organic matter content of the soil. Organic manure plays an important role in improving physical, chemical and biological properties of the soil. Organic manures are content low concentration of plant nutrients and they have a slow acting nature, organic manure alone may fail to tend the high nutritional requirements of crops (Hossian *et al.* 2002). Continuous additions of the manures to the soil increase its organic matter content year after year, improving physical and chemical soil properties (Böhme and Böhme, 2006). This improvement is due to providing of a suitable soil structure, increasing soil cation exchange capacity, increasing the quantity and availability of plant nutrients in addition to furnishing the microbial activities. Besides the positive effect of organic fertilizer on soil structure that lead to better root development that result in more nutrient uptake, compost not only slowly releases nutrients but also prevents the losses of chemical fertilizers through denitrification, volatilization and leaching by binding to nutrients and releasing with the passage of time (Arshad *et al.,* 2004). Thus, it is very likely that when we apply enriched compost along with chemical fertilizers, compost prevents nutrient losses. Consequently, integrated use of chemical fertilizers and organic manure may improve the efficiency of chemical fertilizers and thus reduce their use in order to improve crop productivity as well as sustain soil health and fertility. Chopra *et al.* (2016) reported that organic manures such as FYM and compost are renewable and eco-friendly to achieve sustainable productivity with minimum deterioration effect of chemical fertilizers on soil health and environment. Application of organic and mineral fertilizers also affected the nutrient uptake of shoot. Farmyard manure and recommended rate of mineral fertilizers were found to have maximum NPK uptake in shoot. Incorporation of farmyard manure provided ideal conditions to plant by increasing P mobilization and improving microbial activities (Nevens and Reheul, 2003 and Muneshwar *et al.,* 2001). Incorporation of organic manures alone and along with mineral fertilizers increased N and P uptake in plant (Salim *et al.,* 1986). P helps in maintaining better source-sink inter relationship by increasing sink capacity by its role in energy transformation. The higher yield may be due to fact that these organic manures supplies direct available nutrients such as nitrogen to the plants and improve the proportion of water stable aggregates of the soil. This was attributed to cementing action of polysaccharides and other organic compounds released during the decomposition of organic matters, thus leading to taller plants, increased tillers and final yield (Hendrix *et al.,* 1994; Martens *et al.,* 1992). The significant increase in grain yield under the influence of organic manure was largely a function of improved growth and consequent increase in different yield attributes. The possible reason could be ascribed to the favorable effect on soil properties due to formation of more humus colloidal complex coupled with faceable nutrient content of organic manure (Dhaka *et al.,* 2012). Application of fertilizers has supplied adequate amount of nutrients that helped in expansion of leaf area which might have accelerated the photosynthesis rate and in turn increased the supply of carbohydrates to the plants. Many scientists suggested that the use of organic matter along with chemical fertilizers can give the higher grains yield than obtained with synthetic chemical fertilizers alone (Tahir *et al.,* 2011; Sarwar *et al.,* 2008 and Sarwar *et al.,* 2007). Higher soil organic matter concentrations have been proved to enhance the yield and yield components of cereals as well as soil aeration, soil density and maximizing water holding capacity of soil for seed germination and plant root development (Zia *et al.,* 1998). The addition of organic matter also maintains regular supply of macro and micro nutrients in soil, resulting in higher yields. These results are in conformity with the findings of Sharma and Subehia (2014) that maximum wheat grain (36.40 q ha^{-1}) and straw (60.50 q ha^{-1}) yield was obtained with 50% N was substituted through FYM plus 50% NPK through chemical fertilizers to rice and 100% NPK through chemical fertilizers to wheat. Urkurkar *et al.* (2010) reported the integrated use of chemical fertilizers with organic manures *viz.* FYM, wheat straw or green manure might have added huge quantity of organic matter in soil and thereby producing increased grain yield. Nawab *et al.* (2011) and Negi and Gulshan (2000) reported that 10 t FYM ha^{-1} caused a significant increase in grain yield of wheat. The results of the investigation in line with those reported by Singh *et al.* (2018); Chekolle (2017); Phullan *et al.* (2017); Yadav *et al. (*2017); Abbas *et al.* (2016); Rasul *et al.* (2015); Jat *et al.* (2014); Chauhan (2014); Shah *et al.* (2013); Abay and Tesfaye (2012); Jala-Abadi *et al.* (2012); Devi *et al.* (2011); Abedi *et al.* (2010); Sarwar *et al.* (2008); Khan *et al.* (2007); Sarwar *et al.* (2007); Cheuk *et al.* (2003) and Parma and Sharma (2002) who concluded that grain yield of wheat was significantly affected by application of synthetic fertilizer along with organic manure than the sole application of synthetic fertilizers.



F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

Figure 16. Effect of different fertilizers management on the grain yield of wheat ($LSD_{0.05}$=0.25).

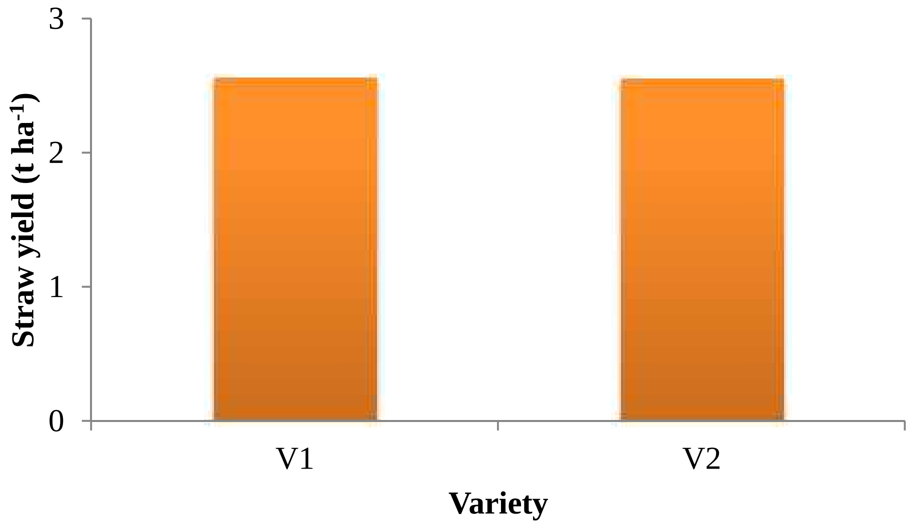
4.8.3 Combined effect of variety and fertilizer management

Grain yield influenced significantly by the interaction of variety and fertilizer management (Table 5). Among the treatment combinations, the highest grain yield (2.90 t ha^{-1}) was produced by the interaction of V_1F_5 followed by V_2F_5 (2.52 t ha^{-1}), V_1F_6 (2.35 t ha^{-1}) and V_2F_6 (2.25 t ha^{-1}) contrarily, the lowest grain yield (1.23 t ha^{-1}) was produced by the interaction of V_2F_7 followed by V_2F_1 (1.39 t ha^{-1}), V_2F_2 (1.52 t ha^{-1}), and V_1F_7 (1.54 t ha^{-1}). Treatment combination V_1F_5 produced 137.77% more grain than treatment combination V_2F_7.

4.9 Straw yield

4.9.1 Effect of variety

Straw yield of wheat did not differ significantly due to varietal variations (Fig. 17 and Appendix viii). Numerically the higher straw yield (2.56 t ha^{-1}) was attained by V_1 and the lower one (2.55 t ha^{-1}) was attained by V_2.

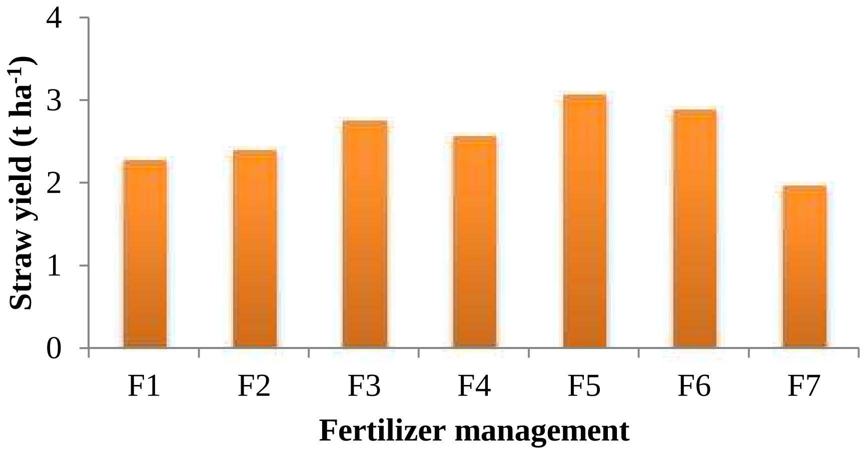


V_1: BARI Gom -29 and V_2: BARI Gom -30

Figure 17. Efect of variety on the straw yield of wheat ($LSD_{0.05}$=NS).

4.9.2 Effect of fertilizer management

Straw yield varied significantly with the different levels of fertilizer (Fig. 18 and Appendix viii). Straw yield was significantly highest (3.06 t ha^{-1}) at treatment F_5 that followed by treatment F_6 (2.88 t ha^{-1}). The lowest straw yield (1.96 t ha^{-1}) was found in F_7 treatment. These results were supported by those of Tahir *et al*. (2011) and Sarwar *et al.* (2008) who reported that straw yield of wheat was significantly increased by the application of organic matters along with inorganic fertilizers.



F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

Figure 18. Effect of different fertilizers management on the straw yield of wheat ($LSD_{0.05}$=0.30).

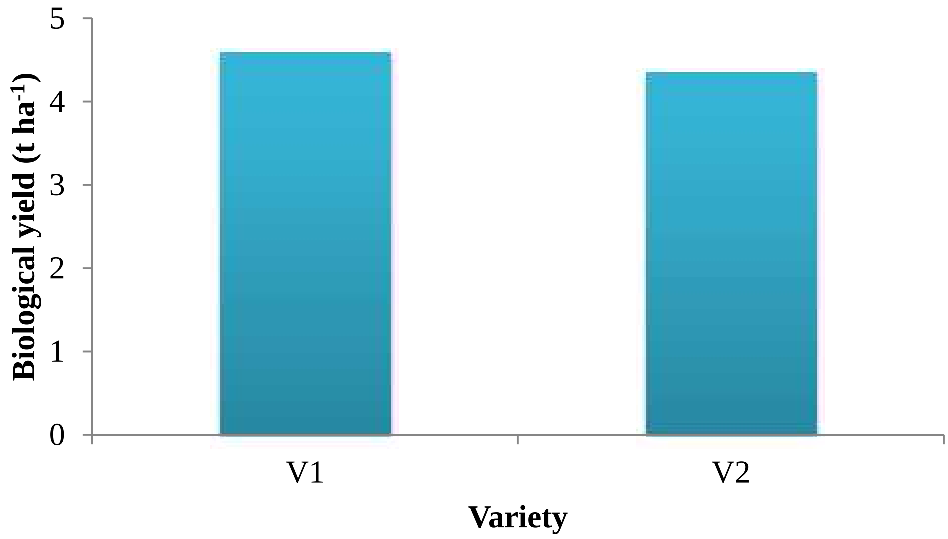
4.9.3 Combined effect of variety and fertilizer management

There observed a significant difference among the interactions of varietal variation and fertilizer management in respect of straw yield (Table 5). The maximum straw yield (3.10 t ha^{-1}) was scored by the interaction of V_1F_5 which was statistically similar with V_2F_5, V_2F_6, V_1F_6, V_2F_3 and V_1F_3. The minimum straw yield (1.92 t ha^{-1}) was scored by the interaction of V_2F_7 which was statistically similar with V_1F_7, V_2F_1 and V_1F_1.

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

4.10.1 Effect of variety

Biological yield of wheat did not differ significantly due to varietal variations (Fig. 19 and Appendix viii). Numerically the higher biological yield (4.60 t ha^{-1}) was attained by V_1 and the lower one (4.35 t ha^{-1}) was attained by V_2.

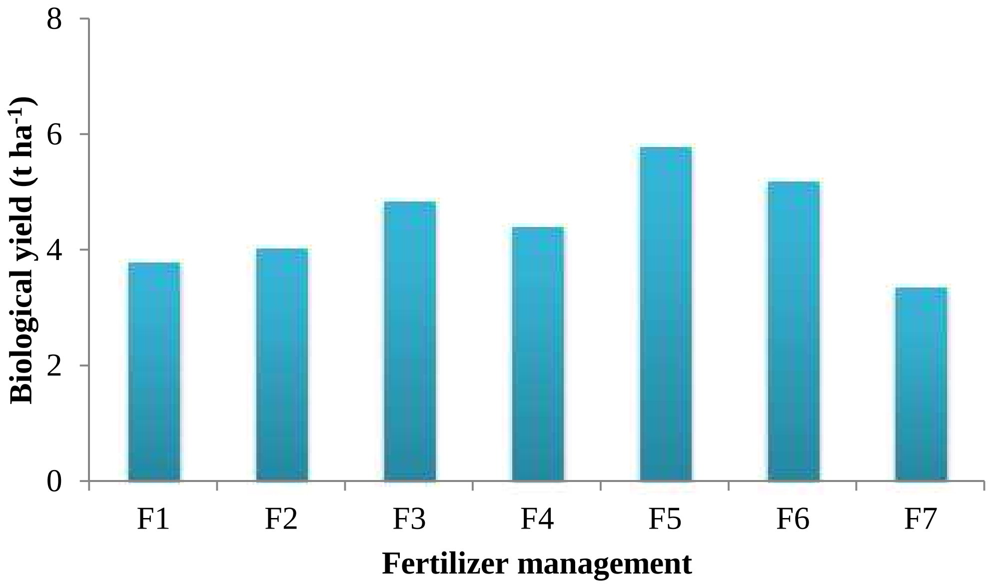


V_1: BARI Gom -29 and V_2: BARI Gom -30

Figure 19. Effect of variety on the biological yield of wheat ($LSD_{0.05}$=NS).

4.10.2 Effect of fertilizer management

Biological yield varied significantly with the different levels of fertilizer (Fig. 20 and Appendix viii). Biological yield was distinctly highest (5.77 t ha^{-1}) at treatment F_5. The lowest biological yield (3.35 t ha^{-1}) was found in F_7 treatment followed by F_1 (3.77 t ha^{-1}). Biological yield indicate the total dry mater produced by the plants during its life cycle. Organic manures are an excellent source for multi nutrient supply to crop plants, although in a variable manner are depending on their type and quality (Ahmad *et al.,* 2007). Channabasanagowda *et al.* (2008) reported that the high biological yield may be due to fact that the organic manures supplies direct available nutrients such as nitrogen to the plant and the organic manures improve the proportion of water stable aggregates of the soil. Jala-Abadi *et al.* (2012) reported that the superiority of mixed organic manure may be attributed to balanced and gradual release of plant nutrients and increased nutrient uptake to support growth consequently increased the biological yield of wheat. The findings of our study were in line with those reported by Subhan *et al.* (2017); Rasul *et al.* (2015); Shaheen *et al.* (2014); Tahir *et al.* (2011); Alvarez *et al.* (2004); Afifi *et al.* (2003) and Badruddin *et al.* (1999) who concluded that the organic matter along with the recommended dose of synthetic fertilizers significantly affected the biological yield of the plant.



F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

Figure 20. Effect of different fertilizers management on the biological yield of wheat ($LSD_{0.05}$=0.47).

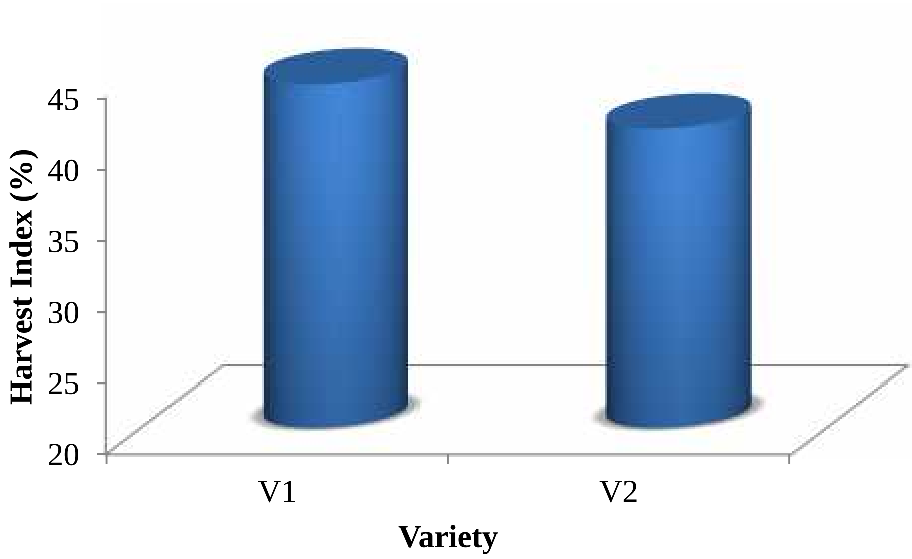
4.10.3 Combined effect of variety and fertilizer management

There observed a significant difference among the combineds of varietal variation and fertilizer management in respect of biological yield (Table 5). The maximum biological yield (6.00 t ha^{-1}) was scored by the interaction of V_1F_5 which was statistically similar with V_2F_5. The minimum biological yield (3.15 t ha^{-1}) was scored by the interaction of V_2F_7 which was statistically similar with V_1F_7 and V_2F_1.

4.11 Harvest Index

4.11.1 Effect of variety

Significant difference was observed for harvest index (%) due to varietal variations (Fig. 21 and Appendix viii). However, BARI Gom-29 (V_1) showed the maximum harvest index (44.06 %) and the minimum harvest index (40.96 %) was found in BARI Gom-30 (V_2).

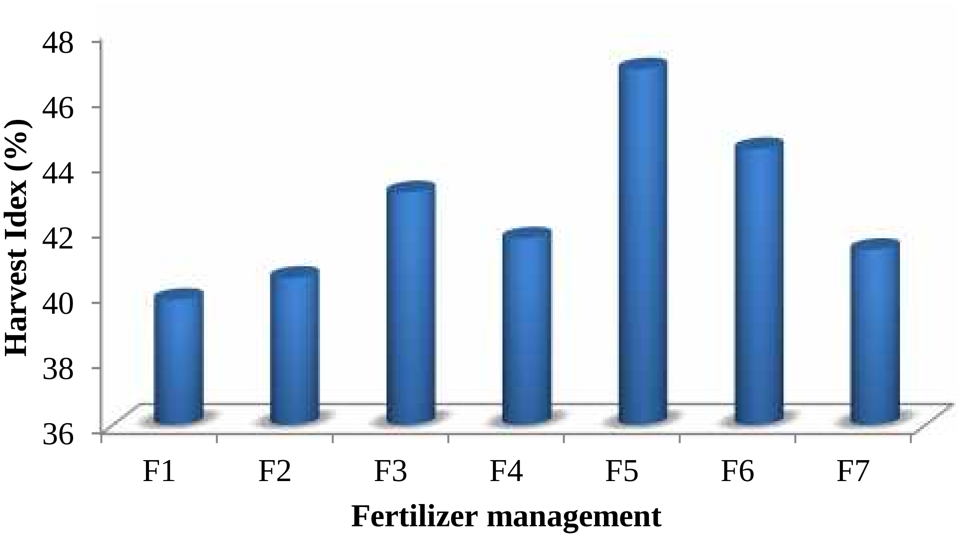


V_1: BARI Gom -29 and V_2: BARI Gom -30

Figure 21. Effect of variety on the Harvest Index of wheat ($LSD_{0.05}$=2.51).

4.11.2 Effect of fertilizer management

Effect of different fertilizer management exerted significant variation on harvest index (Fig. 22 and Appendix viii). The highest harvest index (46.83%) was recorded from treatment F_5 which was statistically similar with F_6 and F_3 and the lowest harvest index (39.81%) was recorded from F_1 which showed similarity with all the fertilizer treatments except F_5 and F_6. Jala-Abadi *et al.* (2012) reported that there was an inverse relationship between application of chemical fertility and harvest index, this may be due to increased rate of photosynthesis and utilization of assimilates obtained by organic fertility systems which turn resulted in heavier grains, there by increased the harvest index. Subhan *et al.* (2017) reported the highest HI by the application of manures along with inorganic fertilizers. Hammad *et al.* (2011) reported higher harvest index by the application of green manures, poultry litter and sewage sludge over the recommended NPK fertilizer. The same result was observed by White and Wilson (2006).



F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

Figure 22. Effect of different fertilizers management on the Harvest Index of wheat ($LSD_{0.05}$=4.33).

4.2.11.3 Combined effect of variety and fertilizer management

Harvest index was significantly influenced by the interaction effect of variety and fertilizer management (Table 5). The maximum harvest index (48.26%) was observed in V_1F_5 interaction which was statistically similar with interactions ofV_2F_5, V_2F_6, V_1F_6, V_1F_2, V_1F_3, V_1F_4 and V_1F_7. The minimum harvest index (37.49%) was found in V_2F_1 which was statistically similar with interactions of V_2F_2, V_2F_7, V_2F_4, V_2F_3, V_1F_1, V_1F_2, V_1F_4 and V_1F_7.

Table 5. Combined effect of variety and different fertilizers management on the yield characteristics of wheat

Treatment combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1F_1	1.62 f-h	2.22 e-g	3.84 hi	42.13b-e
V_1F_2	1.75 e-g	2.36 c-f	4.11 f-i	42.61a-e
V_1F_3	2.16 cd	2.73 a-d	4.89 b-e	44.16 a-d
V_1F_4	1.95 d-f	2.58 b-e	4.53 d-g	42.95 a-e
V_1F_5	2.90 a	3.10 a	6.00 a	48.26 a
V_1F_6	2.35 bc	2.90 ab	5.25 bc	44.86 a-c
V_1F_7	1.54 g-i	2.01fg	3.55ij	43.47 a-e
V_2F_1	1.39 hi	2.32 d-g	3.71 h-j	37.49 e
V_2F_2	1.51 g-i	2.43 c-f	3.93 g-i	38.33 de
V_2F_3	2.00 c-e	2.76 a-c	4.76 c-f	42.00 b-e
V_2F_4	1.72 e-h	2.53b-e	4.25 e-h	40.39 b-e
V_2F_5	2.52 b	3.03 a	5.54ab	45.41 ab
V_2F_6	2.25 b-d	2.86ab	5.11 b-d	43.92 a-d
V_2F_7	1.23 i	1.92 g	3.15 j	39.17 c-e
LSD $_{(0.05)}$	**0.35**	**0.43**	**0.66**	**6.13**
CV (%)	**10.87**	**9.88**	**8.80**	**8.56**

V_1: BARI Gom -29 and V_2: BARI Gom -30;F_1: Recommended fertilizer dose (RF) for wheat (100%), F2: Compost (100%) + RF (75%), F3: Compost (100%) + RF (50%), F4: Compost (100%) + RF (25%), F5: Poultry manure (100%) + RF (75%), F6: Poultry manure (100%) + RF (50%) and F7: Poultry manure (100%) + RF (25%)

CHAPTER 5

SUMMARY AND CONCLUSIONS

The experiment was carried out at the Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2017 to March, 2018 to determine the response of heat tolerant wheat varieties to inorganic and organic fertilizer management. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of two factors. Factor A: Variety (2) *viz.*, V_1= BARI Gom-29 and V_2= BARI Gom-30and factor B: Fertilizer managements (7) *viz.*, F_1= Recommended fertilizer doses (RF) (100 %), F_2= 100 % Compost + 75 % RF, F_3= 100 % Compost + 50 % RF, F_4=100 % Compost + 25 % RF, F_5= 100 % Poultry manure + 75 % RF, F_6=100 % Poultry manure + 50 % RF and F_7= 100 % Poultry manure + 25 % RF. The experiment was laid out following split-plot design with three replications where main plot was for variety and subplot was for fertilizer treatment. There were 14 treatment combinations. The field was fertilized with nitrogen, phosphate, potash and sulphur in the form of urea, triple super phosphate, muriate of potash and gypsum at the rate of 220, 180, 50 and 120 kg ha^{-1}, respectively as per treatment. Inorganic fertilizers compost and poultry manure also provided to the soil as nutrient source at the rate of 10 t $ha^{-1}$and 8 t ha^{-1} respectively. Urea was applied in three equal splits on sowing, 25 and 46 DAS. TSP, MP, gypsum was applied as basal dose. Compost and poultry manure was applied 2 days before sowing.

Results revealed that variety had no significant effect on maximum plant growth, yield and yield contributing charactersistics of wheat except grain yield and harvest index. Numerically the tallest plant (80.27 cm at harvest), maximum leaf area (17.73 cm^2 at harvest), dry matter weight $plant^{-1}$ (15.90 g at harvest), spike length (15.35 cm), spikelets $spike^{-1}$ (13.32), grains $spike^{-1}$ (39.62), 1000 grain weight (38.93 g), shelling percentage (68.01 %), straw yield (2.56 t ha^{-1}) and biological yield (4.60 t ha^{-1}) were recorded from BARI Gom -29 (V_1) and the shortest plant (76.54 cm at harvest), minimum leaf area (16.25 cm^2 at harvest), dry matter weight $plant^{-1}$ (14.45 g at harvest), spike length (14.85 cm), spikelets $spike^{-1}$ (12.72), grains $spike^{-1}$ (38.08), 1000 grain weight (37.32 g), shelling percentage (66.49 %), straw yield (2.55 t ha^{-1}) and biological yield (4.35 t ha^{-1}) was recorded from BARI Gom-30 (V_2). Again the higher grain yield (2.04 t ha^{-1}) and harvest index (44.06 %) was recorded from BARI Gom-29 (V_1) and the lowest grain yield (1.80 t ha^{-1}) and harvest index (40.96 %) was recorded from BARI Gom-30 (V_2).

Different fertilizer management significantly affected growth, yield and yield contributing characters of wheat. The tallest plant (83.26 cm at harvest), maximum leaf area (22.03 cm^2 at harvest), dry matter weight $plant^{-1}$ (20.55 g at harvest), spike length (16.63 cm), spikelets $spike^{-1}$(15.05), grains $spike^{-1}$ (44.55), 1000 grain weight (44.55 g), grain yield (2.71 t ha^{-1}) straw yield (3.06 t ha^{-1}), biological yield (5.77 t ha^{-1}) and harvest index (46.83%) was recorded from poutry manure (100%) + RF (75%) (F_5) treatment and the shortest plant (72.78 cm at harvest), minimum leaf area (12.73 cm^2 at harvest), dry matter weight $plant^{-1}$ (11.36 g at harvest), spike length (13.55 cm), spikelets $spike^{-1}$ (10.07), grains $spike^{-1}$ (34.50), 1000 grain weight (31.80 g), grain yield (1.39 t ha^{-1}), straw yield (1.96 t ha^{-1}) and biological yield (3.35 t ha^{-1}) was recorded from poultry manure (100%) + RF (25%)(F_7) treatment. The lowest harvest index (39.81%) was recorded from recommended fertilizer dose (RF) for wheat (100%) (F_1).

Combined effect of variety and different fertilizer management significantly affected growth, yield and yield contributing characters of wheat. Results revealed that the tallest plant (84.81cm at harvest), maximum leaf area (22.58cm^2 at harvest), dry matter weight $plant^{-1}$ (21.51g at harvest), spike length (16.77 cm), spikelets $spike^{-1}$(15.17), grains $spike^{-1}$ (45.27), 1000 grain weight (45.01 g), grain yield (2.90 t ha^{-1}), straw yield (3.10 t ha^{-1}), biological yield (6.00 t ha^{-1}) and harvest index (48.26 %) was recorded from BARI Gom -29 (V_1) in combination with poultry manure (100%) + RF (75%) (F_5) treatment and the shortest plant (71.08cm at harvest), minimum leaf area (11.85 cm^2 at harvest), dry matter weight $plant^{-1}$ (10.70 g at harvest), spike length (13.17 cm), spikelets $spike^{-1}$ (9.56), grains $spike^{-1}$ (33.37), 1000 grain weight (31.50 g), grain yield (1.23 t ha^{-1}), straw yield (1.92 t ha^{-1}) and biological yield (3.15 t ha^{-1}) was recorded from BARI Gom -30 (V_2) in combination with poultry manure (100%) + RF (25%) (F_7) treatment. The lowest harvest index (37.49%) was recorded from BARI Gom-30 (V_2) in combination with recommended fertilizer dose (RF) for wheat (100%) (F_1).

Reviewing above the results of the present investigation, it might be concluded that poultry manure (100%) + RF (75%) showed the higher yield (2.71 t ha^{-1}) irrespective of varietal difference. 100 % poultry manure + 75% RF had great influence on wheat production and improvement. Wheat variety BARI Gom-29 along with fertilizer management as 100% poultry manure + 75 RF gave the higher yield (2.90 t ha^{-1}).

Recommendation

The present findings may be further verified by conducting such experiment in different growing areas of wheat.

REFERENCESS

Abay, A. and Tesfaye, D. (2012). Combined application of organic and inorganic fertilizers to increase yield of barley and improve soil properties at Fereze, Southern Ethiopia. *Innovative Syst. Design Eng.* **3**: 1-11.

Abbas, M., Shah, J. A., Irfan, M. and Memon, M. Y. (2016). Growth and yield performance of candidate wheat variety 'BWQ-4' under different nitrogen and phosphorus levels. *American-Eurasian J. Agric. Environ. Sci.* **16**: 952-959..

Abedi, T., Alemzadeh, A. and Kazemeini, S. A. (2010). Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. *Australian J. Crop Sci.* **4**(6): 384-389.

Afifi, M. H., Manal, F. M. and Gomaa, A. M. (2003). Efficiency of applying biofertilizers to maize crop under different levels of mineral fertilizers .*Annal. Agric. Sci. Moshtohor*. **41**: 1411-1420.

Ahmad, R., Jilani, G., Arshad, M., Zahir, Z. A. and Khalid, A. (2007). Bio-Conversion of organic wastes for their recycling in agriculture: An overview of perspectives and prospects. *Anim. Microbiol.* **57**(4): 471-479.

Ahmad, R., Naveed, M., Aslam, M., Zahir, Z. A. and Arshad, M. (2008). Economizing the use of nitrogen fertilizer in wheat production through enriched compost.*Renew Agric. Food Syst.* **23**: 244-249.

Ahmad, S., Naz, S. Y. and Raja, M. R. (1998). Effect of farm yard manure, crop residues and mineral fertilizers on wheat yield under rain fed conditions. *Pakistan J. Soil Sci.* **14**: 111-113.

Alvarez, R.H., Steinbach, S., Grigera, S. M., Cartier, E., Obregon, G., Torri, S. and Garcia, R. (2004). The balance sheet method as a conceptual framework for nitrogen fertilization of wheat in pampeanagroecosystem. *Agron. J.* **96**:1050-1057.

Arshad, M., Khalid, A., Mahmood, M. H. and Zahir, Z. A. (2004). Potential of nitrogen and L-tryptophan enriched compost for improving growth and yield of hybrid maize. *Pakistan J. Agric. Sci.* **41**: 16-24.

Badruddin, M., Reynolds, M.P. and Ageeb, O. A. A. (1999). Wheat management in warm environments: Effect of organic and inorganic fertilizers, irrigation frequency and mulching. *Agron. J.* **91**: 975-983.

Bakash, A., Gurmani, A. H., Bhatti, A. U. and Rehman, H. (1999). Effect of balanced application of N, P and K on the yield of wheat. *Sarhad J. Agric.* **15**: 453-457.

Bodruzzaman, B., Meisner, C. A., Sadat, M. A. and Hossain, M. I. (2010). Long term effects of applied organic manures and inorganicfertilizers on yield and soil fertility in a wheat-rice cropping pattern. *World Congr. Soil Sci. Australia.* pp. 142-145.

Böhme, L. and Böhme, F. (2006). Soil microbiological and biochemical properties affected by plant growth and different long-term fertilization. *European J. Soil Biol.* **42**: 1-12.

Bos, C., Juillet, B., Fouillet, H., Turlan, L., Dare, S., Luengo, C., N`tounda, R., Benamouzig, R., Gausseres, N., Tome, D. and Gaudichon, C. (2005). Postprandial metabolic utilization of wheat protein in humans. *American J. Clin.Nutr.* **81**: 87-94.

Brady, N.C. (1996)**.** The Nature and Properties of Soils.10th eds. Prentice Hall of India Pvt. Ltd., New Delhi. pp. 501-502.

Brown, B.D. and Petrie, S. (2006). Irrigated hard winter wheat response to fall, spring, and late season applied nitrogen. *Field Crops Res.* **96**: 260-268.

Channabasanagowda, N.K., Patil, B., Patil, B.N., Awaknavar, J.S., Ninganurn, B.T. and Hunje, R. (2008). Effect of organic manures on growth, seed yield and quality of wheat. *Karnataka J. Agric. Sci.* **21**(3): 366-368.

Chauhan, R.S. (2014). Effect of fertility and weed management on yield, nutrient uptake and economics of wheat. *Ann. Plant Soil Res.* **16**(4): 304-307.

Chekolle, A. W. (2017). Evaluation of synergistic effect organic and inorganic fertilizing system on grain yield of bread wheat at Southern Tigray, Northern Ethiopia.*Adv. Crop Sci. Tech.* **5**: 269.

Cheuk, W., Lo, K. V., Branion, R. M. R. and Fraser, B. (2003). Benefits of sustainable waste management in the vegetable greenhouse industry. *J. Environ. Sci. Health.* **38**: 855-863.

Chopra, R., Sharma, M., Sharma, S.K., Nepalia, V., Jain, H. K. and Singh, A. (2016).Effect of integrated nutrient management on growthand yield of wheat in Haplustepts.*Int. J. Sci. Nat.* **7**(3): 622-628.

Devi, K.N., Singh, M.S., Singh, G. and Athokpam, H. S. (2011). Effect of integrated nutrient management on growth and yield of wheat. *J. Crop Weed*. **7**(2): 23-27.

Dhaka, B. R., Chawla, N. and Pathan, A. R. K. (2012).Integrated nutrient management on performance of wheat. *Ann. Agril. Res.* **33**(4): 214-219.

Faisal, I. M. and Parveen, S. (2004). Food security in the face of climate change, population growth, and resource constraints: implications for Bangladesh. *Environ. Manag*. **34**(4): 487-498.

Farooq, M., Bramley, H., Palta, J. A. and Siddique, K. H. (2011). Heat stress in wheat during reproductive and grain filling phases. *Crit. Rev. Plant Sci.* **30**: 491-507.

Hammad, H.M., Khaliq, A., Ahmad, A., Aslam, M.,Malik, A.H.,Farhad,W. and Laghari,K. Q. (2011). Influence of different organic manures on wheat productivity. *Int. J. Agric. Biol.* **13**(1): 137-140.

Hendrix, P. F., Callaham, M. A. and James, S. W. (1994). Ecology of nearetic earthworms in the Southern USA-I.Charasteristics of diplocardia longa surface casts in grass, hardwood and pinc micro habitats on the lower pied mount of Georgia. *Megadrilogica*. **5**: 45-51.

Hossain, A. and Teixeira da Silva, J. A. (2013). Wheat production in Bangladesh: its future in the light of global warming. *Plants Sci.* **5**: 35-42.

Hossain, A., Teixeira da Silva, J. A. (2012). Phenology, growth and yield of three wheat (*Triticum estivum* L.) varieties as affected by high temperature stress. *Nat. Sci. Biol.* **4**(3): 97-109.

Hossain, I., Epplin, F.M. and Krenzer, E. G. (2003). Planting date influence on dual-purpose winter wheat forage yield, grain yield, and test weight. *Agron. J.***1**: 179-188.

Hossain, S.M.A., Kamal, A. M. A., Islam, M. R. and Mannan, M. A. (2002). Effects of different levels of chemical and organic fertilizers on growth, yield and protein content of wheat. *J. Biol. Sci*. **2**:304-306.

Ibrahim, M., Rashid, M., Nadeem, M. Y. and Mahmood, K. (2000). Integrated use of green manuring, FYM, wheat straw and inorganic nutrients in rice-wheat crop rotation. In: Ahmad N. and Hamid A. (Eds.). Proceedings of Symposium Integrated Plant Nutrition Management; Nov.8-10, 1999. NFDC, Islamabad, Pakistan. pp. 186-195.

IPCC, (2014). Chapter 5, coastal systems and low-lying areas. In: Field, C.B., Barros V.R., Dokken, D.J., Mach K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel E.S., Levy A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Inter- governmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA. pp. 11-32.

Iqtidar, H., Ayyaz, K. M. and Ahmad, K. E. (2006). Bread wheat varieties as influenced by differen tnitrogen levels.*J. Zhejiang Univ. Sci*. **7**: 70-78.

Jala-Abadi, A. L., Siadat, S.A., Bakhsandeh, A. M., Fathi, G. and Saied, K. H. A. (2012). Effect of organic and inorganic fertilizers on yield and yield components in wheat (*T. aestivum* and *T. durum*) genotypes.*Adv. Environ. Biol*. **6**(2): 756-762.

Jamil, M., Qasim, M. and Umar, M. (2004). Impact of organic wastes (sewage sludge) on the yield of wheat (*Triticum aestivum* L.) in a Calcareous soil. *Int. J. Agric. Bio*. **6**(3): 465-467.

Jat, S.L., Nepalia, V., Chaudhary, J. and Singh, D. (2014). Effect of nitrogen and weed management on productivity and quality of durum wheat. *Indian J. Agron.* **59**(2): 281-285.

Jedidi, N., Hassen, A., Van Cleemput, O., M'Hiri, A. (2004). Microbial biomass in a soil amended with different types of organic wastes. *Waste Manag.* **22**: 93-99.

Khan, A. M. and Hussain, I. (2001). Manuring effect on the potential grain yield of wheat in the light of Holy Quran*.* *J. Biol. Sci.* **1**: 62-64.

Khan, M. A., Kazi, T.G., Ansari, R., Mujtaba, S.M., Khanzada, B., Khan, M.A., Shirazi, M. U. and Mumtaz, S. (2007). Effects of un-treated sewage sludge on wheat yield, metal uptake by grain and accumulation in the soil. *Pakistan J. Bot.* **39(**7): 2511-2517.

Khan, M. U., Qasim, M. and Khan, I. U. (2007). Effect of integrated nutrient management on crop yields in rice wheat cropping system. *Sarhad J. Agric*. **23**(4):1019-1026.

Knapp, B. A., Ros, M. and Insam, H. (2010). Do composts affect the soil microbial community? In: Insam, H. Franke Whittle, I. Goberna, M. (Eds). microbes at work: fromwastes to resources. *Springer Berlin Heidelberg*. pp. 93-114.

Kumar, M., Bauddh, K., Kumar, S., Saingar, M., Saingar. P.A. and Singh, R.P. (2013). Increase in growth, productivity and nutritional status of wheat and enrichment in soil fertility applied with organic matrix entrapped urea. *J. Environ. Bio.* **34**: 1-9.

Kumari, R., Kumar, S., Kumar, R., Das, A.,Kumari, R., Choudhary, C. D. and Sharma, R.P. (2017). Effect of long - term integrated nutrient management on crop yield, nutrition and soil fertility under rice-wheat system. *J. App. Nat. Sci.* **9**(3): 1801-1807.

Lamps, S. (2000). Principles of integrated plant nutrition management system. In: Proc. Symp. Integrated plant nutrition management. (Nov. 8-10, 1999), NDFC, Planning and Development Division, Govt. of Pakistan. 2000. pp. 3-7.

Martens, D.A., Johanson, J.B. and Frankenberger, W. T. (1992). Production and persistence of soil enzymes with repeated addition of organic residues. *Soil Sci*. **153**: 53-61.

Muhammad, H., Zaman, A., Khalil, S. K. and Shah, Z. (2014).Effect of beneficial microbes (BM) on the efficiency oforganic and inorganic N fertilizers on wheat crop.*Sarhad J. Agric*. **30**(1): 7-14.

Muneshwar, S., Singh, V. P., Reddy, K. S. and Singh, M. (2001).Effect of integrated use of fertilizer nitrogen and farm manure or green manure on transformation of N, K and S and productivity of rice-wheat system on a Vertisol. *J. Indian Soc. Soil Sci.* **49**: 430-435.

Nawab, K., Amanullah, Shah, P.,Rab, A., Arif, M., Khan, M. A.,Mateen, A. and Munsif, F. (2011).Impact of integrated nutrient management on growth andgrain yield of wheat under irrigated cropping system. *Pakistan J. Bot.* **43**(4): 1943-1947.

Negi, S.C. and Gulshan, M. (2000). Effect of FYM, planting methods and fertilizer levels on rainfed wheat. *Crop Res. Hisar*. **3**(20): 534-536.

Nevens, F. and Reheul, D. (2003). The application of vegetable, fruit and garden waste (VFG) compost in addition to cattle slurry in a silage maize monoculture: nitrogen availability and use. *European J. Agron.* **19**: 189-203.

NFDC, (2008). Annual fertilizer review 2007-08. National Fertilizer Development Centre, Planning and Development Division, Islamabad, Pakistan.

Noreen, F. and Noreen, S. (2014). Effect of different fertilizers on yield of wheat. *Int. J. Sci. Res.* **3**(11): 1596-1599.

Nyangani, E. T. (2010). Effect of combined application of organic manure and chemical fertilizers on soil properties and crop yields. Nigerian J. Sci. Technol. Environ. Edd. **3**: 28-32.

Odlare, M., Pell, M. and Svensson, K. (2008). Changes in soil chemical and microbiological properties during 4 years of application of various organic residues. *Waste Manag. Res.* **28**: 1246-1253.

Parma, D. K. and Sharma, V. (2002). Studies on long term application and manure on yield of maize wheat rotation and soil properties under rainfed conditions in Western-Himalayas. *J. Indian Soc. Soil Sci.* **50**: 311-312.

Peltonen-Sainio, P., Kangas, A., Salo, Y. and Jauhiainen, L. (2007). Grain number dominates grain weight in temperate cereal yield determination: Evidence based on 30 years of multi-location trials. *Field Crops Res.* **100**: 179-188.

Phullan, N. K., Memon, M., Shah, J. A., Memon, M. Y., Sial, T. A., Talpur, N. A. and Khushk,G. M. (2017).effect of organic manure and mineral fertilizers on wheat growth and soil properties. *J. Basic App. Sci.* **13**:559-565.

Pietz, R. I., Peterson, J.R., Hinesly, T.D., Ziegler, E.L., Redborg, K.E. and Lue-Hing, C. (1982). Sewage sludge application to calcareous strip-mine soil: I. Effect on corn yields and N, P, K, Ca, and Mg compositions. *J. Environ. Qual.* **11**(4): 685-689.

Pimentel, D. (1996). Green revolution and chemical hazards. *Sci Total Environ*.**188**: 86-98.

Pong, X.P. and Laty, J. (2000). Organic farming: challenge of timing n availability to crop N requirements. *Soil Sci. Soc.* pp. 247-253.

Prasad, J., Karmakar, S., Kumar, R. and Mishra, B. (2010). Influence of integrated nutrient management on yield and soil properties in maize-wheat cropping system in an alfisol of Jharkhand. *J. Indian Soc. Soil Sci.* **58**(2): 200-204.

Rasul, G. A. M., Ahmedand, S. T. and Ahmed, M. Q. (2015).Influence of different organic fertilizers on growth and yield of wheat.*American-Eurasian J. Agric. Environ. Sci*. **15**(6): 1123-1126.

Rehman, S., Kahlil, S.K., Rehman, A. and Saljoqi, A. U. (2008). Organic and inorganic fertilizers increase wheat yield components and biomass under rainfed condition. *Sarhad J. Agric.* **24**(1): 11- 20.

Reynold, M. P., Hobbs, P. R. and Braun, H. J. (2006). Challenges to international wheat improvement. Summary papers presented at international workshop on increasing wheat yield potential CIMMYT, Obregon, Mexico, 20-24 March, 2006.

Salim, M., Muhammad, S. and Hassan, M. (1986). Studies on synergistic effect of organic manure and mineral fertilizers on wheat yield and NP content of straw. Annual Report.Land Resource Section. NARC, Islamabad. pp. 1980-87.

Sarwar, G., Hussain, N., Schmeisky, H., Muhammad, S., Ibrahim, M. and Safdar, E. (2008). Improvement of soil physical and chemical properties with compost application in rice-wheat cropping system. *Pakistan J. Bot*. **40**: 275-282.

Sarwar, G., Naseem, A. R. and Mujeeb, F. (2009). Efficacy of various organic materials for improving chemical characteristics of normal soil. *Int. J. Agric. App. Sci.* **1**: 97-101.

Sarwar, G.T., Hussain, N., Schmeisky, H., Sarwar, S., Hussain, G.N. and Muhammad, S. (2007). Use of compost an environment friendly technology for enhancing rice-wheat production in Pakistan. *Pakistan J. Bot.* **39**: 1553-1558.

Shah, J. A., Depar, N., Memon, M. Y., Aslam, M. and Sial, N. A. (2013). Integration of organic and mineral nutrient sources enhances wheat production. *Pakistan J. Agric. Agril. Eng. Vet. Sci*. **29**: 106-113.

Shaheen, S., Jamil,M. and Jilani, S. (2014).Effect of Organic Manures and NPK With and without EM-Technology on Plant Growth and Yield of Spinach (*Spinachia olerace*). *Sarhad J. Agric*. **30**(4): 411-418.

Sharma, G.D, Thakur, R., Somraj, Kauraw, D. L. and Kulhare, P.S. (2013). Impact of integrated nutrient management on yield, nutrient uptake, protein content of wheat and soil fertility in a *typichaplustert. Bioscan.* **8**(4): 1159-1164.

Sharma, U. and Subehia, S.K. (2014). Effect of long-term integrated nutrient management on rice-wheat productivity and soil properties in North-Western Himalaya. *J. Indian Soc. Soil Sci.* **62**: 248-254.

Shen, Q. R. andShen, Z. G. (2001).Effects of pig manure and wheat straw on growth of mung bean seedlings grown in aluminium toxicity soil. *Biores. Tech.* **76**: 235-240.

Singh, A., Darvhankar, M. S., Singh, G. and Sonam. (2018). Impact of organic and inorganic amendments on yield and growth of wheat. *Int. J. Curr. Microbiol. App. Sci.* **7**(8): 789-794.

Singh, G., Sharma, G.L.,Golada, S. L. and Choudhary, R. (2012). Effect of integrated nutrient management on quality protein maize (*Zea mays* L.). *Crop Res.* **44**: 26-29.

Slafer, G.A., Satorre, E.H. and Andrade, F.H. (1994). Increase in grain yield in bread wheat from breeding and associated physiological changes. In: Genetic Improvement of Field Crops. Slafer, G.A. and Marcel, D., New York. pp. 1-67.

Soleiman zadeh, H. and Gooshchi, F. (2013). Effects of *Azotobacter* and nitrogen chemical fertilizer on yield and yield components of wheat. *World App. Sci. J.* **21**(8): 1176-1180.

Song, J.Y., Leung, T., Ehler, L. K., Wang, C. and Liu, Z. (2000). Regulation of meristem organization and cell division by TSO1, an Arabidopsis gene with cysteine-rich repeats. *Dev.* **127**(10): 2207-2217.

Subehia, S.K. and Sepehya, S. (2012). Influence of Long-Term Integrated Nitrogen substitution through organics on yield, uptake and available nutrients in rice wheat system in acid soil. *J. Indian Soc. Soil sci.* **60**: 213-217.

Subhan., A., Khan., Q. U., Mansoor, M. and Khan, M. J. (2017). Effect of organic and inorganic fertilizer on the water use efficiency and yield attributes of wheat under heavy textured soil. *Sarhad J. Agric.* **33**(4): 582-590.

Tadesse, T., Dechassa, N., Bayu, W. and Gebeyehu, S. (2013). Effects of farmyard manure and inorganic fertilizer application on soil physic-chemical properties and nutrient balance in rain-fed lowland rice ecosystem. *American J. Plant Sci.* **4**: 309-316.

Tahir, M., Ayub, M., Javeed, H.M.R., Naeem, M., Rehman, H., Waseem, M. and Ali, M. (2011). Effect of different organic matter on growth and yield of wheat. *Pakistan Life Soc. Sci.* **9**(1): 63-66.

Tandon, H.L.S. and Narayan, P. (1990). Fertilizer in Indian agriculture, past, present and future (1950-2000) FDCO, C -110, Greater Kailash I, New Delhi.

Thakur, R., Khandkar, U.R., Nath, D., Patidar, R.K. and Patidar, N. K. (2017). Documentation on Enhancing Nutrient Uptake and Yield of Rice with Application of Sewage Sludge and Different Fertility Levels on Sodic Vertisols. *Int. J. Curr. Microbiol. App. Sci*. **6**(10): 2986-2998.

Thind, H. S., Sharma, S., Singh, V., Sran, H. S., Singh, V. and Singh, Y. (2016).Integration of fertilizer nitrogen, farmyard manure and multi-strain microorganisms for sustainable production of rice-wheat system. *J. Indian Soc. Soil Sci.* **64**: 78-85.

Tisdale, J.R. (2002). Strategies for soil conservation in no tillage and organic farming system. *J. Soil Conserv. Ankeny*. **62**: 144-147.

Turk, M. A. and Tawaha, A. R. M. (2002). Response of winter wheat to applied N with or without ethrel spray under irrigation planted in semi-arid environments. *Asian J. Plant Sci*. **4**: 464-466.

Urkurkar, J.S., Tiwari, A., Chitale, S. and Bajpai, R.K. (2010). Influence of long term use of inorganic and organic manures on soil fertility and sustainable productivity of rice and wheat in Inceptisols. *Indian J.Agril. Sci.* **80**(3): 208-212.

Wells, A., Chan, K. and Cornish, P. (2000). Comparison of conventional and alternative vegetable farming systems on the properties of a yellow earth in New South Wales. *Agric. Ecosyst. Environ*.**80**: 47-60.

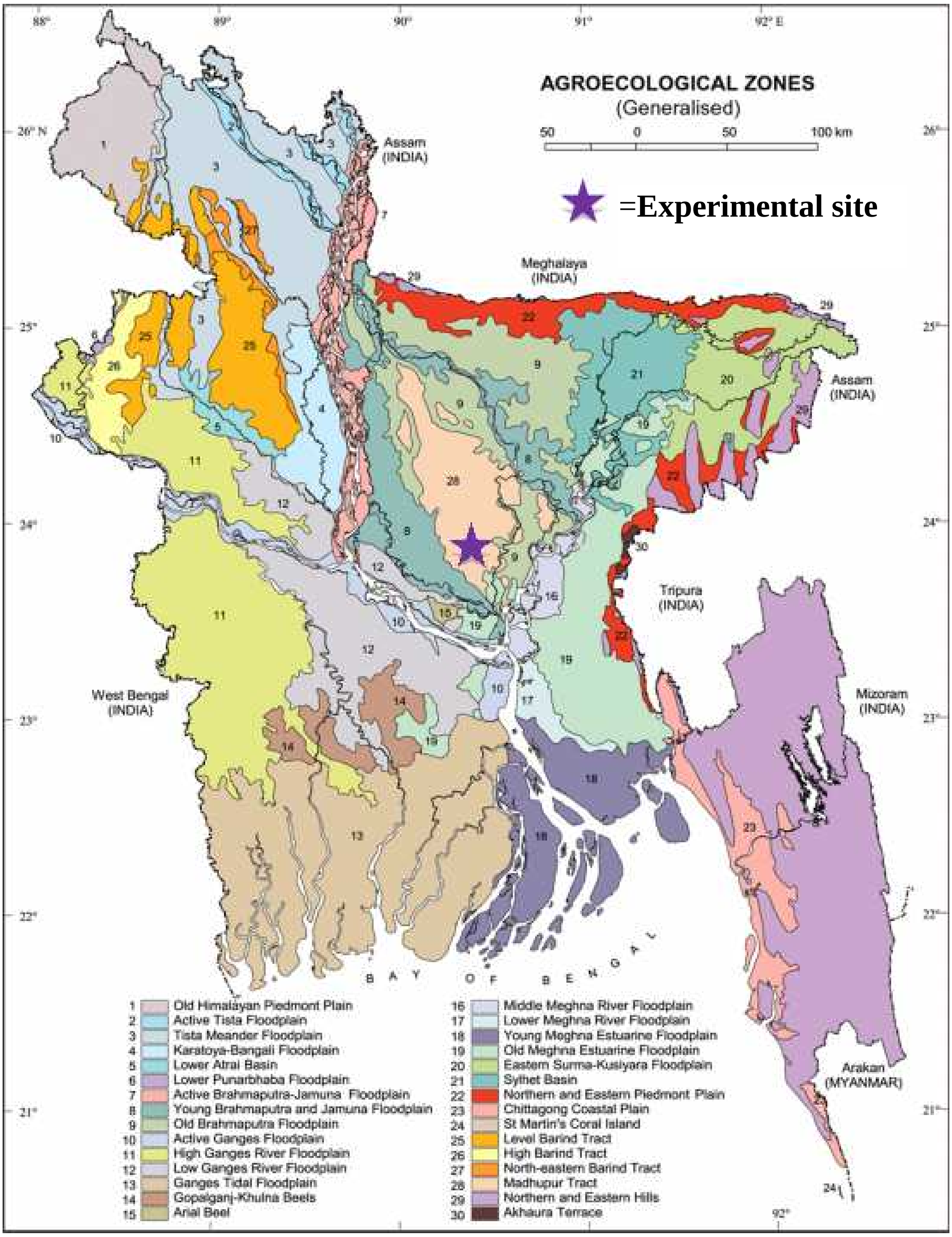
White, E. M. and Wilson, F. E. A. (2006). Responses of grain yield, biomass and harvest index and their rates of genetic progress to nitrogen availability in winter wheat varieties. *Irish J. Agril. Food Res.* **45**: 85-101.

Yadav, A., Kumar, A., Prakash, V., Kumar, N., Tiwari, A., and Yadav, R.K. (2017). Effect of integrated nutrient management on soil properties, yield attributes and yield of wheat. *Int. J. Curr. Microbiol. App. Sci*. **6**(10): 225-228.

Zia, M. S., Baig, M. B. and Tahir, M. B. (1998). Soil environment issues and their impact on agricultural productivity of high potential areas of Pakistan. *Sci. Vision.* **4**: 56-61.

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

Appendix III. Monthly meteorological information during the period from November, 2017 to April, 2018

Year	Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2017	November	28.89	11.88	56.58	51
	December	25.13	8.98	69.85	1.21
2018	January	23.97	9.28	71.09	Trace
	February	25.12	13.89	76.99	Trace
	March	29.21	14.09	75.89	1.01
	April	30.85	16.96	65.98	63.00

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Analysis of variance of the data on plant height of wheat as influenced by combined effect of different varieties and fertilizer management

Source of variation	df	Mean square of plant height at different days after sowing (DAS)				
		20	40	60	80	At harvest
Replication	2	0.368	109.726	24.682	31.785	47.970
Variety(A)	1	9.109^{NS}	44.537^{NS}	53.901^{NS}	11.109^{NS}	146.347^{NS}
Error	2	3.123	19.087	29.302	88.034	92.296
Fertilizer management (B)	6	2.888^{NS}	52.258*	177.833*	42.738^{NS}	86.779*
Variety (A) X Fertilizer management (B)	6	1.458^{NS}	0.963*	1.386*	2.680^{NS}	6.824*
Error	24	6.198	19.501	49.085	43.582	48.146

*Significant at 5% level of significance

^{NS} Non significant

Appendix V. Analysis of variance of the data on above ground dry weight plant^{-1} of wheat as influenced by combined effect of different varieties and fertilizer management

Source of variation	df	Mean square of above ground dry weight plant^{-1} at different days after sowing (DAS)				
		20	40	60	80	At harvest
Replication	2	0.008	0.366	1.596	3.006	2.216
Variety(A)	1	0.041^{NS}	0.418^{NS}	0.010^{NS}	3.550^{NS}	22.207^{NS}
Error	2	0.020	1.384	0.033	1.021	0.343
Fertilizer management (B)	6	0.109*	6.116*	8.063*	19.678*	61.542*

Variety (A) X Fertilizer management (B)	6	0.069*	0.041*	0.665*	0.351*	1.106*
Error	24	0.012	0.196	0.865	1.389	3.037

*Significant at 5% level of significance

NS Non significant

Appendix VI. Analysis of variance of the data on leaf area of wheat as influenced by combined effect of different varieties and fertilizer management effect of different varieties and fertilizer management

Source of variation	df	Mean square of leaf area at different days after sowing (DAS)				
		20	**40**	**60**	**80**	**At harvest**
Replication	2	8.305	25.186	0.856	6.720	0.023
Variety(A)	1	8.264 NS	13.829 NS	23.475 NS	14.620 NS	22.763 NS
Error	2	5.466	25.134	10.088	1.275	1.474
Fertilizer management (B)	6	31.403*	194.662*	84.166*	53.594*	68.385*
Variety (A) X Fertilizer management (B)	6	23.970*	11.121*	1.213*	0.897*	0.469*
Error	24	8.093	14.943	7.581	4.341	4.339

*Significant at 5% level of significance

NS Non significant

Appendix VII. Analysis of variance of the data on yield contributing characters of wheat as influenced by combined effect of different varieties and fertilizer management

Source of variation	df	Mean square of			
		Spike length	**Spikelets spike^{-1}**	**Grains spike^{-1}**	**1000 grain weight**
Replication	2	0.226	1.832	9.942	7.680
Variety(A)	1	2.670 NS	3.792 NS	24.840 NS	27.265 NS
Error	2	2.873	0.306	10.937	8.610
Fertilizer management (B)	6	7.814*	19.637*	75.806*	133.529*
Variety (A) X Fertilizer management (B)	6	0.063*	0.153*	0.425*	1.043*
Error	24	1.897	1.644	15.089	11.837

*Significant at 5% level of significance

NS Non significant

Appendix VIII. Analysis of variance of the data on yield characters of wheat as influenced by combined effect of different varieties and fertilizer management

Source of variation	df	Mean square of			
		Grain yield	Straw yield	Biological yield	Harvest index
Replication	2	0.050	0.003	0.136	13.811
Variety(A)	1	0.593*	0.000^{NS}	0.627^{NS}	101.277*
Error	2	0.009	0.057	0.104	3.578
Fertilizer management (B)	6	1.340*	0.861*	4.276*	36.125*
Variety (A) X Fertilizer management (B)	6	0.012*	0.009*	0.028*	2.775*
Error	24	0.044	0.064	0.155	13.231

*Significant at 5% level of significance

^{NS} Non significant