EFFECT OF VERMICOMPOST AND NPK FERTILIZERS ON THE GROWTH AND YIELD OF WHEAT (*Triticum aestivum* L.)

A THESIS

BY

SAHASIKA APSAREE

Student No. 1605351

Semester: July-December, 2017

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MASTER OF SCIENCE (M.S.)

IN

SOIL SCIENCE

DEPARTMENT OF SOIL SCIENCE

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DECEMBER, 2017

DEDICATED

TO MY

BELOVED PARENTS

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The Author

ABSTRACT

An experiment was conducted in the Soil Science research field of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period of November 2016 to March 2017 in order to investigate the effects of vermicompost and NPK fertilizers on the yield and yield contributing characteristics of wheat. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five treatments and four replications. Fertilizer treatments were T_1 =Control (without fertilizer) T_2= Recommended doses of N P K fertilizer, T_3= Recommended dose of vermicompost, T_4= $\frac{1}{2}$ recommended doses N P K fertilizers + $\frac{1}{3}$ recommended doses of vermicompost, T_5= $\frac{1}{3}$ recommended doses of N P K fertilizers + $\frac{2}{3}$ recommended doses of vermicompost. The experimental results revealed that plant height, spike length, number of tillers hill^{-1}, number of spikelet spike^{-1}, straw weight and grain weight were significantly dependent on combined effect of vermicompost and NPK fertilizers. The highest plant height (88.50 cm) was observed in T_2 treatment which was statistically similar to the T_4 (87.35 cm) and T_5 (86.30 cm) treatment and the lowest was found in the control. The maximum number of tillers (7.85) was produced in the treatment T_4 and minimum number (3.9) was found in the control. The highest number of grain (58.90) was found in the treatment T_4 and the lowest number of grain spike^{-1} (25.25) was observed in the control treatment. Grain and straw yield of wheat plants were significantly influenced with the application of NPK fertilizer along with vermicompost. It was found that the application of $\frac{1}{2}$ NPK fertilizer along with $\frac{1}{3}$ vermicompost produced the highest grain (3.38 t ha^{-1}) and straw (4.73 t ha^{-1}) yields. The control treatment produced the lowest grain (1.2 t ha^{-1}) and straw (2.13 t ha^{-1}) yields. The findings of the experiment revealed that the performance of the treatment T_4 ($\frac{1}{2}$ NPK fertilizer + $\frac{1}{3}$ vermicompost) was the best among the other treatments in respects of tillers hill^{-1}, number of grain spike^{-1}, spike length, grain yield and straw yield of wheat. Therefore, the overall results indicate that the application of ½ NPK fertilizers along with $\frac{1}{3}$ vermicompost can be more efficient and economic for wheat production.

CONTENTS

CONTENTS (CONTD.)

CONTENTS (CONTD.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AEZ	=	Agro-ecological zone
@	=	At the rate of
Agric.	=	Agriculture
Agril.	=	Agricultural
ANOVA	=	Analysis of Variance
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
BINA	=	Bangladesh Institute of Nuclear Agriculture
C.V.	=	Co-efficient of Variation
cm	=	Centimeter
DIPA	=	Directorate of Information and Publications of Agriculture
DMRT	=	Duncan’s Multiple Range Test
e.g.	=	For example
et al.	=	And authors
FAO	=	Food and Agriculture Organization
Fig	=	Figure
g	=	Gram
Kg	=	Kilogram
LSD	=	Least Significant Difference
M.S	=	Master of Science
NS	=	Non significant
RCBD	=	Randomized Complete Block Design
S.I.	=	Serial
UNDP	=	United Nations Development Programme
USDA	=	United States Department of Agriculture
VC	=	Vermicompost
Viz.	=	Namely

CHAPTER I

INTRODUCTION

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INTRODUCTION

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

In Bangladesh, the climatic and edaphic conditions are suitable for wheat cultivation except some coastal districts. Wheat is more widely cultivated than any other crop after rice. In Bangladesh, the total area under wheat crop has been estimated 10,99,158 acres (4,44,805 ha) compared to 10,79,411 acres (4,36,814 ha) of the last year (BBS, 2016). With rapidly increasing population, the demand of food is increasing. So there is great need to increase the productivity of wheat. Average yield rate of wheat has been estimated 32.86 maunds per acre (3.031MT ha^{-1}) which is 1.78% lower than that of last year (BBS, 2016).

Fertilizers are usually applied to soil for increasing or maintaining crop yields to meet the increasing demand of food (Haynes ,1998).With the improvement in the agricultural technologies and release of high yielding dwarf varieties of cereals, demand for fertilizers has increased manifolds and nitrogenous fertilizers in particular. N can limit crop yield and its judicious use is essential for sustainable crop production. It represents 28% of the cost of inputs. Mengel *et al.* (2006) reported that optimum N rate should be explored as too high rates may cause severe N losses and low rates depress the yield. Indiscriminate use of chemical fertilizers to get maximum yields leads to the depletion of inherent soil fertility

(Gupta *et al,*1998). Most soils are far from being ideally fertile and should therefore, be improved not only by adding nutrients, but also by other soil amendments, like organic matter for maintaining the activity of "Soil life". Since, agriculture becomes more intensive and chemical dependent, therefore soil toxicities and nutrient imbalance threaten sustainable production. So, we have to think about the cheap and easily available alternate source of nutrients. Thus, demand for fertilizers can be lowered by supplementing the nutrients through organic manures. Judicious use of farmyard manure (FYM) with chemical fertilizers improves soil physical, chemical and biological properties and improves the crop productivity (Sharma *et al*. 2007). Application of organic manures may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers (Sawrup, 2010). Among different sources of organic manures, vermicompost is most important source and used since long as a nutrients supplement to crop production. Vermicompost contains highly enriched nutrients, especially nitrogen, which gradually makes them available to plants (Atiyeh *et al*, 2001).

The use of vermicompost organic fertilizer with chemical fertilizer could be reduced the consumption of chemical fertilizers. Andhikari and Mishra (2002) showed in that the combined application of vermicompost organic manure with urea chemical fertilizer can reduce by 50% the amount of urea in the field conditions. Also the yield was 12% higher than treatments that only received fertilizer. Behera *et al.* (2007) showed that the use of 2.5 ton ha^{-1} vermicompost manure fertilizer with 50% fertilizer recommendations for wheat, grain yield was 4.08 ton ha^{-1}. While in the treatments of only the fertilizer, the yield was 4.87 t ha^{-1}, respectively. There were significant differences between these two treatments that probably due was to low consumption of vermicompost. Gopinath *et al.* (2008) concluded that the treatments that received manure vermicompost were significantly increased in grain yield compared to control. While the maximum grain yield was obtained in treatment that had received only fertilizer. This indicated that the application of vermicompost organic fertilizer alone does not provide plant nutrient requirement. Therefore, the present study was undertaken with the following objectives:

1. To study the influence of vermicompost and N P K fertilizers on yield of wheat.

2. To get higher yield with minimum use of chemical fertilizers.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The use of vermicompost has long been recognized as an effective means of increasing crop yields through improved soil physical, chemical and biological properties. Since synthetic mineral fertilizers are disallowed in organic crop production, there has been a renewed interest in recycling wastes into valuable organic fertilizer through vermicomposting and its subsequent utilization in organic crop production. Depending on the origin, Vermicomposts differ in chemical composition (Handreck, 1986); however, vermicomposts of the same waste origin have reproducible characteristics (Tomati *et al.* 1990). Vermicompost is a nutritive 'organic fertilizer' rich in NKP (nitrogen (N) 2-3%, potassium (K) 1.85-2.25% and phosphorus (P) 1.55-2.25%), micronutrients, beneficial soil microbes like 'nitrogen-fixing bacteria' and 'mycorrhizal fungi' and plant growth hormones. (Kale and Bano, 1986) reports as high as 7.37% N and 19.58% P as P_2O_5 in worms' vermicast. They are scientifically proving as 'miracle plant growth promoters' much superior to conventional composts and chemical fertilizers (Sinha and Bharambe, 2007; Sinha *et al.* 2009a).

Suhane (2007) asserts that vermicompost is at least 4 times more nutritive than cattle dung compost. In Argentina, farmers who use vermicompost consider it to be seven times richer than conventional composts in nutrients and growth promoting values (Munroe, 2007).

Similarly, Atiyeh *et al.* (2000) found that the conventional compost was higher in 'ammonium', while the vermicompost tended to be higher in 'nitrates', which is the more available form of nitrogen to promote better growth and yield. They also found that vermicompost had higher N availability than the conventional compost on a weight basis and the supply of several other plant nutrients e.g. P, K, sulfur (S) and magnesium (Mg), were significantly increased by adding vermicompost as compared to conventional compost to soil. Then vermicompost retains nutrients for long time and while the conventional compost fails to deliver the required amount of macro- and micronutrients including the vital NKP to plants in shorter time, the vermicompost does (Subler *et al*. 1998). Vermicomposts have the same reported benefits as conventional composts such as a source of organic matter, increased moisture-holding characteristics, and enhanced nutrient uptake and plant hormone like activity (Tomati *et al*. 1988; Galli *et al*. 1990; Suthar, 2010).

Sudhakar (2000) revealed that vermicompost of various agricultural wastes significantly increased the yield attributes and yield of rice compared with recommended dose of NPK application. Similarly, Edwards (1998) reported that vermicompost was an excellent source of nutrients to rice. A study conducted by Kale and Bono (1986) found that the vegetative growth like shoot weight, root weight, shoot and root length of rice were influenced by the application of worm casts in a better way than chemical fertilizer.

Gopinath *et al*. (2008) evaluated the impact of vermicompost application on wheat yield during a two-year transition to organic production. Vermicompost application resulted in significantly lower crop growth and ears per plant than did the mineral fertilizer treatment. Both treatments, however, produced similar number of grains per ear and 1000-grain weight. The grain yield reduction for Vermicompost treatment ranged from 28-41% compared with mineral fertilizer treatment. Lower grain yields in the plots amended with vermicompost may have been associated with the less readily available nutrients in the initial years of transition as nutrient cycling processes in first-year organic systems change from inorganic N fertilization to organic amendments (Harris *et al*. 1994; Reider *et al*. 2000) and slower release rates of organic materials (Liebhardt *et al*. 1989; MacRae *et al*. 1993). After one year of transition, protein content of wheat grain was significantly higher for the mineral fertilizer treatment than for the vermicompost treatment. After the second year of transition, however, both mineral fertilizer and vermicompost treatments had similar effect on protein content of wheat grain. The latter treatment, however, registered significantly higher P and K contents in wheat grain than with mineral fertilizer treatment. Similarly, Ramesh *et al*. (2005) also reported that the grain and straw yields of wheat were reduced by 12.6 and 10.2%, respectively due to vermicompost application compared with mineral fertilizer treatment. However, the harvest index and protein content of grain were not affected by source of plant nutrition.

On the contrary, several studies on cereal crops done in India at University of Rajasthan (1997-2001) and at Bihar Agriculture University (2007-2009) and in Australia at Griffith University (2007-2009), have revealed that application of vermicompost in potted and field crops displayed excellent growth performances in terms of height of plants, color and texture of leaves, appearance of fruiting structures etc. as compared to chemical fertilizers and the conventional compost. There is also less incidences of pest and disease attack, and reduced demand of water for irrigation (Sinha *et al*. 2009b).

Suhane *et al*. (2008) examined that exclusive application of vermicompost at 2.5 t ha^{-1} in farm wheat crops supported yield better than chemical fertilizers. The wheat grain yield was 4.0 t ha^{-1} from vermicompost amended plots compared with the mineral fertilizer treatment (3.4 t ha^{-1}). The wheat yield was about 3.3 t ha^{-1} from the plots amended with cattle dung compost at 10.0 t ha^{-1} (4 times of vermicompost). Application of vermicompost had other agronomic benefits. It significantly reduced the demand for irrigation by nearly 30-40%. The results also indicated better availability of essential micronutrients and use of essential microbes in vermicompost applied soils. Most remarkable observation was significantly less incidence of pests and disease attacks in vermicompost applied plots.

Nainawatt (1997) also found that the application of vermicompost resulted in higher dry matter production and increased grain yield in comparison to organic manure and chemical fertilizer.

Sinha and Bharmbe (2007), Chauhan (2009) and Valani (2009) also reported higher growth of potted corn and wheat crops on vermicompost as compared to conventional composts and chemical fertilizers.

Singh *et al.* (2007) studied that the rice grain yield (4.0 t ha^{-1}) obtained under combined application of four organic amendments (blue green algae, Azolla, vermicompost and farmyard manure) was at par with the yield recorded under recommended dose of chemical fertilizer application. However, application of vermicompost alone gave about 39% lower grain yield of rice than mineral fertilizer treatment.

Some studies indicate that smaller amounts of vermicompost in fact promote better growth performances of crops. Subler *et al.* (1998) reported that in all growth trials the best growth responses were exhibited when the vermicompost constituted a relatively small proportion (10-20%) of the total volume of the container medium.

Valani (2009) observed that 200 g of vermicompost applied in pot soils performed better growth in wheat crops than those with 400 and 500 g of vermicompost.

Singh *et al.* (2009) found that the application rate of vermicompost may be reduced after 3-4 years of successive application. They found that both application rates (2.0 and 2.5 t ha^{-1}) of vermicompost produced similar wheat yields during the fourth year of field experiment.

On contrary, Ramesh *et al.* (2008) reported that vermicompost application gave significantly lower grain yield and protein content of maize compared with chemical fertilizers treatment.

Soil organic carbon was higher in vermicompost-amended plots than in those under mineral fertilizer treatment (Gopinath *et al.* 2008). Plots that had mineral fertilizer applied, however, had higher levels of available N and P than did those under vermicompost. However, plots under both mineral fertilizer and vermicompost treatments had similar K levels. Gopinath *et al.* (2009) also reported similar results.

On the contrary, Bhaskaran *et al*. (2009) reported that the treatments with vermicompost application registered superior values for all the soil chemical properties like pH, cation exchange capacity, organic carbon, and C/N ratio.

Sinha (2009) interviewed some farmers in India using vermicompost for agriculture. Most of them asserted to have switched over to organic farming by vermicompost completely eliminating the use of chemical fertilizers in the last 3-4 years with very encouraging results, benefiting both, their economy (reduced cost of inputs and significantly high outputs from good crop production, sale of vermicompost and worms) and the environment (reduced use of chemical pesticides, improved physical, chemical and biological properties of farm soil). Some of them asserted to have harvested three (3) different crops in a year (reaping 2-3 times more harvest) due to their rapid growth and maturity and reduced harvest cycle. Several villages have become 'BIO-VILLAGE' using only vermicompst in crop production and completely giving up chemical agriculture.

Suthar (2008) reported that vermicompost may be potential sources of nutrients for field crops if applied in suitable ratios with synthetic fertilizers. The earlier workers have reported a positive effect of vermicompost application on growth and productivity of cereals and legumes (Suthar, 2006). Phosphate solubilizing microorganisms (PSM) involve different character of micro-organisms which turn insoluble organic compound of phosphorus to soluble form (Raju and Reddy, 1999; Sundara *et al*. 2002).

Galal *et al*. (2001) reported that biofertilization technology minimizes production costs and at the same time avoid the environmental hazards. The demand of wheat in India by 2020 has been projected to be between 105 to 109 m tonnes as against 72 m tonnes production of present day. Wheat is an important cereal crop and requires a good supply of nutrients especially nitrogen for its growth (Mandal *et al*. 1992) and yield (Krylov and Pavlov, 1989).

Hamdi *et al*. (2002) explained that the highest wheat grain yield obtained by combined use of 80 tons of urban solid waste compost per hectare and fertilizers.

Jamali *et al*. (2004) reported that the use of sewage sludge improves wheat grain and spike yield. Besides, the maximum grain and spike yield was obtained by the application of 40 tons of sludge per hectare.

Chaoui *et al*. (2003) found that wheat yield and shoot biomass were less in fertilizer treatment than in compost treatment. In addition, some symptoms of salinity were observed in these two treatments but not in vermicompost treatment. It was also noted that K and P availability and uptake by wheat were higher in vermicompost and compost treatments than in the control treatment and chemical fertilizers. In fact, the application of vermicompost is preferred over compost due to non-moving nitrogen, salinity effects, levels of pathogens, as well as the risks of environmental pollutions in the long term use of these fertilizers (Eskandari and Astarayei, 2007). The study aimed to explore the effect of the long-term use of different organic materials of urban waste compost and vermicompost on the concentration of nitrogen, phosphorus, and potassium and also on some growing properties on wheat at booting stage.

In addition, Kazemeini *et al.* (2008) conducted a study on the use of various organic materials on rainfed wheat growth and yield and observed that the maximum wheat yield including the highest plant height is obtained by applying 10% vermicompost.

Kochaki *et al*. (2008) said that today economic and environmental losses due to excessive use of chemical fertilizers have been recognised in agriculture. Therefore must be considered a good alternative for these types of fertilizers one solution could be the use of vermicompost organic manure.

Atiyeh (2001) concluded that vermicompost contains highly enriched nutrients, especially nitrogen, which gradually makes them available to plants.

Gaind and Nain (2007) showed that application of vermicompost to 3 ton ha^{-1} phosphorus content in the wheat 121.11 µg per gram of dry matter. Whereas its content obtained 116.86 µg per gram of dry matter in the control treatment.

Andhikari and Mishra (2002) showed that the use of vermicompost organic fertilizer with chemical fertilizer could be reduced consumption of chemical fertilizer. They examined that the combined application of vermicompost organic manure with urea chemical fertilizer can reduce by 50 percent the amount of urea in the field conditions. Also the yield was 12% higher than treatments that only received fertilizer.

Behera *et al*. (2007) examined that the use of 2.5 t ha^{-1} vermicompost manure fertilizer with 50 percent fertilizer recommendations for wheat, grain yield in 4.08 t ha^{-1}. While the in treatments of only the fertilizer was added to yield 4.87 t ha^{-1}, respectively. There were significant differences between these two treatments that probably due was to low consumption of vermicompost.

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Devi *et al*. (2011) was conducted a field experiment on clay loam soil to assess the effect of integrated nutrient management practices on growth and yield of wheat (*Triticum aestivum* L.). The experiment consists of eleven treatments viz., T_1-100% recommended dose of fertilizer (RDF) i.e. 120: 26.4: 50 N: P: K kg ha^{-1}, T_2- 100% RDF+Vermicompost @ 1 t ha^{-1}, T_3-100% RDF + Vermicompost @ 1 t ha^{-1} + Phosphate Solubilizing bacteria (PSB), T_4- 100% RDF + PSB, T_5-75% RDF + vermicompost @ 1 t ha^{-1}, T_6- 75% RDF + vermicompost @ 1 t ha^{-1} + PSB, T_7- 50% RDF+ Vermicompost @ 1 t ha^{-1},T/1""50% RDF+Vermicompost @ 1 t ha^{-1} + PSB, T< r Vermicompost @ 1t ha^{-1} + PSB, Tio-Vermicompost @ 1 t ha^{-1} and Tu-absolute control. The results revealed that the application of 100% recommended dose of fertilizers (RDF) i.e. 120:26:4:50 N:P:K kg ha^{-1}+ vermicompost @ 1 t ha^{-1} + phosphate solubilizing bacteria (PSB) and 75% RDF + vermicompost @ 1 t ha^{-1}+ PSB produced higher yield attributes and grain yield than the other treatments. The higher yield led to higher NPK uptake by wheat.

Further, the available NPK content of soil also increased in above treatment over control. The highest benefit: cost ratio (2. 73) was obtained from the application of 75% RDF + vermicompost @1 t ha^{-1} + PSB.

Dekhane *et al.* (2017) set an experiment to study the effect of different organic products on wheat variety Amber during Rabi 2015-16 in Randomized Block Design at ASPEE Agricultural Research and Development Foundation, Tansa Farm, Nare, Taluka Wada, Dist Palghar, Maharashtra. The study comprised sixteen different treatments of organic products viz. FYM @ 10 t ha^{-1}, Vermicompost @ 5 t ha^{-1}, FYM @ 5 t ha^{-1}+ vermicompost @ 2.5 t ha^{-1}, Noval fertilizer @ 1%, Vermiwash @ 2%, Panchgavya @ 2%, FYM @ 10 t ha^{-1} + Noval fertilizer @ 1%, FYM @ 10 t ha^{-1}+ Vermiwash @ 2%, FYM @10 t ha^{-1} + Panchgavya @ 2%, Vermicompost @ 5 t ha^{-1}+ Noval fertilizer @ 1%, Vermicompost @ 5 t ha^{-1}+Vermiwash @ 2%, Vermicompost @5 t ha^{-1}+ Panchgavya @ 2%, FYM @ 10 t ha^{-1} +Vermicompost @ 2.5 t ha^{-1} +Noval fertilizer@ 1%, FYM @ 10 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} + Vermiwash @ 2%, FYM @ 10 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} + Panchgavya @ 2% and 100% RDF @ 120:60:40 NPK kg ha^{-1}. Wheat was sown at row spacing 20 cm X 5 cm on flat beds. The results showed that the treatments of FYM @ 10 t ha^{-1} along with vermicompost @ 2.5 t ha^{-1} and spray with Noval fertilizer @ 1% at 30 and 60 days after sowing recorded highest seed yield of 2100 kg ha^{-1} followed by FYM @ 10 t ha^{-1} with vermicompost @ 2.5 t ha^{-1} and Panchgavya @ 2% (2049 kg ha^{-1}). The same treatment proved its superiority in increasing all yield attributing factors along with grain yield of wheat indicating the most effective organic treatment for wheat under North Konkan Coastal Zone of Maharashtra.

Kumar *et al.* (2017) conducted a field experiment to study the effect of integrated nutrient management modules on wheat with variety NW-1014, at student's instructional farm, Narendra Deva university of Agriculture and Technology Narendra Nagar Faizabad in during Rabi season of 2014-15 and 2015-16. The experiment consists of fourteen treatments viz. T_1: RDF (150:60:40 kg ha^{-1} NPK), T_2: RDF + 20 kg $ZnSO_4$ ha^{-1}, T_3 : RDF + 5 t FYM ha^{-1}, T_4 : RDF + 2.5 t VC ha^{-1},

T_5: RDF + 5 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_6: RDF +2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}, T_7: 75% RDF, T_8: 75 % RDF +20kg $ZnSO_4$ ha^{-1}, T_9: 75 % RDF + 10 t FYM ha^{-1}, T_{10}: 75 % RDF + 5 t VC ha^{-1}, T_{11}: 75 % RDF +10 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_{12}: 75 % RDF + 5 t VC +20 kg $ZnSO_4$ ha^{-1}, T_{13}: 125 % RDF, T_{14}: 125 % RDF + 20 kg $ZnSO_4$ ha^{-1}. The results revealed that the application of 100% recommended dose of fertilizer (RDF) i.e.150:60:40 N:P:K kg ha^{-1}+ vermicompost @ 2.5 t ha^{-1}+ $ZnSO_4$ @ 20 kg ha^{-1} produced highest grain yield (50.80 q ha^{-1}), straw yield (71.07 q ha^{-1}), protein content (11.71 %), net return (68538.48 ha^{-1}) and B:C ratio (2.71%).

A greenhouse pot experiment was conducted by Hadis *et al.* (2017) to determine effects of vermicompost, inorganic fertilizers and their combinations on nutrient uptake, yield and yield components of wheat. A factorial combination four levels (0, 2, 4 and 6 t ha^{-1}) of vermicompost and four levels (0, 33.33, 66.67 and 100% ha^{-1}) of the recommended NPK fertilizers was laid out in RCB design with three replications. Bread wheat variety, Kekaba was used as a test crop. Main effect results indicated that both vermicompost and NPK fertilizers significantly increased yield components, yield and nutrient uptake of wheat. Vermicompost applied at 2, 4 and 6 t ha^{-1} increased grains yield of wheat by 11, 17 and 26% over control respectively whereas 33.33, 66.67 and 100% NPK fertilizers increased the grain yield by 10, 24 and 30%, respectively over the control. Vermicompost applied at 6 t ha^{-1} resulted in the highest nutrient uptake and it increased grain uptake of N, P and K by 51, 110 and 89% over control respectively whereas among fertilizer rates, the highest uptake was produced by 100% NPK treatment and it increased the N, P and K uptake in the grain by were 79, 100 and 96% over control respectively. Combined application of vermicompost and NPK fertilizers has also significantly increased nutrient uptake, yield and yield components of wheat. It is concluded that wheat responds significantly to application of vermicompost and NPK fertilizers suggesting that nutrient contents of experimental soil is low for optimum production of wheat. Field verification and demonstration of results are recommended.

Dastmozd *et al*. (2015) conducted an experiment on the topic named after combined application of vermicompost and NPK fertilizers on Wheat production in Marvdasht, Iran. The results showed that application of 1800 kg ha^{-1} vermicompost with 80 kg ha^{-1} NPK fertilizers improved significantly grain yield and wheat morphological and physiological characteristics such as thousand grain weight, plant height, number of spikes per hectare, number of grains per spike, and harvest index. The results of the experiments also indicated that vermicompost fertilizer can improve soil productivity and soil quality. The application of such fertilizers also enhances water retention in the soil.

Sheoran *et al*. (2015) showed that application of Nitrogen (N) at 150 mg kg^{-1} soil significantly increased the grain and straw yield of wheat from 2.70 to 8.24 and 4.97 to 9.44 g pot^{-1}, respectively over control. Addition of vermicompost at 1% alone increased the grain and straw yield of wheat from 2.70 to 4.81 and 4.97 to 6.60 g pot^{-1} respectively over control and in combination with N at 150 mg kg^{-1} soil further improved from 4.81 to 10.73 and 6.60 to 11.89 g pot^{-1}, respectively. Use of *Clodinafop propargyl* at 60 and 90 g a.i. ha^{-1} significantly decreased the grain yield of wheat from 4.74 to 3.60 and to 2.93 g pot^{-1}, respectively and that of straw yield from 7.16 to 5.87 and to 4.31 g pot^{-1}, respectively over control (without *C. propargyl*). The grain and straw yield of wheat also decreased significantly with the application of *C. propargyl* (60 to 90 g ha^{-1}) in presence of both vermicompost and N. Nitrogen (N), Phosphorus (P) and Potassium (K) uptake by grain and straw increased significantly with the increase in each successive dose of N upto the level of 200 mg kg^{-1} soil and highest uptake of NPK by grain were 149.56, 57.59 and 40.87 mg $pot^{-1,}$ respectively and that of by straw the highest value recorded were 54.72, 18.24 and 143.78 mg pot^{-1}, respectively. Application of vermicompost at 1% significantly increased NPK uptake in both grain and straw over control. Use of *C. propargyl* at 60 and 90 g ha^{-1} significantly decreased the NPK uptake by grain and straw.

Yousefi and Mehdi (2014) conducted a field experiment on the effect of vermicompost and urea chemical fertilizers on yield and yield components of wheat (*Triticum aestivum*). They have included the treatments with three levels of vermicompost organic fertilizer (5, 10 and 15 t ha^{-1}) and five levels of urea chemical fertilizer (0, 25, 50, 75 and 100% the recommended rate based on soil test). At time physiological maturity, grain spike grain, number of grains per spikelet, fertile spikelet per spike, grain weight, grain yield, spike length, plant height, biological yield and harvest index were measured. Also nutrients nitrogen, phosphorus and potassium were measured in plants. The results indicated that the combined application of urea fertilizer, organic fertilizer vermicompost had significant effects on grain yield and grain weight. The maximum yield of the treatments 100% of the recommended urea with 10 and 15 t ha^{-1} vermicompost and treatments recommended by 75% urea plus 15 t ha^{-1} vermicompost, respectively, which is statistically there was no significant difference between the three groups (4977.3, 4890.7 and 4953.0 kg ha^{-1}, respectively). Thus it can be concluded that the application of vermicompost organic fertilizer, can be reduced chemical fertilizer urea up to 25 %.

Ahmadinejad *et al*. (2013) studied the impact of organic and N fertilizers on water use efficiency and yield and growth properties of wheat (Alvand Cultivar) in the form of randomized complete block design with the aim of optimizing the use of organic and chemical fertilizers for sustainable agriculture. The results showed that application of 150 and 300 kg ha^{-1} urea significantly improved grain yield, biological yield, plant height, stem diameter, number of leaves per plant, leaf chlorophyll index, and water use efficiency as compared to the control group. However, the use of such fertilizers had no significant effect on the number of grains per spike, thousand grain weight, number of spikelets per spike, and harvest index.

Mousavi *et al*. (2012) evaluated the effect of application of N fertilizer on the morphological characteristics and wheat production under rainfed conditions in split plots through randomized complete block design with N base fertilizer at three levels (without base fertilizer, striped application, and full application). Data from growth rate, leaf weight, total biomass and leaf chlorophyll, all confirmed a positive effect of nitrogen base fertilizer on wheat growth indices.

Ibrahim *et al*. (2010) examined wheat response to various levels of compost and manure and found that the application of manure and compost significantly increases plant height, number of tillers per plant, spike height, and grain and straw yield compared to the control group. The authors attributed this increases to the improvement of physical and chemical properties of the soil and higher availability of nutrients due to the use of organic fertilizers.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter describes the materials and methods that were used in this study. For convenience, the chapter has been divided into some sections: site and soil, climate, crop, treatment, land preparation, experimental design, fertilizer application, seed sowing, intercultural operations, harvesting, data collection and soil analysis.

3.1 Site and Soil

The experiment was conducted in the farm of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from November 2016 to March 2017.The experimental field is located at 25˚41́ N latitude and 88˚39́ E longitude at a height of 37.5m above the mean sea level. It belongs to the AEZ 1, "Old Himalayan Piedmont Plain". The soil is Ranisankail sandy loam, a member of hyperthermic Aeric Haplaquept under the order Inceptisol having only few horizons, developed under aquic moisture regime and variable temperature conditions. General characteristics of the soil are presented in Table 1.

3.2 Climate

The experiment field is situated under Sub-tropical climate; usually the rainfall is heavy during khrarif season (April to September) and scanty in rabi season (October to March). In rabi season temperature is generally low and there is plenty of sunshine. The temperature tends to increase from February as the season proceeds towards kharif. Rainfall was almost scanty during the period from November 2016 to April 2017.

Table 1 Morphological, physical and chemical characteristics of the soil

A. Morphological characteristics

AEZ	Old Himalayan Piedmont Plain (AEZ 1)
General Soil Type	Non-calcareous Brown Floodplain Soil
Parent Material	Piedmont alluvium
Drainage	Moderately well drainded
Topography	High land
Flood level	Above flood level

B. Physical characteristics

Sand (%)	: 60
Silt (%)	: 27
Clay (%)	: 13
Textural class	: Sandy loam

C. Chemical characteristics

pH (soil: water = 1:2.5)	5.20
Organic matter (%)	1.19
Total N (%)	0.05
Available P (ppm)	35.0
Exchangeable K (meq 100 g^{-1} soil)	0.21
Available S (ppm)	12.36

3.3 Crop

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

3.4 Treatments

There were five different rates of fertilizer application in wheat as follows

T_1: Control (without fertilizer)

T_2: Recommended doses of N P K fertilizers

T_3: Recommended dose of Vermicompost

T_4: $^1/_2$ recommended doses of N P K fertilizers + $^1/_3$ recommended doses of vermicompost

T_5: $^1/_3$ recommended doses of N P K fertilizers + $^2/_3$ recommended doses of vermicompost

3.5 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD). All the treatments were replicated four times. There were altogether 20 (5×4) unit plots.

3.6 Layout of the experimental plots

Total number of plots	: 20
Individual plot size = 2 m x 2.5 m	: 5m^2
Space between block to block	: 1m
Space between plot to plot	: 0.5m
Treatment	: 5
Replication	: 4

The layout of the experimental field has shown in Fig. 1.

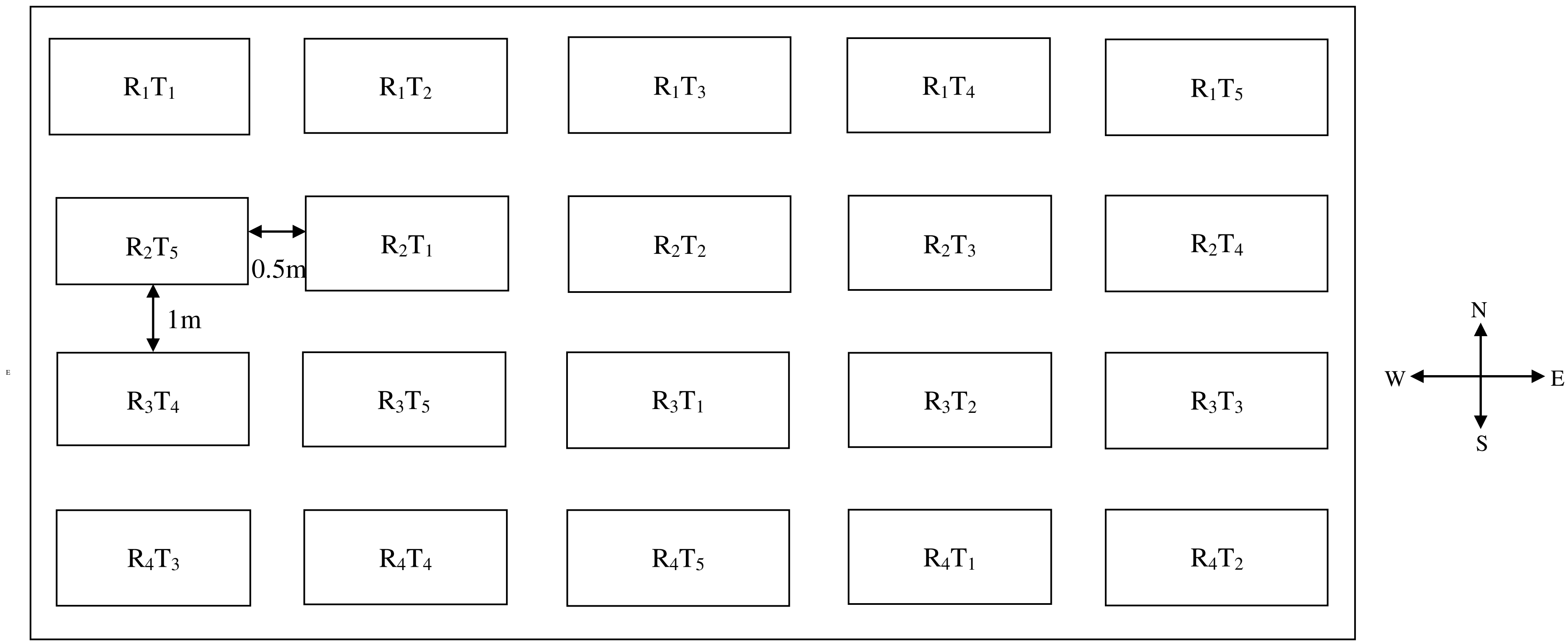

Fig. 1: Layout of the experiment

3.7 Land preparation

Land preparation was started 10 days before seed sowing. The land was first opened by a tractor and the land was prepared thoroughly by ploughing and cross ploughing with a power tiller. Every ploughing was followed by laddering to obtain a good tilth. Weeds and stubbles were collected and removed from the field. Field lay out was done on 18^{th} November 2016, according to the design adopted. Finally, individual plots were prepared with spade on 20^{th} November 2016.

3.8 Fertilizer application

2.5 t ha^{-1} vermicompost and 150, 140, 100 kg ha^{-1} of Urea, TSP and MOP were applied respectively. Vermicompost was applied 10 days before sowing whereas two thirds of urea and the full amount of the other synthetic fertilizers were applied as a basal amount during final land preparation. Another one third of urea was applied at 2^{nd} irrigation.

3.9 Source of vermicompost

Vermicompost was collected from a village of Birganj, Dinajpur who is a contract vermicompost producer of Bangladesh Rural Advancement Committee (BRAC). The nutrient content of vermicompost as per BRAC test result is given below:

Table 2: Nutrient content of applied vermicompost

Nutrients	**Amount present**
Total nitrogen	2.10 %
Total phosphorus	1.4 %
Total potassium	0.60 %
Calcium	60 m.e./100 g soil
Sulfur	450 ppm

3.10 Sowing of seeds

Seeds of BARI Gom 26 were collected from Wheat Research Center, Dinajpur and seeds were sterilized with 0.4% vitavax. Seeds were sown in the plots 1st December, 2016. Sowing was made continuously in lines and seeds were covered by soil. The seed rate was 120 kg ha^{-1} and the spacing between lines was 20 cm.

3.11 Intercultural operation

Intercultural operations were done to ensure normal growth of the crop. The following intercultural operations were followed:

3.11.1 Irrigation

Three irrigation were applied, the first irrigation after 12 days of sowing, second irrigation after 22 days of sowing at crown root initiation stage and the third after 58 days of sowing at heading stage.

3.11.2 Weeding

Weeding was done twice during the whole growing period, the one after 20 days of sowing and the other after 46 days.

3.11.3 Insect and pest control

During maturation, three plots were slightly infested by field rat and the pest was controlled instantly by using mechanical control measures and application of zinc phosphide.

3.12 Harvesting

The crop was harvested at maturity after about four months of sowing (March 30, 2017). For data collection, 5 plants from each plot were sampled randomly. The crop was uprooted with the roots. Threshing, cleaning and drying of grain were done separately for every plot. Then plot wise weights of grain and straw were recorded.

3.13 Data collection

Data were collected on the following yield and yield components.

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

i. Plant height

ii. Spike length

iii. Number of tillers hill^{-1}

iv. Number of spikelet spike^{-1}

v. Number of grain spike^{-1}

vi. 1000 grain weight

vii. Grain yield

viii. Straw yield

3.13.1 Plant height

The plant height was measured from the ground level to top of the spike. For each plot, height of 5 plants were measured and averaged.

3.13.2 Spike length

Length of spike of 5 plants per plot was recorded and averaged.

3.13.3 Number of tillers hill^{-1}

Number of tillers hill^{-1}was counted from the selected 5 hills of each plot and total number of tillers hill^{-1} was recorded.

3.13.4 Spikelet spike^{-1}

Data on the number of spikelet spike^{-1} was counted. Five spike bearing plants were randomly selected and the average data were collected from inner rows of each plot except harvest area during the time of harvesting.

3.13.5 Grain spike^{-1}

The total number of filled grains from randomly selected five spikes were counted and averaged, which gave the number of total filled grains spike^{-1}.

3.13.6 1000 grain weight

1000 grain weight was recorded from each plot after harvest.

3.13.7 Grain yield

Grains from each unit of plot were dried and then weighed carefully. The results were expressed as t ha^{-1} on 14% moisture basis.

3.13.8 Straw yield

Like grain yield, dry weight of straw for individual plot was recorded and expressed as t ha^{-1}.

3.13.9 Biological yield

Grain yield together with straw yield are regarded as biological yield and expressed as t ha^{-1}.

3.14 Protein content (%) in grain

Wheat grain was sent to laboratory for protein analysis and % protein content of grain was detected and noted down.

3.15 Analysis of soil sample

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

i. Soil pH
ii. Organic matter content

iii. Total N content
iv. Available P
v. Exchangeable K
vi. Available S

3.15.1 Soil pH

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

3.15.2 Organic matter content

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

3.15.3 Total N content

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

3.15.4 Available P

Available phosphorus (P) was extracted from the soil with 0.5 M sodium bicarbonate solution, pH 8.5 (Olsen *et al.* 1954). Phosphorus in the extract was then determined by developing blue color with $SnCl_2$ reduction of phosphomolybdate complex and the color intensity was measured colorimetrically at 660 nm wave lengths (Page *et al.* 1982).

3.15.5 Exchangeable K

Exchangeable potassium (K) was determined from the ammonium acetate extraction method using flame photometer as described by Page *et al.* (1982).

3.15.6 Available S

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

3.16 Statistical analysis

The data were analyzed statistically (Gomez and Gomez, 1984) by F-test to examine whether the treatment effects were significant. The mean comparisons of the treatments were evaluated by DMRT (Duncan’s Multiple Range Test). The analysis of variance (ANOVA) for different parameters was done by a computer package programme “MSTATC”.

CHAPTER IV
RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to determine the effect of vermicompost and NPK fertilizer on yield and yield contributing characters of wheat. The result has been discussed and possible explanations have been given under the following headings.

Yield and yield contributing characters

Yield contributing characters such as plant height (cm), number of tillers hill^{-1}, spike length (cm), number of spikelet spike^{-1}, number of grain spike^{-1}, 1000 grain weight (gm), straw yield (t ha^{-1}), grain yield (t ha^{-1}) and biological yield (t ha^{-1}) were recorded in every trial.

4.1 Effect of vermicompost and NPK fertilizers on the growth of wheat

4.1.1 Plant height

The plant height of wheat was significantly influenced by the different treatments (Table 3). The application of vermicompost and NPK fertilizer significantly increased the plant height of wheat compared to that found in control. The highest plant height (88.50 cm) was recorded in the treatment T_2 which was closely followed by the treatment T_4 and T_5. The lowest plant height (73.90 cm) was recorded in control treatment (T_1). The treatment may be ranked in order of $T_2>T_4>T_5>T_3>T_1$.

4.1.2 Number of tillers hill^{-1}

A significant change in number of tillers was noticed with different treatments (Table 3). The number of tiller hill^{-1} enhanced with the application of vermicompost and NPK fertilizer. The maximum tiller hill^{-1} (7.85) was found in the treatment T_4 which was statistically similar with those found in the treatments T_2, T_3 and T_5. The lowest tiller number (3.9) was observed in the control treatment (T_1).The treatment may be ranked in order of $T_4>T_2>T_5>T_3>T_1$.

4.1.3 Spike length

The application of vermicompost and NPK fertilizer affects the length of spike significantly (Table 3). The spike length varied from 6.38 to 8.98 cm. The highest spike length was 8.98 cm recorded in the treatment T_2 which was statistically similar to the combination of ½ NPK fertilizer and ⅓ vermicompost on the treatment T_4 (8.83 cm).On the other hand, the lowest spike length 6.38 cm obtained in the treatment T_1 (control).The treatment may be ranked in order of $T_2>T_4>T_5>T_3>T_1$.

4.1.4 Number of spikelet spike^{-1}

The maximum number of spikelet spike^{-1} significantly increased with the application of vermicompost and NPK fertilizer. The effect of different levels of vermicompost and NPK fertilizer was significant as observed on number of spikelet spike^{-1}. The maximum number of spikelet spike^{-1} (18.17) was observed at T_4 treatment. The value of T_5 treatment (16.92) was comparable to the value of the treatment T_4 (18.17). The lowest number of spikelet spike^{-1} (8.87) was found in T_1 treatment (Table 3). The treatment may be ranked in order of $T_4>T_5>T_2>T_3>T_1$.

4.1.5 Number of grains spike^{-1}

The effect of different levels of vermicompost and NPK fertilizer was significant as observed on number of grain spike^{-1}. The maximum number of grain spike^{-1} (58.9) was noticed at T_4 treatment. The lowest number of grain spike^{-1} (25.25) was found in T_1 treatment (Table 3). The treatment may be ranked in order of $T_4>T_5>T_2>T_3>T_1$.

4.1.6 1000 grain weight

Thousand grain weight ranged from 47.50 to 49.10 g. The highest thousand grain weight was found in the treatment T_4 (49.10 g) and the lowest was found in the control treatment T_1 (47.50 g). But the values of thousand grain weight for all the treatments were statistically similar. That means there was no significant difference among the treatments in thousand grain weight. Ahmadinejad *et al.* (2013) also stated the same.

Table 3 Effect of vermicompost and NPK fertilizer on the growth parameter of wheat

Treatments	Plant height (cm)	No. of tillers hill^{-1}	Spike length (cm)	Spikelet spike^{-1}	No. of grain spike^{-1}	1000 grain weight (g)
T_1	73.90 b	3.90 b	7.03 bc	8.87 d	25.25 e	47.50
T_2	88.50 a	7.45 a	8.98 a	16.30 b	45.90 c	48.70
T_3	74.40 b	5.9 ab	6.38 c	12.58 c	35.05 d	48.42
T_4	87.35 a	7.85 a	8.83 a	18.17 a	58.90 a	49.10
T_5	86.30 a	6.5 a	8.6 ab	16.92 ab	53.30 b	48.55
LSD	4.91	2.03	1.65	1.63	5.33	7.04
CV%	3.88	20.88	13.45	7.27	7.93	9.43

In the column, figures having similar letter (s) do not differ significantly at 5% level of probability.

Where,

T_1: Control (without fertilizer)

T_2: Recommended doses of N P K fertilizers

T_3: Recommended dose of vermicompost

T_4: $\frac{1}{2}$ recommended doses of N P K fertilizers + $\frac{1}{3}$ recommended doses of vermicompost

T_5: $\frac{1}{3}$ recommended doses of N P K fertilizers + $\frac{2}{3}$ recommended doses of vermicompost

4.1.7 Straw yield

Straw yields also varied significantly by different treatments under study (Table 4). The straw yield ranged from 2.13 to 4.73 t ha^{-1} (Table 4). The highest straw yield of 4.73 t ha^{-1} was obtained in T_4 treatment and the lowest straw yield of 2.13 t ha^{-1} was obtained in the control treatment (T_1) which was statistically comparable to the another treatment of T_3 with the value of 2.95 t ha^{-1}.Treatments T_2 and T_5 were statistically similar. The treatments may be ranked in the order of $T_4>T_2>T_5>T_3>T_1$. Kumar *et al.* (2017) found that application of NPK fertilizer along with 2.5 t ha^{-1} vermicompost produced highest straw yield, grain yield and protein content.

4.1.8 Grain yield

The grain yield of wheat was significantly influenced by the different treatments. Application of vermicompost along with different levels of NPK fertilizer showed the variation for grain yield (Table 4). The highest yield (3.38 t ha^{-1}) was recorded in the treatment T_4 which was closely followed by T_2 treatment (3.1 t ha^{-1}) and the lowest grain yield (1.2 t ha^{-1}) was recorded in the treatment T_1 (control) (Table 4). The treatments may be ranked in the order of $T_4>T_2>T_5>T_3>T_1$. Hadis *et al.* (2017) stated that combined application of vermicompost and NPK fertilizers significantly increased nutrient uptake, yield and yield components of wheat. Similar results were reported by other researchers (Kumar *et al.* 2017; Sheoran *et al.* 2015).

4.1.9 Biological yield

Application of vermicompost along with different amount of NPK fertilizer showed the variation for biological yield (table 4). The highest yield (8.10 t ha^{-1}) was recorded in the treatment T_4. Second highest biological yield was found in T_2 treatment (7.10 t ha^{-1}) which was closely followed by T_5 treatment (6.68 t ha^{-1}). T_2 and T_5 are statistically identical in case of biological yield. Lowest grain yield (3.28 t ha^{-1}) was recorded in the control treatment (Table 4). The treatments may be ranked in the order of $T_4>T_2>T_5>T_3>T_1$.

Table 4. Effect of vermicompost and NPK fertilizer on the grain yield, straw yield and biological yield of BARI Gom 26

Treatments	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)
T_1	1.2 d	2.13 d	3.28 d
T_2	3.1 ab	4.0 b	7.10 b
T_3	1.55 c	2.95 c	4.50 c
T_4	3.38 a	4.73 a	8.10 a
T_5	2.84 b	3.84 b	6.67 b
LSD	0.297	0.381	0.56
CV %	7.96	6.97	6.08

In the column, figures having similar letter (s) do not differ significantly at 5% level of probability.

where,

T_1: Control (without fertilizer)

T_2: Recommended doses of N P K fertilizers

T_3: Recommended dose of vermicompost

T_4: ½ recommended doses of N P K fertilizers + ⅓ recommended doses of vermicompost

T_5: ⅓ recommended doses of N P K fertilizers + ⅔ recommended doses of vermicompost

4. 2 Protein content (%) in wheat

The percent protein content in wheat grain at different treatments do not show significant differences at all. The highest protein content was observed in all the treatments of T_4, T_5 and T_2 treatment (10.68%) followed by T_3 treatment (10.63%). The lowest protein content was found in control treatment T_1 (10.15%). Percentage of protein content of wheat for all the treatments were statistically similar (Table 5).

Table 5: Protein Content (%) in wheat grain

Treatments	% protein content in wheat grain
T_1	10.15
T_2	10.68
T_3	10.63
T_4	10.68
T_5	10.68
LSD	0.26
%CV	1.62

Where,

T_1: Control (without fertilizer)

T_2: Recommended doses of N P K fertilizers

T_3: Recommended dose of vermicompost

T_4: ½ recommended doses of N P K fertilizers + ⅓ recommended doses of vermicompost

T_5: ⅓ recommended doses of N P K fertilizers + ⅔ recommended doses of vermicompost

4.3 Chemical Properties of the soil collected after harvesting

4.3.1 Soil pH

The post-harvest soil was slightly acidic. The value of post-harvest soil pH ranged from 5.16 to 5.32. In T_2 treatment, soil pH value (5.16) was slightly decreased due to the application of NPK fertilizer. Whereas T_3 (5.32) showed the maximum pH compared to others. Bhaskaran *et al.* (2009) reported that the treatments with vermicompost registered superior values for all the soil chemical properties like pH, cation exchange capacity, organic carbon and C/N ratio.

4.3.2 Organic matter content in soil

The effect of vermicompost and NPK fertilizer was statistically non significant on organic matter (OM) content in the soil. The application of NPK fertilizer along with vermicompost affects on increasing the organic matter status in the soil though. Organic matter content of the post-harvest soil was higher in T_3 (1.32%) compared to the initial soil. The lowest content in the treatment T_2 (1.17%).

4.3.3 Total N in soil

Soil N of the post-harvest soil was higher than the initial soil. The highest soil N was found both inT_3 and T_5 treatments and the lowest soil was found in the T_1 treatment (Table 6). The value of the % N showed that, there were no significant differences among the different treatments of the post-harvest soil.

Table 6. Effect of vermicompost and NPK fertilizer on the soil pH, organic matter and total N content of the post-harvest soil

Treatments	Soil pH	Organic matter content (%)	Total N (%)
T_1	5.19	1.18	0.05
T_2	5.16	1.17	0.06
T_3	5.32	1.32	0.07
T_4	5.26	1.26	0.06
T_5	5.29	1.29	0.07
LSD	0.47	0.29	0.06
CV%	4.79	12.51	22.23

Here,

T_1: Control (without fertilizer)

T_2: Recommended doses of N P K fertilizers

T_3: Recommended dose of vermicompost

T_4: $\frac{1}{2}$ recommended doses of N P K fertilizers + $\frac{1}{3}$ recommended doses of vermicompost

T_5: $\frac{1}{3}$ recommended doses of N P K fertilizers + $\frac{2}{3}$ recommended doses of vermicompost

4.3.4 Available P in soil

The p content of the post-harvest soil varied significantly by the different treatments (Table 7). The maximum P content (44.32 ppm) was found in the treatment T_4 which was followed by T_5 (43.45 ppm) and mostly comparable to T_2 (42.15 ppm) treatments. The lowest P content (34 ppm) was observed in the control treatment (T_1).

4.3.5 Exchangeable K in soil

The exchangeable K content of the post-harvest soil was influenced by the different treatments. The values of the exchangeable K were travelling around from 0.21 to 0.29 meq $100g^{-1}$ soil (Table 7). The utmost value of 0.29 meq 100 g^{-1} soil was observed in the treatment T_4 which was statistically identical to T_2 treatment. The lowest value of 0.21 meq 100 g^{-1} soil was found in the T_1 treatment.

4.3.6 Available S in soil

The post-harvest soil which content available S was different for the different treatments. The available sulphur content in the studied soil ranged from 12.36 to 16.24 ppm (Table 7). The highest S content (16.24 ppm) was found in the treatment T_5. The lowest S (12.36 ppm) was observed in the treatment T_1. All of these were statistically similar.

Table 7. Effect of vermicompost and NPK fertilizer on the available P, S and exchangeable K content of the post-harvest soil

Treatments	Available P (ppm)	Exchangeable K (meq 100 g^{-1} soil)	Available S (ppm)
T_1	34.00 b	0.21 b	12.36
T_2	42.15ab	0.28 a	14.46
T_3	38.20ab	0.27 ab	14.33
T_4	44.32 a	0.29 a	13.33
T_5	43.45 a	0.26 ab	16.24
LSD	8.80	0.059	4.08
CV%	11.56	12.10	15.33

In the column, figures having similar letter (s) do not differ significantly at 5% level of probability.

Where,

T_1: Control (without fertilizer)

T_2: Recommended doses of N P K fertilizers

T_3: Recommended dose of vermicompost

T_4: ½ recommended doses of N P K fertilizers + ⅓ recommended doses of vermicompost

T_5: ⅓ recommended doses of N P K fertilizers + ⅔ recommended doses of vermicompost

4.4 Correlation results of research

4.4.1 Grain yield and number of tillers hill^{-1}

The relationship between the number of tillers hill^{-1} and the grain yield shown positive and significant correlation those were presented in the fig. (2). The correlation co-efficient value of the number of tillers hill^{-1} and the grain yield were (r=0.868). The line of regression X (tillers hill^{-1}) on Y (Grain yield) having Y=0.591x-1.322 was shown in the fig. (2). The positive slope indicates that the grain yield and tillers hill^{-1} was directly correlated each other thus, due to the increase of tillers hill^{-1} also increased the grain yield.

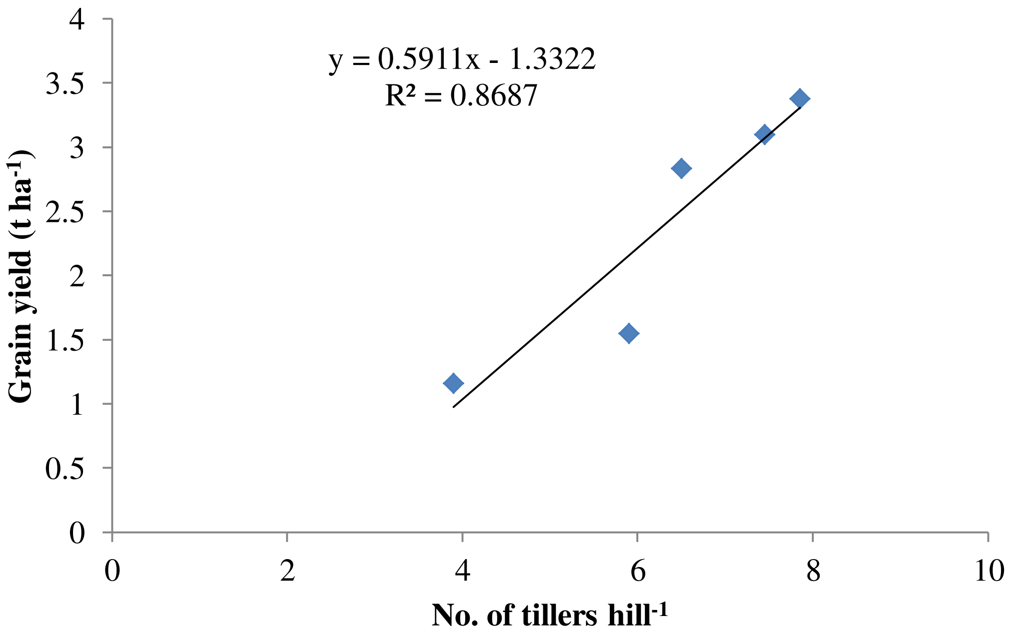

Fig: 2 Relationship between no. of tillers hill^{-1} and grain yield

4.4.2 Grain yield and spike length

The relationship between the grain yield and spike length (cm) were shown in the fig. (3). The correlation co-efficient value of (r=0.867) and the line of regression X (spike length) on Y (Grain yield) having equation of Y= 0.778x-3.794 was shown in fig. (3). The positive slope indicates that the grain yield depends on the spike length, hence the higher spike length economically increase the grain yield of wheat.

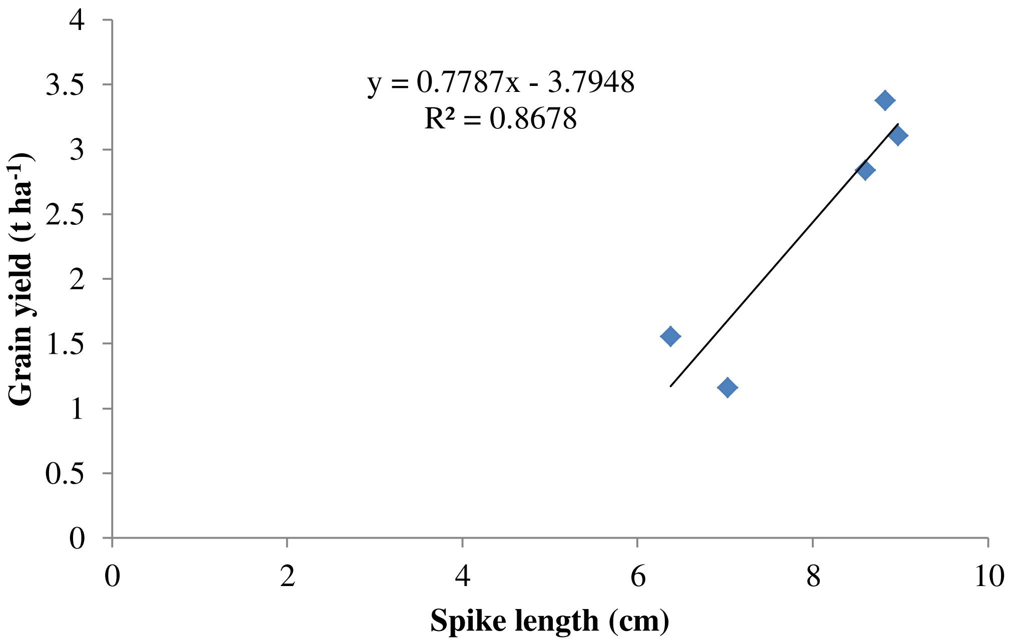

Fig: 3 Relationship between spike length and grain yield

4.4.3 Grain yield and spikelet spike^{-1}

The relationship between the grain yield and spikelet spike^{-1} shown positive and significant correlation those were presented in the fig. (4). The correlation co-efficient value of grain yield and spikelet spike^{-1} were (r=0.933). The line of regression X (spikelet spike^{-1}) on Y (Grain yield) having equation of Y= 0.250x-1.242 was shown in fig. (4). The positive slope indicates that the grain yield and spikelet spike^{-1} was directly correlated each other thus, due to the increase of spikelet spike^{-1} also increased the grain yield.

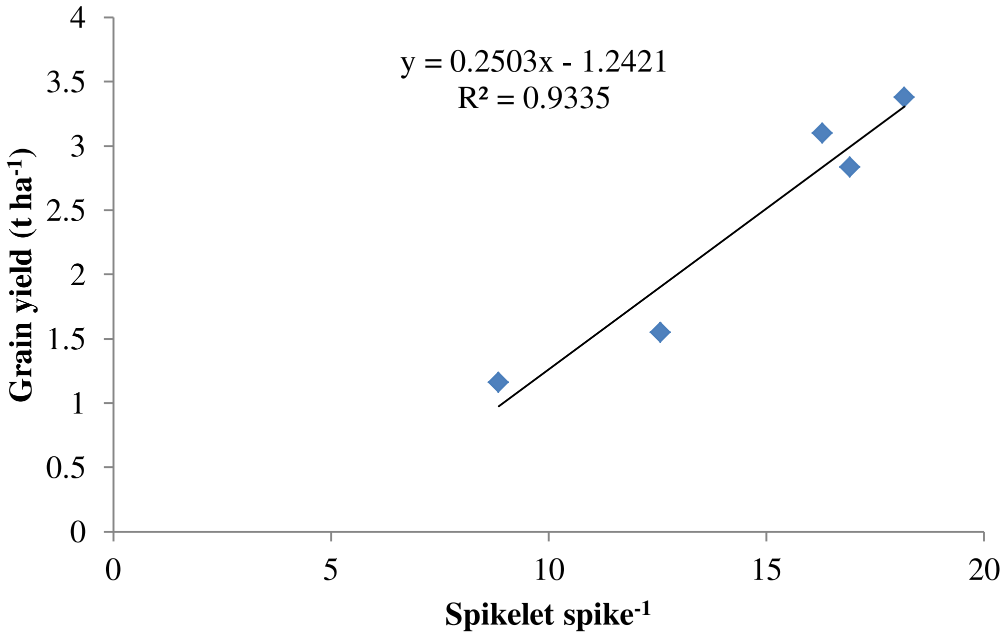

Fig: 4 Relationship between spikelet spike^{-1} and grain yield

4.4.4 Grain yield and number of grain spike^{-1}

The relationship between the grain yield and number of grain spike^{-1} shown positive and significant correlation those were presented in the fig. (5). The correlation co-efficient value of grain yield and number of grain spike^{-1} were (r=0.891). The line of regression X (number of grain spike^{-1}) on Y (Grain yield) having equation of Y= 0.068x-0.582 was shown in fig. (5). The positive slope indicates that the grain yield and number of grain spike^{-1} was directly correlated each other thus, due to the increase of number of grain spike^{-1} also increased the grain yield of wheat.

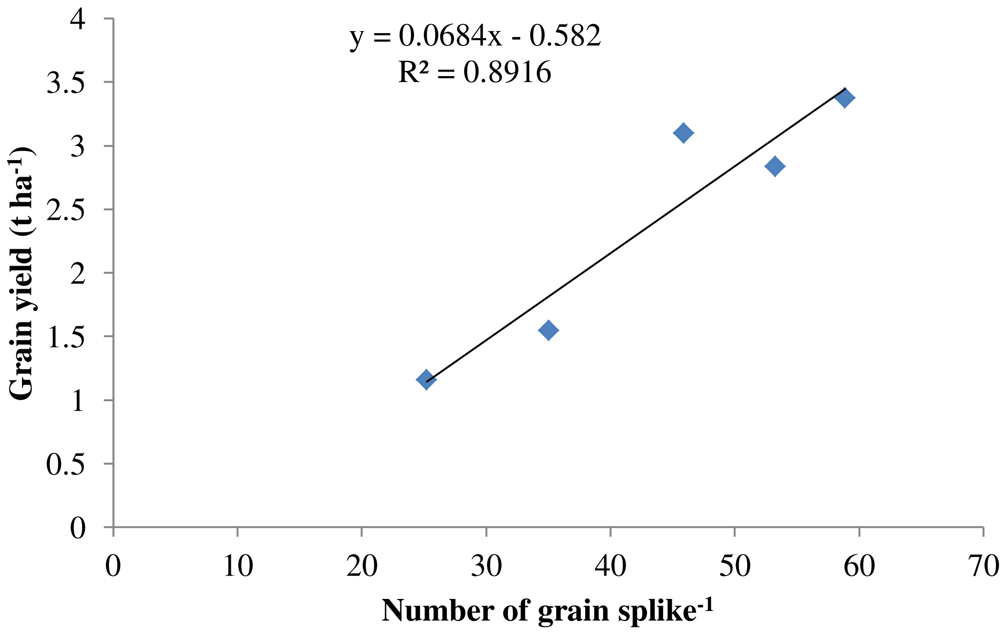

Fig: 5 Relationship between no. of grain spike^{-1} and grain yield

CHAPTER V

SUMMARY AND CONCLUSIONS

CHAPTER V
SUMMARY AND CONCLUSIONS

The experiment was conducted in Soil Science research field, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of November 2016 to March 2017. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five treatments and four replications. The unit plot size was 5 m^2 (2.5m × 2m). Five fertilizer treatments were used which were T_1 =Control (without fertilizer) T_2= Recommended doses of N P K fertilizers, T_3= Recommended dose of vermicompost, T_4= ½ recommended doses N P K fertilizers + ⅓ recommended doses of vermicompost, T_5= ⅓ recommended doses of N P K fertilizers + ⅔ recommended doses of vermicompost.

The fertilizers were distributed according to the treatment in individual plots. The total numbers of plots were 20 (5×4). N, P, K was applied as urea, triple super phosphate and muriate of potash at the rate of 150, 140 and 100 kg ha^{-1} respectively. Seeds were sown on the 1st December 2016. The crop was allowed to grow until maturity and intercultural operations such as weeding and irrigation were done whenever required in order to support normal growth of the plant. At maturity, the crop was harvested on 30^{th} March, 2017. Plot wise yield and yield components were recorded.

Vermicompost and NPK fertilization significantly increased the plant height. The highest plant height (88.50 cm) was observed in the treatment T_2 followed by T_4 (87.35) and T_5 (86.30) compared to control plot (73.90 cm). The number of tillers $plant^{-1}$ varied significantly by the application of different doses of NPK fertilizer and vermicompost. The maximum number of tillers was observed in T_4 (7.85) treatment and minimum in the control treatment T_1 (3.9). The number of grain $spike^{-1}$ also increased by vermicompost and NPK fertilization and ranged from 58.90 to 25.25. The significant increase was obtained up to T_4 treatment. Spike length was also significantly influenced by combined application of vermicompost and NPK fertilizer which varied between 6.38 and 8.83 cm with all the treatments.

1000 seed weight was found non significant with different levels of vermicompost and NPK fertilizer application and was found maximum in the treatment T_4 showing other levels more or less same. Grain yield ranged from 3.38 to 1.2 t ha^{-1} due to the effect of different levels of fertilizer application. The lowest grain yield was observed in T_1 treatment (1.2 t ha^{-1}) and the highest was in T_4 (3.38 t ha^{-1}). Grain yield was positively correlated with spike length, number of tillers $hill^{-1}$, spikelet $spike^{-1}$ and effective grain $spike^{-1}$. Straw yield was also significantly positive as a combined effect of NPK fertilizers and vermicompost application. The rate of increase in straw yield found in treatment T_4 (4.73 t ha^{-1}).

The treatment of T_4 followed by T_2 and T_5 of BARI Gom 26 produced higher values of yield, whereas the lowest was recorded in the treatment T_1 (control). It was found that T_3 was mostly followed by control treatment T_1, which was not satisfactory in yield attributing characters. T_4 carried out the best yield with combined application of vermicompost and NPK fertilizer. Thus examined that exclusive application of vermicompost at 2.5 t ha^{-1} in farm wheat crops supported yield better than chemical fertilizers.

Recommendation

- Combined application of vermicompost and NPK fertilizers can significantly increase the yield and yield contributing components of wheat and ½ NPK fertilizer with ⅓ vermicompost produced the maximum yield of wheat compared to conventional fertilizer application (only NPK fertilizers).
- Application of ½ NPK fertilizer and ⅓ vermicompostcan satisfactorily increase the amount of organic matter, total N, available P, exchangeable K and available S in soil to some extent.
- Considering the above observation further study may be needed to enhance the soil fertility status by combined application of vermicompost as organic fertilizer and NPK fertilizer to ensure the better growth and yield performance of wheat in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.

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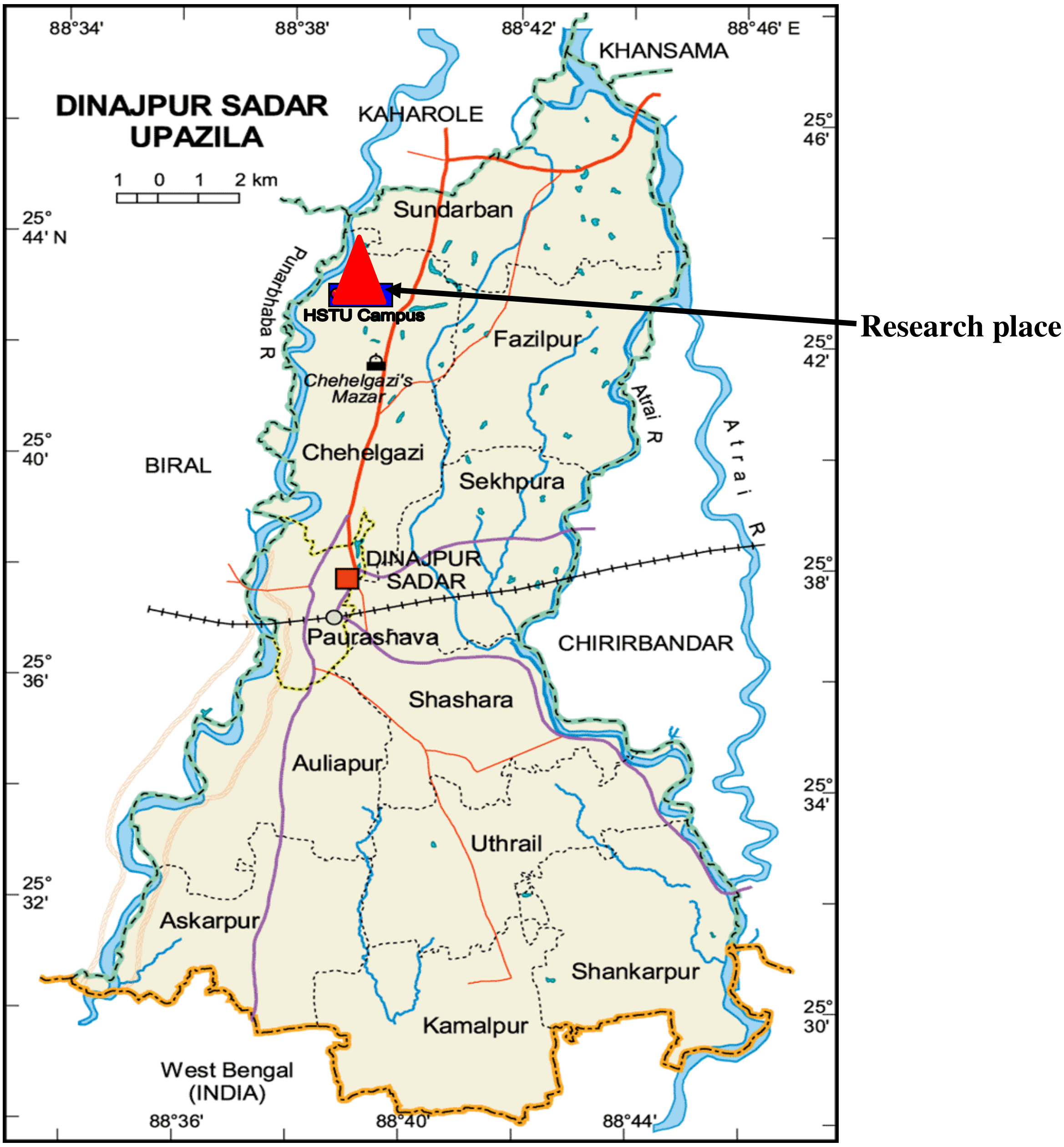
APPENDICES

APPENDICES

Appendix I.

Location of the experimental site (map of Dinajpur Sadar Upazila showing the research plot)



Appendix II

Monthly recorded air temperature, relative humidity and rainfall during November, 2016 to March, 2017.

Year	Month	** Air temperature (^oC)			**Humidity (%)	**Rainfall (mm)
		Maximum	Minium	Average		
2016	November	26.8	12.5	19.65	87	8
	December	26.4	12.1	19.25	85	7
2017	January	25	9.7	17.35	81	4
	February	12.5	28.1	20.3	77	0
	March	28.7	15.10	21.9	78	97.0

**Monthly average

Source: Wheat Research Centre, Nasipur, Dinajpur

Appendix III

Schedule of cultural operations in the experimental plot

Serial no	Cultural operations	Date
1	Opening of the land	18.11.2016
2	Cross ploughing	18.11.2016
3	Breaking of clods, laddering and weeding	18.11.2016
4	Layout of the experiment	18.11.2016
5	2^{nd} and 3^{rd} (ploughing)	20.11.2016
6	Final weed collection	20.11.2016
7	Vermicompost application	20.11.2016
8	Application of the 2/3 doses of urea and entire of other fertilizers	01.12.2016
9	Sowing of seeds	01.12.2016
10	1st irrigation	13.12.2016
11	1^{st} weeding & thinning	21.12.2016
12	2^{nd} irrigation	23.12.2016
13	Application of the $1/3^{rd}$ doses of urea	23.12.2016
14	2^{nd} weeding	16.01.2017
15	3^{rd} irrigation	20.02.2017
16	Harvesting	30.03.2017
17	Threshing	11.04.2017
18	Weighing	11.04.2017

Appendix IV

Some photographs of research work