EFFECT OF POULTRY MANURE AND MAGNESIUM ON THE GROWTH AND YIELD OF WHEAT (BARI Gom 25)

A THESIS

BY

UZZAL KUMAR RAY
Student No. 1605028
Semester: January-June, 2017
Session: 2016-2017

MASTER OF SCIENCE (M.S.)

IN

SOIL SCIENCE

DEPARTMENT OF SOIL SCIENCE

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

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DEPARTMENT OF SOIL SCIENCE
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DECEMBER, 2017

DEDICATED

TO MY

BELOVED PARENTS

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The Author

ABSTRACT

The experiment was conducted in Soil Science research field, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of November 2016 to February 2017 to determine the effect of poultry manure (PM) and magnesium (Mg) on the growth and yield of wheat (BARI Gom-25). The HSTU research field belongs to Old Himalayan Piedmond plain' (AEZ 1). There were twelve treatments- T_1 = PM_0Mg_0, T_2 = PM_0Mg_{10}, T_3 = PM_0Mg_{15}, T_4= PM_0Mg_{20}, T_5 = PM_5Mg_0, T_6 = PM_5Mg_{10}, T_7 = PM_5Mg_{15}, T_8 = PM_5Mg_{20}, T_9 = $PM_{10}Mg_0$, T_{10} = $PM_{10}Mg_{10}$, T_{11} = $PM_{10}Mg_{15}$, T_{12} = $PM_{10}Mg_{20}$. The experiment was laid out in a randomized complete block design (RCBD), with three replications of each treatment. Besides Mg and PM every plot had received 130 kg N, 80 kg P, 40 kg K, 100 kg S, 5 kg Zinc and 6 kg B ha^{-1} from urea, TSP, MoP and gypsum, zinc sulphate and boric acid respectively. The results revealed that yield and yield contributing characters were influenced significantly by different levels of Mg and PM. The highest plant height (104.7 cm) was observed in T_{11} treatment and the lowest (93.00 cm) was found in the control. The maximum number of tillers (6.00) was produced also in the treatment T_{11} and minimum number (3.00) was found in the control. The number of spikelet $spike^{-1}$ and 1000 grain weight were not significant. The grain yield was highly dependent on the number of grains $spike^{-1}$ indicating that the added Mg and PM had a significant influence on grain set which led to higher grain yield. The highest number of grain $spike^{-1}$ (41.60) was found in the treatment $T_{11.}$ The lowest number of grain (20.20) was observed in the control treatment. Grain yield, straw yield and biological yield of wheat were significantly influenced with the application of Mg along with PM. It was found that the application of 15 kg Mg ha^{-1} with 10 t PM ha^{-1} produced the highest grain yield (5.3 t ha^{-1}), straw yield(4.7 t ha^{-1}) and biological yield (10.0 t ha $^{-1}$.). The control treatment produced the lowest grain (2.9 t ha^{-1}), straw (2.5 t ha^{-1}) and biological (5.4 t ha-1) yield. The findings of the study showed that the performance of the treatment T_{11} ($PM_{10}Mg_{15}$) was the best among the other treatments in respects of plant height, tillers $hill^{-1}$, spike length, spikelet $spike^{-1}$,number of grain $spike^{-1}$, 1000 grain weight, grain yield, straw yield and biological yield of wheat. Therefore, the overall results indicate that the application of 10 t PM ha^{-1} with 15 kg Mg ha^{-1} can be more efficient and economic for wheat production.

ABBREVIATIONS AND ACRONYMS

@	= At the rate of
°C	= Degree Celsius
AEZ	= Agro-Ecological Zone
AEZ	= Agro-ecological zone
Agric.	= Agriculture
Agril.	= Agricultural
Av	= Average
BARC	= Bangladesh Agricultural Research Council
BARI	= Bangladesh Agricultural Research Institute
BBS	= Bangladesh Bureau of Statistics
BINA	= Bangladesh Institute of Nuclear Agriculture
CGR	= Crop Growth Rate
Cm	= Centimeter
CRD	= Complete Randomized Design
CRI	= Crown Root Initiation
CSO	= Chief Scientific Officer
CV	= Coefficient of Variance
Cv	= Cultiver
DAS	= Days After Sowing
DMRT	= Duncan's Multiple Range Test
et. al.	= And authors
FAO	= Food and Agricultural Organization
gm	= Gram

HSTU	= Hajee Mohammad Danesh Science and Technology University,
ISSS	= International Society of Soil Science
Kg m^{-3}	= Kilogram per Cubic Meter
Kg/ha	= Kilogram per Hectare
LAI	= Leaf Area Index
LSD	= Least Significant Difference
MP	= Muriate of Potash
NS	= Not Significant
pp	= Pages
RCBD.	= Randomized Complete Block Design
S.E.	= Standard Error
Sci.	= Science
Soc.	= Society
t ha^{-1}	= Ton per Hectare
TDM	= Total Dry Matter
TSP	= Triple super phosphate
USDA	= United States Department of Agriculture
Viz	= Namely
WRC	= Wheat Research Centre

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CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum L.*) is the most important cereal crop all over the world. It ranks second (after rice) in Bangladesh and first both in acreage and production in the world context (UNDP and FAO, 1999). Its grain has high food value contained 14.7% protein, 2.1% fat, 78.1% starch and 2.1% mineral matter (Peterson, 1965). About one-third of the total population of the world live on wheat grain consumption. Bangladesh produces 901490 metric tons of wheat per annum from 929766 acres of land (BBS, 2016). It ranks first in area (214M ha) and production (570M t) among the grain crops in the world (FAO, 2003).

Wheat is a viable substitution to meet the requirement of cereal. So, it is essential to increase the production of wheat to meet the food requirement of ever increasing population of Bangladesh and consequently it will help achieve food security. During 2015-2016 the cultivated area of wheat was 4,44,805 ha having a total production of 13,48,186 metric tons with an average yield of 3.03 t ha^{-1} (BBS 2016). However, per hectare yield of wheat in Bangladesh is low in comparison with other wheat growing countries in the world. Even the average yield 2.94 t ha^{-1} wheat in 2002 (FAO, 2003) was much higher than that of Bangladesh. The yield of wheat can be increased up to 6.4 t ha^{-1} with appropriate technologies (RARS, 1993). So, there is an opportunity to increase production of wheat per unit area through adoption of improved irrigation and agronomic practices including high yielding varieties.

Yield of wheat is influenced by the interaction of a number of factors including soil fertility, climatic condition, variety, tillage, intercultural operations etc. Soil is the principal supplier of plant nutrients. Practically no soil can sustain high crop yields for an indefinite period from its own nutrient reserves. Even the most soils can do so only for certain years and at one time the yield will be declined due to the deficiency of some nutrients. However, nutrient deficiencies can be corrected by the judicial application of the deficient nutrient containing fertilizers. On the other hand, higher crop yields naturally have higher demands of nutrients and create more pressure on the soil for available forms of nutrients. Moreover, when cropping intensity and yield levels go up, the intake and removal of plant nutrients through harvested crop and other routes from the soil are likely to go up.

Poultry manure is an organic fertilizer which improves the physical properties of soil. Poultry manure application at 10 t ha^{-1} was observed to improve the physical properties of soil specially structure of soil, bulk density, water holding capacity of soil. (Ravikumar and Krishna moorthy, 1975). Not only that it serves as a source of different elements specially micro nutrient element. It contains more nutrients than any other manures (FYM, cow dung etc). It increases the soluble P of soil and available N of soil. Poultry litre contains considerable amount of organic matter due to the manure and bedding material (Mullins 2002). Not only that poultry manure decomposes readily release the nutrients as a van label form timely. In comparison with all other available manures, poultry manure is considered the best one due to its better decomposition rate and timely availability of nutrients (Reddy *et al*., 2010).

Micronutrients are elements with specific and essential physiological functions in plant metabolism (Marschner, 1995). These are regarded as catalytic agents required for growth in lower amount and serve mainly as constituents of prosthetic groups in metallo proteins and also as activators of enzymatic reactions. Of many reviews dealing with plant nutrition and disease, few have seriously considered the micronutrients.

Magnesium plays an important role in the physiological process of wheat plant such as cell elongation, cell maturation, sugar translocation, meristematic tissues development, protein synthesis and ribosome for maturation (Mengel and Kirkby, 1987). Magnesium as a carrier of phosphorous particularly in oil seed cross (eg. canola), as a component or activator of several enzymes, CO_2 assimilation, cation-anion balance and cellular pH (Reuter and Robinson 1998). In the most severely deficient soils, the application of Mg contain fertilizer makes an absolute difference between being able to use land for agriculture. The prevailing situation underscores the need for investigation whether Mg deficiency is a causative factor for poor grain formation, grain yield and nutrient content of wheat. Thus the present study was conducted to asses the effect of magnesium with poultry manure on growth and yield of wheat. Considering the points as mentioned above, the present study was undertaken with the following objectives:

1. To evaluate the effect of magnesium and poultry manure on the growth and yield of wheat.
2. To evaluate the interaction effect of Mg and PM on the growth and yield of wheat.

CHAPTER II

REVIEW OF LITERATURE

Poultry manure and magnesium plays an important role on the yield and yield contributing characteristics of wheat. Appropriate rate of magnesium (Mg) and poultry manure (PM) application may enhance the grain yield of wheat. However few studies have so far been conducted on the response of wheat to magnesium fertilizer. But no studies has been considered for knowing the intersection effects of Mg and PM. The importance of wheat cultivations is being increasingly emphasized and role of Mg and PM in wheat growth, yield and quality are well documented mostly in our country and outside the country.

Even though poultry manure contains more amount of nutrients than other manures, the research work on poultry manure is less when compared to farm yard manure which has been studied extensively, since poultry population is concentrated only in certain areas and hence the manure availability also. In this context, a review of available literatures in respect of effect of Farm Yard Manure (FYM) and poultry manure on yield and quality of crops, nutrient availability, residual effects and composting assumes importance. Some of the findings relevant to the present study have been reviewed below.

2.1 Nutrient status of poultry manure

Krogdahl and Dahlsgard (1981) found that poultry manure is rich in organic manure since solid and liquid excreta are excreted together resulting in no urine loss. In fresh poultry excreta uric acid or uriate is the most abundant nitrogen compound (40-70 per cent of total N) while urea and ammonium are present in small amounts.

Mountney (1983) found that nutrient values of poultry manure vary considerably depending upon the conditions under which it is processed. The ratio of litter to manure and the moisture content caused considerable variation among manures from different houses .

Muller (1984) commented that poultry manure consists of groundnut shell, rice husk in a layer of 10 -15 cm. When excreta are added, the litter becomes moist but remains aerobic. Aerobic fermentation occurs with the production of heat and loss of some CO_2 and ammonia. The nutritional value of unprocessed poultry manure deteriorates rapidly. Deep litter containing more than 22 per cent moisture, when stored in open air rapidly looses its nitrogen due to high proteolytic activity . Hence, the immediate processing of poultry manure to prevent its rapid decomposition and save its nutrient properties is, thus essential.

Bitzer and Sims (1988) founded that land applied poultry manure supplied nutrients necessary for crop growth, the most prevalent being nitrogen.

Hammond *et al*., (1997) reported that approximately 75% of the total N and majority (90-100%) of the P and K in poultry manure are available for plant.

John and Charles (1999) stated that poultry manure contains nitrogen, phosphorus, potassium and micro nutrients essential for plant growth. They also found incremental crop yield with the addition of poultry manure.

NRAES (1999) stated that poultry manure contains all 13 of the essential plant nutrients that are used by plants. These include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), copper (Cu). Zinc (Zn), chlorine (Cl), boron (B), iron (Fe), and molybdenum (Mo).

Egrinya *et al*., (2001) cited that poultry manure contains not only N, but also other elements like P, K, S, Ca and micronutrients.

Mullins (2002) commented that poultry manure is used as a source of N, P and K but litter also contains Ca, Mg, S and some micronutrients.

Khaliq *et al*. (2004) reported that poultry manure provided nutrients and its use could be preferred as it contained macronutrients in greater amount than other manure.

Tewolde *et al.*, (2005) reported that poultry manure not only supplied enough N but also supplied the four other macronutrients viz. P, K, Ca and Mg in amounts of sufficient to support normal cotton growth.

Miah *et al.*, (2006) reported that application of 2 tons poultry manure/ ha may replace the full dose of P and S and 60% N and K fertilizer requirement for a target yield of 5-6 t/ha rice.

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

Farad (2009) stated that poultry manure is an excellent organic fertilizer which contains high N, P, K and other essential nutrients.

2.2 Effect on nutrient uptake

Prasad *et al.* (1984) reported that addition of poultry manure alone or in combination with N, P, K, Zn and Fe increased the uptake of Zn and Fe by wheat and rice.

More and Ghonsikar (1988) reported that the P content in wheat was significantly higher due to the application of poultry manure with super phosphate.

Faiyard *et al.* (1991) recorded an increase in N, P, K, Fe, Mn and Cu contents in faba beans due to the application of poultry manure.

2.3 Loss of nutrients after application

Castellanos and Pratt (1981) reported that nitrogen in poultry litter is present in both organic and inorganic forms that are subject to volatilization, denitrification, immobilization, mineralization, leaching and plant uptake.

Gale and Gilmour (1986) as well as Chescheir *et al.* (1986) have suggested immobilization was responsible for reducing inorganic N shortly (1- 2 weeks) following application of poultry waste.

Gale and Gilmour(1986) identified that undigested feed and the litter bedding material acts as immobilizing agents. Mineralisation occurs quite rapidly following application of poultry waste.

Bitzer and Sims (1988) found that approximately 69 per cent of organic N in poultry manuremanure incorporated into a sandy loam soil was mineralized in 140 days. Shortly following application, conditions generally favour volatilization of the ammoniacal - N.

Wolf *et al.* (1988) found that 37 per cent of the total - N in surface applied poultry manure was volatilized in 11 days. Volatilization losses may significantly reduce the amount of N available for plant uptake.

2.4 Effect of poultry manure on physical properties of soil

Ravikumar and Krishna-moorthy (1975) observed that poultry manure application at 10 t ha-^{1} improve the physical properties of soil .

Ravikumar and Krishna-moorthy, (1975) observed that soil physical properties such as bulk density, water holding capacity and percent water stable aggregation were favourably influenced by poultry manure manure addition to soil.

Kirchmann and Witter (1989) observed composting or the biological degradation of organic wastes has been investigated as a method of stabilizing poultry manure and manure prior to land application. This process of composting produces a material with several advantages with respect to handling by reducing volume, mass of dry matter, odors, fly attraction and weed seed viability.

Mbagwu (1992) reported that poultry manure significantly decreased bulk density and increased total and macro porosity, infiltration capacity and available water capacity.

Apparvu and Saravanan (1999) conducted a field study, Tamil Nadu, India, to study the effect organic manure application on soil physical properties at the harvest of the sorghum crop and its residual effect on the succeeding crop of soybeans. The addition of organic manure to first crop especially poultry manure and farmyard manure increased the yield besides physical properties of soil and organic carbon status. Application of organic matter reduced the bulk density; the capillary non capillary porosity and soil organic carbon improved by the addition of organic manure especially poultry manure followed by farmyard and goat manure compared with the control. Disc ploughing and poultry manure and farmyard manure management without irrigation enhanced the total porosity and hydraulic conductivity of soil significantly.

Andreola *et al.*, (2001) stated that poultry manure increased the soil physical properties. In field studies in Santa Catarina, Brazil, in 1990-95 on structured terra Roxa soil, the effect of the winter plant cover of black oats (*Avena strigosa [A.nuda*]) and forage turnips [radishes] (*Raphanus sativus)* and application of poultry manure or organomineral fertilizers on soil physical properties were investigated. Soils were analyzed in August 1994 and January 1995 at depths of 0-10, 10-20, and 20-30 cm. Soil aggregate stability of aggregates greater than 4.76 mm was decreased and that of aggregates 2.0-4.76 and 1.0-2.0 mm increased with application of poultry manure. Macro porosity increased and soil density decreased in the 0-10cm soil layer with application of poultry manure.

2.5 Effect of poultry manure on chemical properties of soil

Reddy *et al.*, (1980) found that adding single super phosphate and poultry manure together to soil resulted in higher P availability. Application of poultry manure decreased the adsorption capacity and increased the soluble P and phosphorus desorption.

Ravikumar and Krishnamoorthy (1983) reported that application of poultry manure increased the available P content of the soil.

Rayar (1984) reported that poultry manure; swine manure and FYM increased in available N in soil.

More and Ghonsikar (1988) reported that the availability of P increased when super phosphate was mixed with poultry manure and applied to soil than application of super phosphate alone.

Mbah *et al*., (2000) carried out an experiment on changes in chemical and microbiological properties of a sandy clay loam soil in southeastern Nigeria following amendment with some animal wastes were studied. The research was conducted in a dystric Leptosol at the teaching and research farm of Ebony State University, Abakaliki, Nigeria. The treatments comprised three animal waste sources (cow dung, pig manure and poultry manure) and unamended plots laid out in the field using a randomized compete block design. The results of the study show that the waste materials increased cation exchange capacity between 3% and 18% relative to control. Similarly, higher Ca, Mg, K, Na, based saturation were recorded with amended plots relative to the unamended plots, Poultry manure accounting for the highest increase.

Rasnake *et al*., (2000) reported that poultry manure can serve as an economical source of nutrients for crop production. However repeated use of litter can lead to an accumulation of some nutrients in the soil. A study was started in 1991 in West Kentucky, USA, to evaluate nutrient availability from poultry manure for tall fescue hay production. After five years of manure application (a maximum of 45 t / ha) the soils were sampled to determined nutrient accumulation and movement in the soil. Phosphorus, Copper and Zinc increased significantly in the surface soil layer. This study indicates that applying manure to these soils at rates that will supply the nutrient needs of crops.

Lopez *et al*., (2001) carried out a study in Guantanamo's county, Cuba to determine the type of fermented manures more recommended ecologically for healthy vegetable production. Three types of manure were used, poultry, cattle and sheep. It was proven that all the studied manures were of quality and can be applied to all the cultivations. The best germination percentage was obtained with the fermented poultry manure. The variable with higher number of leaves presented was the one fermented with poultry manure. With use of poultry manure US $ 16.80 [per hectare] was saved .They were found improved soil chemical and physical properties and the products obtained were ecologically healthy.

Blay *et al*. (2002) found that poultry manure was beneficial as it enhanced soil fertility, increased soil organic matter, soil biota activities and water holding capacity of soil.

Mullins (2002) revealed that poultry manure contains a considerable amount of organic matter due to the manure and the bedding material. Litter can also have an impact on soil pH and liming due to varying amounts of calcium carbonate in poultry feed.

Ewulo (2005) observed poultry manure gave higher concentration of soil chemical properties of clay loam soil. In order to investigate the effect of poultry dung and cattle manure on clay loam and sandy clay loam soil chemical properties , an incubation experiment was conducted in which clay and sandy clay loam soil were amended with poultry and cattle manure at 0 ,20 ,40 and 60 g / kg. The soil treated was incubated in the dark at 25 degrees C for eight weeks at field capacity. Soil pH , organic carbon, N, P, K, Ca, Mg, Na and cation exchange capacity increased with rate of manure, while exchangeable acidity decreased irrespective of soil type. The poultry manure gave quick response and higher concentration of soil chemical properties especially in case of the clay soil.

Agbede *et al*.(2008) found that the proper application of poultry manure increased soil and plant nutrients status.

Ullah *et al*., (2008) reported that poultry manure enhanced brinjal yield and soil chemical properties. They were conducted a field experiment at the Horticulture Farm of Bangladesh Agricultural University (BAU), Mymenshing during the period from December 2004 to April 2005 to evaluate the effect of manures and fertilizers on the yield of brinjal and soil chemical chemical properties. The treatments were T1(Cowdung @ 22857 kg/ha), T2(mustard oil cake @ 1600 kg/ha) ,T3(poultry manure 5000 kg /ha), T4(chemical fertilizer @ 174 kg urea /ha, 125 kg TSP /ha and 50 kg MoP /ha) and T5 (20% cow dung ,+ 20% mustard oil cake + 20% poultry manure +40% N+P+K fertilizer). The N,P and K content of the manures were tested in the laboratory and according to the results the doses of manures were set in such a way that all the treatments contains same amount of N,P and K. The test crop was brinjal (cv. Shingnath). Application of sole poultry manure and mustard oil cake gave better performance compared to sole chemical fertilizer on the yield and increasing different growth parameters. Soil organic matter decreased by chemical fertilizer and increased with all types of manures application. In all the cases nutrient availability increased and highest availability of N, P and S was found from poultry manure.

2.6 Effect of poultry manure on biological properties of soil

Ibekwe, *et al*., (2006) investigated the effect of poultry manure on biodegradation of soil (5 kg) contaminated with crude oil (50 gm) for seven weeks. Four different test options were prepared namely; (i) 100 gm contaminated soil + 30 gm of poultry manure ,(ii) 100 gm contaminated soil + 60 gm of poultry manure, (iii) 100 gm contaminated soil + 90 gm of poultry manure, (iv) 100 gm contaminated soil only(control). The microbial degradation was monitored by the measurement of total heterotrophic count (THC), hydrocarbon utilizing bacterial count (HUB) and gravimetric loss of the crude oil with time. The cumulative THC of 6.9 x 107 , 9.0 x 107 , 1.03 x 108 and 3.1 x 107 cfu / gm were recorded for test options (i),(ii), (iii) and (iv) respectively. The hydrocarbon utilizing bacterial counts (HUB) were 1.68 x 105, 1.63

Maguire *et al*., (2006) carried out an experiment with different level of poultry manure to asses the bacteria population in soil. They reported that application of poultry manure to soil increased the bacteria population which is also responsible for soil fertility.

Tejada *et al.*, (2006) reported poultry manure amended soil had a positive effect on soil biological properties. One method for recovering degraded soils in semiarid region is to add organic matter to improve soil characteristics, thereby enhancing biogeochemical nutrient cycling. In this paper, they studied the changes in soil biological properties as a result of adding a crushed cotton gin compost (CCGC) and a poultry manure (PM) for 4 year to restore a Xerollic Calciorthid located near Seville (Guadalquivir Velly, Andlusia, Spain). Organic wastes were applied at rates of 5, 7.5 and 10Mg organic matter/ha. One year after the assay began; spontaneous vegetation had appeared in the treated plots, particularly in that receiving a high PM and CCGC dose. After 4 years, the plant cover in these treated plots was around 88 and 79%, respectively, compared with 5% for the control.The effects on soil microbial biomass and six soil enzymatic activities (dehydrogenase, urease, BBA-protease, beta -glucosidase, arylsulfatase, and alkaline phosphatase activities) were ascertained. Both added organic wastes had appositive effect on the biological properties of the soil, although at the end of the experimental period and at high dosage, soil microbial biomass and soil enzyme activities were generally higher in the PM amended soil compared to the CCGC - amended soils.Enzyme activity from the PM - amended soil was 5, 15, 13, 19, 22, 30, and 60% greater than CCGC -amended soil for microbial biomass, urease, BBA-protease, beta -glucosidase, alkaline phosphatease, aryl sulfatase, and dehydrogenase activities, respectively.

2.7 Effect of poultry manure on the growth and yield contributing characteristics

Ravikumar and Krishnamoorthy (1983) reported that poultry manure and FYM gave higher yields of rice and ragi when combined with inorganic fertilizers.

Prasad *et al.* (1984) suggested that maximum grain yield of rice was recorded with the application of poultry manure.

More and Ghon-sikar (1988) recorded that increase in the yield of wheat due to application of poultry manure along with super phosphate was obtained.

Abdel Magid *et al.* (1995) reported that grain and straw yield of wheat increased with increased rate of chicken manure in Saudi Arabia and obtained the greatest economic return by 8.25 t ha^{-1}.

Magid *et al*., (1998) studied the treatment effects of chicken manure on wheat crop in sandy soil of Saudi Arabia. The intention of the study was to assess the quality of crop. Chicken manure significantly improved wheat grain quality, as it resulted in higher crude protein, lower crude fibre and good shape and size of wheat grain. The percent Ca, Mg, and P in plant tissue were also improved in manure additions. This is expected as the chemical analysis of the manure indicated higher contents of these elements.

John and Charles (1999) stated that poultry manure contains nitrogen, phosphorus, potassium and micro nutrients essential for plant growth. They also found incremental crop yield with the addition of poultry manure.

Mikhailovskaya and Batchilo (2002) studied the effect of wet poultry manure (WPM) on sod podzolic sandy loam soil. Spring wheat "Belaruskaya-80" was grown during three years. WPM was used with out additives and in combination with NK fertilizer. WPM studied doses -25, 50 and 75 t /ha. The different composition of wheat grain quality was affected by wet poultry manure application. WPM applied with doses 25 and 50 t /ha resulted in the increas e of protein content from 15.8% to 17.1and 19.7 %. Combination of WPM with NK fertilizers provided the improvement of grain amino acid composition. Higher dose of WPM (75 t/ha) has lead to the reduction of grain protein. Gluten content in wheat grain achieved with 30. 40% at optimal dose of WPM (50 t /ha).

Mitchel and Shuxin (2005) stated, land application of poultry manure in agricultural production is a widely used practice. They conducted field experiments for 13 years to study the poultry manure application on cotton and maize and obtained enhanced yield (cotton 30 to 50% yield and maize 25 to 65% yield) than control.

Noufal (2005) accomplished an experiment in Meet Kenna soil, Egypt to observe the effects of poultry manure, charred rice straw , sugarbeet residues compost and sugar lime on sandy soil properties and impact on maize and barely.The rates of organic materials were 10,20 and 40 metric t/ feddan based on 30 cm soil depth. All the organic materials except charred rice straw increased yield of maize and barley. Among the materials poultry manure contributed highest yield.

Hachicha et. al. (2006) studied that poultry manure, olive mill wastes and mineral rich wastes water as an alternative fertilizer in Tunisia. Poultry manure and olive mill wastes contain good source of nutrients among the wastes. The poultry manure waste was of high quality, characterized by high level of nutrients, relatively low C/ N ratio (15/17) and a fertilizing value similar to that of conventional cattle manure, without phyto-toxicity. Field experiments showed an increase in potato production of 31.50 to 35.50 t/ha with poultry manure compared to 30.50 t/ha using cattle manure. Poultry manure and olive mill by products appear therefore, as a promising ecological alternative to classical fertilizers.

2.8 Integrated effect of poultry manure and chemical fertilizer on the growth and yield contributing characteristics of crops

Vasanti and Kumaraswamy (2000) observed that the poultry manure is more efficacious than the sheep and goat manure, farmyard manure, and biogas manure in producing the green and dry fodder yield of the cereal fodder and soil fertility. In field experiment conducted during 1993 and 1994 in Tamil Nadu , India, on a clay loam soil, three cereal crops of sorghum (Co.27), maize(African tall), and pearl millet (Co. 8) were grown in main plots with eighteen sub plots treatments involving four manures (poultry manure , sheep - goat manure, biogas manure and FYM) at 5 and 10 t /ha and NPK at 50 and 100% of recommended levels (60-40-20 kg of NPK / ha) . The green and dry fodder yields of the cereal fodders, the soil fertility status, and he content of and uptake of N, P and K were significantly higher in the treatment that received poultry manure at 10 t/ha with 50% of the recommended NPK schedule than the yields in the treatment that had received NPK alone.

Blay *et al.*, (2002) carried out a study during the year 1998-1999 to determine the optimum levels of poultry manure, inorganic fertilizer and their combined effect on yield on shallots grown on sandy Anloga soils in Ghana (Africa). Treatments comprised a 4 x 3 factorial combination of poultry manure at 0, 10, 20 and 40 t/ha and three levels of NPK 15-15-15 fertilizer at 0, 300 and 600 kg / ha. A combination of 40 tonnes poultry manure / ha with 300 kg /ha and 600 kg NPK 15-15-15 fertilizer / ha increased plant height, number of leaves per plant and number of plantlets per plant and dry matter content.

Zong Xin *et al.*, (2004) carried out a field experiment with 2 hybrids (Keduo No. 4 and Ludan 50) was conducted in 2002-2003 in Tian, Shangdon, China. Five fertilizer treatments were designed. They were wheat straw (7500kg/ha) + rotted chicken manure (120 kg/ha,), rotted chicken manure (5500 kg/ha) + N fertilizer (120 kg/ha), high N fertilizer (600 kg/ha), medium N fertilizer (300 kg/ha) and control treatment (no fertilizer).Chicken manure +N fertilizer significantly enhanced biomass and kernel yield followed by high N fertilizer treatment. Chicken manure +N fertilizer improved fertility and structure of top soil than the other treatments.

Silva *et al.*, (2005) performed an experiment at Aralaganwila Research Station, Srilanka to evaluate the possibilities of increasing crop yields and soil nutrients by combined application of organic manure (rice straw, cattle manure, poultry manure and compost) and chemical fertilizers under maize / rice crop rotation in 2004 yala and 2004-05 maha seasons. Results of the experiment revealed that higher crop growth and yield can be obtained by combining organic manure and chemical fertilizers. Among the organic manure +chemical fertilizer combination tested, poultry manure+NPK showed the highest (493% in yala and 256% in maha) and rice straw +NPK combinations showed the lowest (361%in yala and 145% in maha) grain yields and increase of soil nutrient status respectively.

Behera *et al.*, (2007) conducted a long term experiment during the year 1995 to 2000 on the fine textured Vertisols at Indore, India to study the effect of combined use of farm yard manure(FYM),poultry manure(PM),vermicompost and biofertilizer + phosphate solublebilizing bacteria with 0.5 and 1.0 NPK (120 kg N+26.2 kg P+ 33.3 kg K /ha) on wheat, and residual effect on following soybean. Grain yield of wheat in the initial 2 years and the durum wheat in the later 3 years was significantly increased with 0.5 NPK+ poultry manure at 2.5 t/ha compared other treatments.

Ying Xin *et al.* (2009) studied the effects of combined application of inorganic and organic fertilizers on grain yield and qualitative traits of wheat. They applied chicken manure and urea. They concluded that combine application of organic and inorganic fertilizers increased grain yield as well as quality traits such as starch improvement in wheat grain.

2.9 Residual effects of poultry manure

Gupta *et al., (1*988) while evaluating the comparative efficacy of poultry manure with or without FYM on the residual effect of wheat grain yield, it was concluded that the residual effect was in the order of poultry manure + FYM followed by poultry manure, FYM and no manure.

Budhar *et al.,* (1991) reported that the post-harvest soil sample analysis indicated that Sesbania, FYM, biogas slurry and poultry manure application resulted in higher amount of residual N, P and K in the soil.

Savithri *et al.* (1991) reported that application of 6.25 t ha^{-1} poultry manure to the first crop of wheat had significant residual effect on succeeding crop yield and that also increased the nutrient content of the soil.

Madhumita Das and Shekar (1996) found that the relative efficacy of organic manures with respect to residual effect in all soils was the highest in poultry manure followed by FYM and pig manure in Meghalaya.

2.10 Effects of poultry manure applications on soil quality

Poultry manure provides nutrient content of N, P, K as well as other minerals needed for plant use. In addition, poultry manure also provides many other benefits to improve soil properties and prevent soil erosion, especially after long time land application.

Flynn *et al.,* (1993) found that the N and P content in crop residues in field plots receiving poultry manure were found higher than non-fertilized or chemical fertilized soils. Nitrogen (N) released through mineralization from broiler litter can supply the N requirements of crops, but litter may cause yield reductions and increased NO3-N leaches losses if applied in excess of crop needs.

Gao and Chang (1996) also found that after 18 annual applications of manure, the sand content in the 0 to 15-cm depth of soil in non-irrigated plots and in the 0 to 15 and 15 to 30-cm depths of soil in irrigated plots had decreased significantly. In addition, the changes in soil CEC, total organic carbon content and total nitrogen content in the 0 to 15 and 15 to 30-cm soil depth were reported to increase with the increasing rates of poultry manure.

Hillel, D (1998) suggested that soil organic content supplied from poultry manure affects greatly the physical condition of the soil such as runoff, infiltration, water retention capacity, soil pH and so on.

Dean *et al.,* 2000; Al-Kasi and Licht, 2004; DeLaune *et al.,* 2004) found that soil fertility was also improved in the amended soil with poultry manure in term of increase in the available N, P for following crop season.

Gilley (2000) proved that the application rates of poultry manure and types of poultry manure (broiler or litter) played the main role on the impacts of poultry manure on soil properties.

Whalen *et al., (*2000), Yang *et al.,* (2004), Moore and Edwards, (2005) Tejada *et al.,* (2006) and Varvel, (2006) found that using poultry manure over a long period of time would change the biological and chemical properties of the soil with the increase of soil organic matter.

Khaliq *et al.* (2004) conducted an experiment on role of Poultry Manure & Nitrogen in late Sown Wheat and commented that combine use of organic and inorganic sources of nutrients not only supply essential nutrients but also have some positive interaction to increase nutrient use efficiency in late sown wheat. In late sown wheat, manure and nitrogen management practices can give good results. One of the possible options to maximize the crop production in late sown wheat by using of organic manure. .

Kiani *et al.* (2005) conducted an experiment in which different combinations of organic and inorganic sources were used. It consists of 100%, 50% and 25% N from PM and N. It was concluded that combine use of organic and synthetic fertilizer have significant improvement with 35 % increase in wheat yield of late sown wheat.

Moore and Edwards (2005) investigated the long-term effects of alum treated poultry litter and normal poultry litter manure on soil fertility and found that both treatments increased soil pH value from (5.1 – 5.3) in the beginning to (5.8 – 6.5) at the end of the experiment; thus, this decreased the exchangeable All toxicity when compared to unfertilized controls. In this study, the authors also observed the decrease in soil pH linear with application rates of applied NH_4NO_3 fertilizer. Besides, with alum added to poultry manure, the losses via volatilization were also reduced significantly.

Shah and Ahmad (2006) investigated that by the application of N from PM and urea @ 120 kg per hectare from two sources in ratios 0:100, 25: 75, 50: 50, 75: 25, 100: 0 and 0:0. It was found that treatment in which N was applied from manure and urea in the ratio of 25:75 gave the highest seed yield.

Agbede *et al.* (2008) stated that poultry manure is the organic waste material from poultry consisting of animal feces and urine. Poultry manure is an excellent fertilizer material because of its high nutrient content, especially for nitrogen. Its proper application increased soil and plant nutrient status, increases soil organic matter and water holding capacity.

Reddy *et al.* (2010) reported that manures decompose (mineralize) in the soil releasing nutrients for crop uptake. Poultry manure contains 3-5% Nitrogen, 1.5-3.5% Phosphorus, 1.5-3% Potassium and considerable amount of micro- nutrients and its pH is 6-7. Poultry Manure application registered over 53% increase of Nitrogen level in the soil, from 0.09% to 0.14%. In comparison with all other available manures, poultry manure is considered the best one due to its better decomposition rate and timely availability of nutrients.

Hammad *et al.* (2011) reported that application of manure in combination with fertilizer releases more nutrients. Combine use of chemical and organic nitrogen sources can play an important role in soil fertility. Integrated use of poultry manure and nitrogen in late sown wheat results in higher yield and improve other components of yield. .

Hammad *et al.* (2011) conducted a trial in which different combinations of poultry manure and inorganic fertilizer were used. It was concluded that yield and other yield components of wheat were significantly increased with the combine application of poultry manure and inorganic fertilizer.

2.11 Role of Magnesium

Jacobs (1958) commented that magnesium is transported within the phloem and as such is fairly mobile within the plant, hence deficiency symptoms usually appear first in the older basal leaves often towards the end of the rapid vegetative period when Mg moves to the more active younger expanding leaves. The typical deficiency symptom is chlorosis between the veins of older leaves caused by a disruption to the chloroplasts and hence chlorophyll production.

Bould *et al., (*1983) and Reuter and Robinson, (1998) concluded that the involvement of magnesium in cell wall structure and cell turgor, protein synthesis, carbohydrate movement and formation, as a carrier of phosphorus particularly in oil seed crops (eg. canola), as a component or activator of several enzymes, CO2 assimilation, cation-anion balance and cellular pH.

Grimme (1987) found in cereals, 57-64% of the Mg was in the grain of which 39-62% was translocated from the stem and leaves.

Archer (1988) reported that in monocotyledons chlorosis is in the form of stripes, a plant first looks pale when the plant blade is held up to the light – in cereals yellow/green spots are often arranged in a string like pearls or beads against a lighter background, in older leaves.

According to Draycott and Allison (1998) the role of Mg in plants is primarily in photosynthesis as a constituent of chlorophyll. A healthy crop has 6-10% of leaf Mg associated bound with chlorophyll, increasing to 35% in a deficient crop.

Recently in Mid Canterbury consultants have ascribed paleness in spinach seed crops, particularly in the older leaves to Mg deficiency although plant analysis has not always been conclusive. It may be related to soil pH since spinach prefers higher levels, pH 6.5 (in water) compared to the New Zealand optimum of 5.8-6.2 for most other crops.

2.12 Responses to Magnesium

Marschner (1995) found that nutrient ratios Mg/P, K/Mg and Ca/Mg of both treatments ranked to the middle of the ideal range which realized best assimilation of Mg to play its role in the control and uptake of nutrients and its role as activator for many enzymatic processes in the plant tissues.

Magnesium is related to the group "secondary elements" and involved in many metabolic processes in the plants. Magnesium ionic form (Mg^{++}) adhered to the colloidal particles in the soil is available to be taken up by the plant roots. Chlorotic or necrotic spots spread over the leaves indicate its deficiency. Magnesium deficiency was reported in some Egyptian soils (Attala *et al.,* 1997; El-Safty and Rabii, 1998; Abou Aziz *et al.,* 2000; Dawood *et al.,* 2001).

Chalmers *et al.,* (1999) reported that ADAS work on cereals in Britain in the 1960's on low magnesium soils showed no yield response on a wheat crop that showed leaf symptoms, yet on a barley crop that did not show symptoms one treatment of 63kgMg (as calcined magnesite) gave a significant yield response.

According to El-Fouly *et al.* (2010) available Mg decreases in the period 1998-2006 reached about 80% from the available Mg in 1998.

2.13 Effect of magnesium sulphate on plant growth:

Marschner (1995) found positive effect of Mg on dry biomass accumulation and plant height can be attributed to its role in photosynthesis, as a carrier of phosphorus, improvement of nutrient uptake, sugar synthesis and starch translocation.

Sabo *et al.* (2002) concluded that winter wheat genotypes assimilated 80-130 kg ha^{-1} from the soil and thus Mg availability from the soil could significantly influence dry matter accumulation and crop productivity.

Upadhyay and Patra (2011) found that 200 mg Mg pot^{-1} significantly increased plant height, number of branches per plant, width of flower, number of flower per plant, fresh weight and oil content of chamomile plants.

Dhiraj and Kumar (2012) concluded that foliar nutrients increases crop quality and yield of wheat.

CHAPTER III

MATERIALS AND METHODS

This chapter briefly describes the materials and methods that are used in performing the research work. The chapter is presented under the following heads: site and soil, climate experimental material, land preparation, fertilizer application, seed sowing, intercultural operation, harvesting and threshing, data collection, plant analysis and statistical analysis.

3.1 Site and soil

A field experiment was conducted in the Soil Science Research Field, Department of soil science in HSTU during November, 2016 to March, 2017. The field is located at 22.04^o N latitude and 88.01^{o}E longitudes at a height 37m above the main sea level. The land was medium high belonging to the Old Himalayan piedmont plain (AEZ 1), which falls into non calcareous brown floodplain soils the general characteristics of the soil are presented in Table 3.1.

Table 3.1: Morphological, physical and chemical characteristics of the soils of soil science research field of HSTU

*** Morphological characteristics**		
Locality	:	HSTU research field
AEZ	:	Old himalayan piedmont plain
General soil type	:	Non calcareous brown floodplain
Drainage	:	Well drained
Topography	:	Medium high land.
Textural class	:	Sandy loam
Drainage	:	Moderate
*** Chemical characteristics**		
pH (soil: water = 1:2.5)	:	5.6
Organic matter (%)	:	0.96
Total N (%)	:	0.05
Available P (µg g^{-1})	:	14.60
Exchangeable K (meq 100g $^{-1}$ soil)	:	0.20
Available S (µg g^{-1} soil)	:	12.36
Available Mg (meq/100gm soil)		2.4

3.2 Climate

In the experimental area, usually the rainfall was heavy during summer season (April to September) and scanty in winter (October to March) season.The summer (March-September) is hot and humid and the winter (November-February) is moderate with occasional rainfall. The maximum temperature during the warm months of April to May varies from 28.8^{o}C to 35.9°C while January is the coldest month. The minimum temperature varies from 9.6^{o}Cto 12.9°C .Winter season starts with low temperature and plenty sunshine. The atmospheric temperature increases from February as the season proceeds towards summer. The average weekly rainfall, temperature, humidity and sunshine hours during the growing period of the crop are given in appendix I.

3.3 Test crop

The test crop under the study was wheat BARI Gom – 25 (*Triticum aestivum).* This variety has gained popularity among the farmers of Bangladesh for its high yield potential. Healthy, vigorous, plumy and well-matured seeds were selected for sowing.

3.4 Treatments

There were twelve treatments comprising two factors. The factors are -

Factor A- 4 levels of Mg (Mg_o Mg_{1o}, $Mg_{15,}$ Mg_{20}) as $MgSO_4$

Factor B- 3 levels of PM ($PM_{0,}$ PM_5, M_{10})

Treatment combination will be as follows:

T_1 = PM_0Mg_0	T_7 = PM_5Mg_{15}
T_2 =PM_0Mg_{10}	T_8 = PM_5Mg_{20}
T_3 = PM_0Mg_{15}	T_9 = $PM_{10}Mg_0$
T_4= PM_0Mg_{20}	T_{10} = $PM_{10}Mg_{10}$
T_5 = PM_5Mg_0	T_{11} = $PM_{10}Mg_{15}$
T_6 = PM_5Mg_{10}	T_{12} = $PM_{10}Mg_{20}$

3.5 Land preparation

Land preparation was started 7 days before seed sowing. The land was first opened by a tractor and the land was prepared thoroughly by ploughing and cross ploughing with a power tiller. Every ploughing was followed by laddering to obtain a good tilth. Weeds and stubbles were collected and removed from the field. Field lay out was done on 9, November, 2016, according to the design adopted.

3.6 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications (Fig. 3.1). The treatments were randomly distributed to the plots.

The lay out of the experiment was as follows:

Total number of plots = 4 (Mg. levels) x 3 (PM levels) x 3 (replications) = 36

Individual plot size = 4 m x 2.5 m = 10 m^2

Space between unit plots = 0.5 m

Space between replication = 1 m

Table 3.2: Nutrient content of poultry manure

Total N (%)	Total P_2O_5 (%)	Total K_2O (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)
2.87	1.07	1.70	1380	90	7.1	210

Source: Mountey, 1983 and Signh, 1992

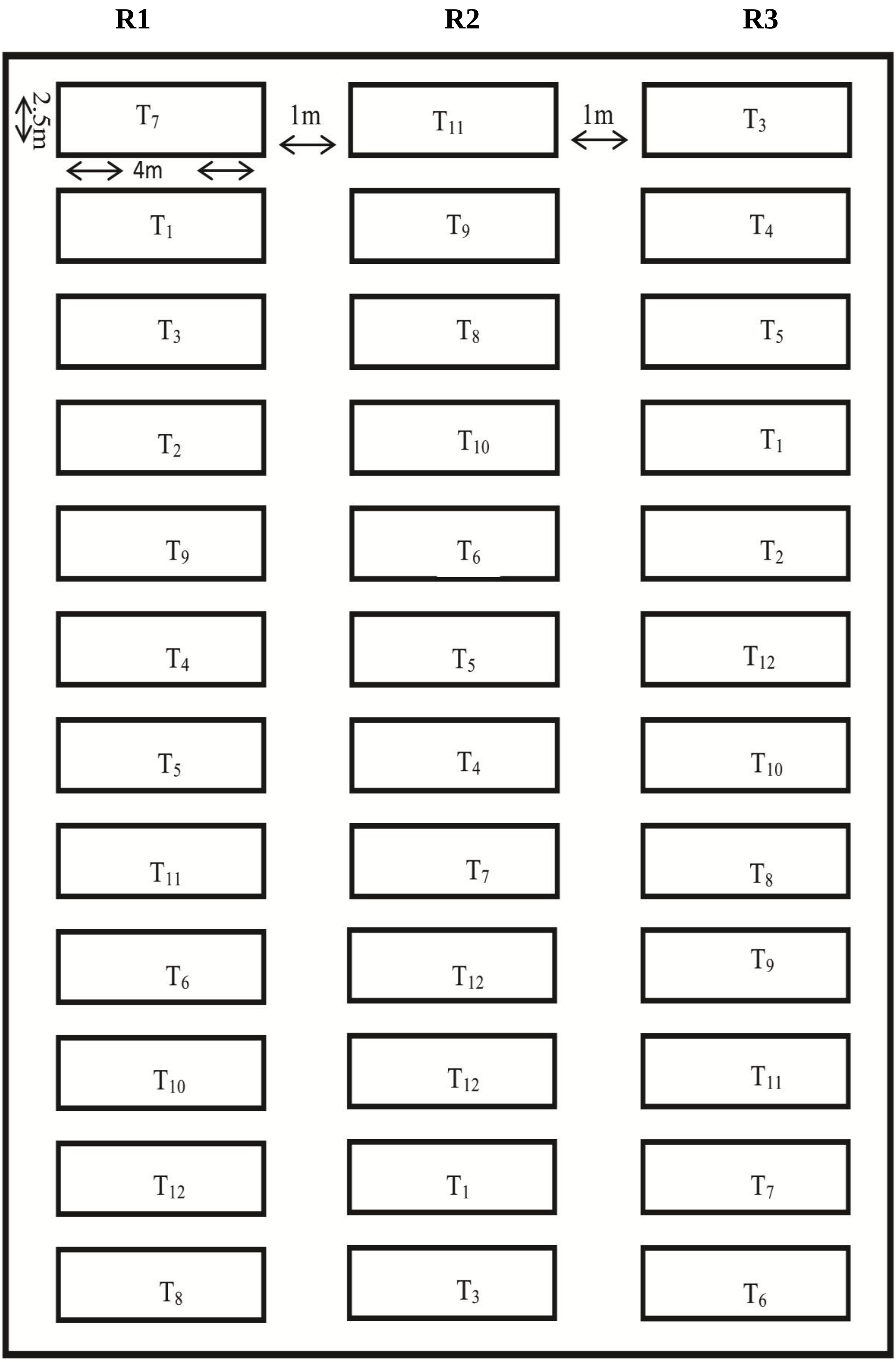

Figure 3.1: Layout of the experimental plot

3.7 Collection of seeds

The seed were collected from the Pourashava Road market, Sadar Upazilla, Dinajpur.

3.8 Fertilizer application

Magnesium containing fertilizer as magnesium sulphate ($MgSO_4$) was applied as per design and treatments and all other fertilizers were applied according to the fertilizer recommendation guide .Poultry manure (PM) was applied as per design and treatments. The full amount of phosphorus, potassium and sulphur and one half of the nitrogen were applied during final land preparation in the form of triple super phosphate, murate of potash, gypsum and urea, respectively. Another one half of nitrogen was added after 30 days of sowing. The fertilizers were incorporated to soil by spading one day before sowing.

Table 3.3: Nutrient elements, their sources and doses used in the experiment

Nutrient elements	Source	Dose
Nitrogen	Urea (46% N)	130 kg ha $^{-1}$
Phosphorus	TSP (48%p)	80 kg ha $^{-1}$
Potassium	MP (60% K)	40 kg ha $^{-1}$
Zinc	$ZnSO_4$ (65% Zn)	5 kg ha $^{-1}$
Sulphur	Gypsum (18% S)	100 kg ha $^{-1}$
Poultry manure		0,5,10 t ha^{-1}
Magnesium	magnesium sulphate	0 kg ha $^{-1}$,10kg ha $^{-1}$,15 kg ha $^{-1}$,20 kg ha $^{-1}$
Boron	Boric acid	6 kg ha $^{-1}$

3.9 Sowing of seeds

Seeds were sown at the rate of 125 kg ha^{-1}.Seeds were sown in the plots on 15th November, 2016. Sowing was made continuously in lines and seeds were covered by soil manually. The spacing between lines was 25 cm.

3.10 Germination of seeds

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

3.11 Intercultural operation

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

3.11.1 Thinning and gap filling

All the seedlings of the crop emerged out within 6-8 days after sowing. Thinning and gap filling were done simultaneously at 16 and 30 days after sowing..

3.11.2 Irrigation

Three irrigation were applied. The first irrigation 20 DAS(CRI stage). 2nd irrigation was done 40 DAS. 3rd irrigation 70 DAS (grain formation stage).

3.11.3 Weeding

Weeding was done twice during whole growing period. The one after 25 days of sowing and the other 40 DAS.

3.11.4 Insect and pest control

During maturation four plots were slightly infested by rat the pest was controlled by using mechanical control measures and application of zinc phosfide.

3.12 Harvesting and threshing

The crop was harvested at maturity on 25th March 2017. The sample plants from each unit plot were uprooted at random prior to harvest, which were dried properly for collecting data on yield components. Threshing, cleaning and drying of grain were done separately for plot. Then plot wise weights of grain and straw were recorded.

3.13 Data collection

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

i. Plant height
ii. Number of tillers hill^{-1}
iii. Spikelets spike^{-1}
iv. Spike length.
v. No of Grains spike^{-1}
vi. 1000- seeds weight
vii. Grain yield
viii. Straw yield
ix. Biological yield

3.13.1 Plant height

Height of plant in cm was measured from the ground level to the top of the spike. From each plot, height of10 plants were measured and averaged.

3.13.2 Number of tillers hill^{-1}

Ten hills were selected from each plot randomly. The number of effective and non –effective tillers plant^{-1} were counted and averaged.

3.13.3 Spike length

Length of spikes in ten selected plants per plot was recorded in cm and their average values were calculated.

3.13.4 Spikelets spike^{-1}

Total number of spikelets spike^{-1} was calculated and averaged from five randomly selected plants from each plot.

3.13.5 Number of grains spike^{-1}

Each spike was selected and the number of grains spike-1 was recorded and averaged.

3.13.6 1000-grains weight

1000-grains were randomly selected from each plots and the weight of grains recorded in gram after sun drying in an electrical balance.

3.13.7 Grain yield

After harvesting of the crop, grain from each unit plot was dried and weighed. The result was expressed as t ha-1 on 14% moisture basis.

3.13.8 Straw yield

Straw obtain from each plot including the straw of 10 sample plants of the respective plot was dried in the sun and weighed to determine the straw yield/plot and was expressed in t ha^{-1}.

3.13.9 Biological yield

The sum of grain yield and straw yield are termed as the biological yield of a crop. The biological yield of wheat was measured for each plot and express in t/ha.

3.14 Soil analysis

The initial and post harvest soil samples were stored for analysis of pH, organic matter, CEC, Textural class, N, P, K, S, Zn and Mg contents. The post harvest soil were analyzed for soil pH, available P, Ca and Mg.

3.14.1 Collection and preparation of soil sample

Before final land preparation soil sample were collected randomly from 10 spots of the filed from a depth of 15 cm. A composite sample was prepared by mixing sub-sample and the weeds, stubbles, stones, etc were removed from the sample.

After harvest the soil sample were collected plot wise. Then the soil sample were air dried ground and sieved through 2mm (10 mesh) sieve. The sieved soil sample were stored in a clean plastic container for subsequent mechanical and chemical analysis.

3.15 Mechanical analysis

Mechanical analysis was done by hydrometer method (Bauyoucos, 1954). The textural class was determined following Marshalls triangular coordinate using USDA system.

3.15.1 Soil pH

Soil pH was determined in a soil/water extract (1:2.5) by using glass electrode pH meter according to Jackson (1973).

3.15.2 Organic carbon and organic matter content in soil

Organic carbon of the soil sample was determined by wet oxidation method of Walkley and Black (1934). The underlying principle of this method is to oxidize the organic matter with an excess of $K_2Cr_2O_7$ in presence of concentrated H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 0.5 N $FeSO_4$. The organic matter content of the soil was calculated multiplying the percent of organic carbon with Van Bemmelen factor. The result was expressed in percentage.

$$\text{Organic Carbon (\%)} = \frac{V_1 - (V_2 \times N)}{W} \times 0.003 \times 1.3 \times 100$$

Where,

V_1 =Volume of N $K_2Cr_2O_7$ solution

V_2 = Volume of N $FeSO_4$ solution

W = Weight of soil

N = Normality of $FeSO_4$ solution

1.3 = Conventional recovery factor

Organic matter (%) = Organic carbon (%) × 1.73

1.73 = Van Bemmelen factor

Organic matter was determined using the potassium di-chromate method according to Walkely and Black (1934).

3.15.3 Total nitrogen content in soil

Nitrogen was determined using Micro-Kjeldahl method (Brenner and Mulvancey, 1982). The soil sample was digested with conc. H_2S0_4 in presence of catalyst mixture (K_2SO_4: $CuSO_4$: Se = 10: 1: 0.1). Nitrogen in the digest was estimated by distillation with 10N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01 N H_2S0_4).

3.15.4 Available phosphorus in soil

Soil P was extracted using sodium bicarbonate ($NaHCO_3$) (Olsen *et al.*, 1954). Phosphorus was photometrical determined using the molybdate-vanadate method Chemical and physical properties of the soil are shown in Table 1.

3.15.5 Exchangeable potassium in soil

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

3.15.6 Available sulphur in soil

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

3.15.7 Exchangeable magnesium in soil

Exchangeable magnesium content of soil was determined by extraction with 1M ammonium acetate, pH 7.0 solution followed by measurement by atomic absorbtion spectrometer (Petersen, 2002).

3.16 Plant sample

Plant samples were collected from the plot during harvesting. Ten plants from each plot were carefully uprooted through random selections with the help of a nirani. The fresh weight of plant samples were recorded and then dried in air followed by oven drying at 60^0 C for 48 hours and the dry weight of the plants were noted.

3.17 Statistical analysis

All the collected data were subjected to statistical analysis following the ANOVA technique and the mean were compared by Duncan's New Multiple Range Test. The analysis of variance for different parameter was done a computer package programme DMRT.

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to determine the effect of magnesium (Mg) and poultry manure (PM) on the 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, spike length, number of tillers hill^{-1}, number of grain spike^{-1}, 1000 grain weight, straw yield, grain yield ha^{-1} and biological yield were recorded in every trial.

4.1 Effect of poultry manure and magnesium on the growth of wheat

4.1.1 Plant height

The plant height of wheat was significantly influenced by the different treatments (Table 4.1). The application of magnesium (Mg) and poultry manure (PM) significantly increased the plant heights of wheat compared to that found in control. The plant height increased progressively with the application of increasing level of Mg and PM. The highest plant height (104.7 cm) was recorded in the treatment $T_{11.}$ The lowest plant height (93.00 cm) was recorded in control (T_1). Magnesium transport through the xylem vessel and increasing sugar and hydrocarbons which helps in the higher growth of the plant. Many research worker reported that combine application of manure and fertilizers increased plant height (Khan *et al.,* 2007). Similar results were recorded by Moeinian *et al.* (2011).

4.1.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} is an important yield determining factor in wheat. It affects number of grains per spike and grain weight. A significant change in number of tillers was noticed with the application of Mg and PM. The number of tiller hill^{-1}

enhanced with increasing doses of Mg and PM. The maximum tiller hill^{-1} (6) was found in the treatment T_{11} which was statistically similar the treatments T_{12}, T_5, T_8, T_{10} and T_{12}. The lowest tiller number (3.00) was observed in the control treatment (T_1). Agbede *et al.* (2008) stated that the poultry manure is an excellent fertilizer material because of its high nutrients contents, especially for nitrogen which increases the number of tiller plant $^{-1}$. The increase in number of tillers hill^{-1} with PM due to the reason of more nutrient availability by PM throughout the growing season.

4.1.3 Spike length

The application of Mg and PM effect the length of spike significantly (Table 4.1). The spike length varied from 17.46 to 18.54 cm. The highest and statistically superior spike length 18.54 cm was recorded in the treatment T_{10}. On the other hand, the lowest spike length 17.7 cm was obtained in the treatment $T_1$and T_9.The increase in spike length with increasing doses of PM. This was due to the reason of more nutrient availability by PM throughout the growing season. Similar result was recorded by Hammad *et al., 2011.*

4.1.4 Spikelet spike^{-1}

The number of spikelet spike^{-1} in different treatments more or less same. The number of spikelet spike^{-1} ranged from 16.40 to 19.00. The highest number of spikelet per spike was found in the treatment T_{11}. On the other hand the lowest number of spikelet spike^{-1} was found in control treatment.

4.1.5 Number of grains spike^{-1}

The number of grains per spike is also an important parameter contributing towards final yield. Data presented in table 4.1 show that the number of grain per spike was significantly affected by different level of PM and Mg. The effect of different levels of Mg and PM was significant as observed on number of grain spike^{-1}. The number of grain spike^{-1} increased with increasing Mg and PM levels. The maximum number of grain spike^{-1} (41.6) was noticed at T_{11} treatment which was statistically identical with the treatments T_6. T_2, T_5, $T_{7,}$ T_{10} and T_{12}. The lowest number of spike^{-1} (30) was found in T_1 treatment (Table 4.1).

4.1.6 1000 grain weight

Magnasium and poultry manure greatly influenced the 1000 grain weight of wheat (Table 4.1).The highest 1000 grain weight (46.8 g) was recorded from the treatment T_{11}. The lowest weight (43.4 g) was recorded under control. These results suggest that combined use of appropriate doses of Mg and PM produced maximum 1000 grain weight than the use of same dose of Mg or PM along.

4.1.7 Grain yield

The grain yield of wheat was significantly influenced by the different treatments. Application of PM along with different levels of Mg showed the variation for grain yield (Table 4.2). The highest yield (5.3 t ha^{-1}) was recored in the treatment T_{11} which was closely followed by T_{12} treatment (5.3 t ha^{-1}) and the lowest grain yield (2.9 t ha^{-1}) was recorded in the control treatment (Table 4.2). Asit *et al.* (2007) found that increased grain yield with the application of manure and fertilizer in an integrated way. Similar result was found by Abdel Magid *et al.* (1995) who reported that grain and straw yield of wheat increased with increased rate of poultry manure. The increase in grain yield with the increase level of PM could be due to balanced supply of nutrient from PM throughout the plant development to grain formation.

4.1.8 Straw yield

The different levels of PM and Mg application showed significant variation of straw yield of wheat (Table 4.2). The straw yield varied from 2.5 to 4.7 t ha^{-1} (Table 4.2). The highest straw yield of 4.7 t ha^{-1} was recorded in the treatment of (T_{11}) which was identical with the treatment T_{12}.On the other hand, the lowest straw yield of 2.5 t ha^{-1} was obtained in the control treatment (T_1). Akhtar *et al.* (2011) observed that the combined application of manure and fertilizers increased the straw yield of wheat. Similar result was recorded by Abdel Magid *et al.* (1995)

who reported that grain and straw yield of wheat increased with increased rate of poultry manure.

4.1.9 Biological yield

The different levels of PM and Mg application showed significant variation of biological yield of wheat (Table 4.2). The biological yield varied from 5.4 to 10.0 t ha^{-1} (Table 4.2). The highest biological yield of 10.0 t ha^{-1} was recorded in the treatment combination of (T_{11}). On the other hand, the lowest biological yield of 5.4 t ha^{-1} was obtained in the control treatment (T_1).

Table 4.1: Effect of poultry manure and magnesium on yield contributing characters of wheat (BARI Gom 25).

Treatment	Plant height (cm)	Tiller numbers hill^{-1}	Spike length (cm)	Spiklet number spike^{-1}	No. of grain spike^{-1}	1000 grain wt.(gm)
T_1	93.00	3.00 d	17.46	16.40	20.20 e	43.40
T_2	99.00	3.60 cd	18.10	18.20	39.60 abc	44.00
T_3	96.00	3.60 cd	18.28	16.80	31.20 d	43.60
T_4	99.66	4.60 bc	17.70	18.40	32.80 cd	44.10
T_5	100.3	5.00 abc	18.48	17.20	35.60 abcd	44.40
T_6	103.7	4.60 bc	17.62	18.00	40.20 ab	44.40
T_7	99.00	4.20 bcd	18.12	17.60	39.80 abc	45.00
T_8	102.0	5.00 abc	18.32	17.40	33.20 bcd	44.50
T_9	103.0	4.60 bc	17.46	17.80	30.00 d	44.90
T_{10}	104.0	4.80 abc	18.54	17.40	35.00 abcd	46.00
T_{11}	104.7	6.00 a	18.40	19.00	41.60 a	46.80
T_{12}	104.0	5.60 ab	18.42	17.40	39.20 abc	46.10
LSD	11.48	1.226	3.340	3.318	6.407	4.254
CV %	6.73	15.91	10.91	11.11	10.85	6.44

In the column, figures without letter do not differ significantly whereas figures with dissimilar letter differ significantly at 5% level of Probability (as per DMRT).

Treatment combination will be as follows:

$T_1 = PM_0Mg_0$ | $T_7 = PM_5Mg_{15}$
$T_2 = PM_0Mg_{10}$ | $T_8 = PM_5Mg_{20}$
$T_3 = PM_0Mg_{15}$ | $T_9 = PM_{10}Mg_0$
$T_4 = PM_0Mg_{20}$ | $T_{10} = PM_{10}Mg_{10}$
$T_5 = PM_5Mg_0$ | $T_{11} = PM_{10}Mg_{15}$
$T_6 = PM_5Mg_{10}$ | $T_{12} = PM_{10}Mg_{20}$

Table 4.2: Effect of poultry manure and magnesium on the grain yield, straw yield and biological yield of wheat (BARI Gom 25).

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
T_1	2.9 d	2.5 e	5.4 cd
T_2	3.0 d	2.6 de	5.6 d
T_3	3.4 cd	3.07 cd	6.47 c
T_4	4.3 b	3.8 b	8.1 b
T_5	3.2 d	2.8 de	6.0 cd
T_6	4.0 bc	3.5 bc	7.5 b
T_7	4.1 b	3.6 b	7.7 b
T_8	4.2 b	3.7 b	7.9 b
T_9	3.1 d	2.7 de	5.8 cd
T_{10}	4.1 b	3.6 b	7.7 b
T_{11}	5.3 a	4.7 a	10.0 a
T_{12}	5.2 a	4.6 a	9.8 a
LSD	0.6058	0.4512	0.7942
CV %	9.17	7.78	6.36

In the column, figures without letter do not differ significantly whereas figures with dissimilar letter differ significantly at 5% level of Probability (as per DMRT).

Treatment combination will be as follows:

T_1 = PM_0Mg_0 T_7 = PM_5Mg_{15}

T_2 =PM_0Mg_{10} T_8 = PM_5Mg_{20}

T_3 = PM_0Mg_{15} T_9 = $PM_{10}Mg_0$

T_4= PM_0Mg_{20} T_{10} = $PM_{10}Mg_{10}$

T_5 = PM_5Mg_0 T_{11} = $PM_{10}Mg_{15}$

T_6 = PM_5Mg_{10} T_{12} = $PM_{10}Mg_{20}$

4.2 Chemical Properties of the soil collected after harvesting

4.2.1 Soil pH

The application of PM and Mg had a significant difference on soil pH. The pH of the post-harvest soil was acidic in nature which ranges from 5.6 to 6.3 (Table 4.3). The initial soil also showed the acidic nature (Table 4.3). The highest soil pH (6.3) was found in the treatment T_{11} and T_{12}. The lowest soil pH (5.6) was found in the treatment T_1 and T_2.

4.2.2 Organic matter content in soil

The effect of Mg and PM was significant on organic matter (OM) content in the soil. The application of Mg and PM effects on the increased the organic matter status in soil. This contents ranged from 0.95 to 2.31%. The highest amount of organic matter content was found in T10 treatment which was statistically similar with T_7, T_8, T_{11} and T_{12}. And the lowest amount of organic matter content was observed in the treatment T_1. Similar result was recorded by Agbede *et al.* (2008) stated that poultry manure increases soil organic matter content in soil.

4.2.3 Total nitrogen in soil

The application of Mg and PM has a significant effect on total nitrogen in soil. Due to the application of Mg and PM increased the total soil nitrogen content in different treatments. Soil nitrogen of the post-harvest soil was higher than the initial soil. The highest total soil nitrogen was found both in T_{11} and T_{12} treatments and the lowest soil was found in the T_1 treatment (Table 4.3). Similar result was stated by Rayar (1984) that increase in available N was noticed when poultry manure; swine manure and FYM were applied to the soil.

Table 4.3: Effect of poultry manure and magnesium and on the soil pH, organic matter and total N content of the post-harvest soil

Treatment	pH	Organic matter (%)	Total Nitrogen (%)
T_1	5.6 c	0.95 f	0.05 b
T_2	5.6 c	1.50 e	0.07 ab
T_3	5.7 bc	1.90 cd	0.07 ab
T_4	5.8 abc	1.96bc	0.08 ab
T_5	5.9 abc	1.64 de	0.10 ab
T_6	6.00 abc	1.93bcd	0.10 ab
T_7	5.9 abc	2.15abc	0.09 ab
T_8	6.0 abc	2.21 abc	0.08 ab
T_9	6.1 abc	1.37 e	0.08 ab
T_{10}	6.2 ab	2.31a	0.11ab
T_{11}	6.3 a	2.25 ab	0.12a
T_{12}	6.3 a	2.29 a	0.12a
LSD	0.4937	0.2933	0.05355
CV %	4.91	9.19	13.87

In the column, figures without letter do not differ significantly whereas figures with dissimilar letter differ significantly at 5% level of Probability (as per DMRT)

Treatment combination will be as follows:

$T_1 = PM_0Mg_0$ $T_7 = PM_5Mg_{15}$
$T_2 = PM_0Mg_{10}$ $T_8 = PM_5Mg_{20}$
$T_3 = PM_0Mg_{15}$ $T_9 = PM_{10}Mg_0$
$T_4 = PM_0Mg_{20}$ $T_{10} = PM_{10}Mg_{10}$
$T_5 = PM_5Mg_0$ $T_{11} = PM_{10}Mg_{15}$
$T_6 = PM_5Mg_{10}$ $T_{12} = PM_{10}Mg_{20}$

Table 4.4: Effect of poultry manure and magnesium and on the available P, exchange K, available S and exchangeable Mg content of the post-harvest soil

Treatment	Availlable Phosphorus (ppm)	Exchangeable Potassium (meq/100 gm soil)	Available Sulpher (ppm)	Exchangleable Magnesium (meq/100gm soil)
T_1	40.01 e	0.27	25.79 g	2.4 c
T_2	57.42 d	0.32	25.98g	3.4 b
T_3	64.70 cd	0.37	29.68 efg	3.5 b
T_4	56.49 d	0.29	32.70 def	3.7 ab
T_5	88.26 a	0.43	33.91 cde	2.5 c
T_6	93.68 a	0.33	27.26 fg	3.5 b
T_7	72.87 bc	0.35	29.38 efg	3.6 ab
T_8	69.59 bc	0.38	35.43 bcd	3.8 ab
T_9	75.60 b	0.37	38.27 abc	2.7 c
T_{10}	71.40 bc	0.36	41.00 a	3.5 b
T_{11}	72.88 bc	0.38	41.20 a	3.6 ab
T_{12}	73.82 bc	0.42	39.80 ab	4.0 a
LSD	9.018	5.936	5.039	0.3935
CV %	7.64	12.29	8.92	6.94

In the column, figures without letter do not differ significantly whereas figures with dissimilar letter differ significantly at 5% level of Probability (as per DMRT)

Treatment combination will be as follows:

$T_1 = PM_0Mg_0$ | $T_7 = PM_5Mg_{15}$
$T_2 = PM_0Mg_{10}$ | $T_8 = PM_5Mg_{20}$
$T_3 = PM_0Mg_{15}$ | $T_9 = PM_{10}Mg_0$
$T_4 = PM_0Mg_{20}$ | $T_{10} = PM_{10}Mg_{10}$
$T_5 = PM_5Mg_0$ | $T_{11} = PM_{10}Mg_{15}$
$T_6 = PM_5Mg_{10}$ | $T_{12} = PM_{10}Mg_{20}$

4.2.4 Available phosphorus in soil

The phosphorus content of the post-harvest soil varied significantly by the different treatments (Table 4.4). The maximum phosphorus content (93.68 ppm) was found in the treatment T_6 which was identical with followed by T_5 treatment. The lowest phosphorus content (40.01ppm) was observed in the control treatment (T_1). Ravikumar and Krishnamoorthy (1983) reported that application of poultry manure increased the available P content of the soil.

4.2.5 Exchangeable potassium in soil

There were no significant difference in the exchangeable potassium content in soil. The exchangeable potassium content of the post-harvest soil was influenced by the different treatments. The values of the exchangeable potassium varied from 0.27 to 0.43 meq 100 g^{-1} soil (Table 4.4). The highest value of 0.43 meq 100 g^{-1} soil ^{1}was observed in the treatment $T_{5.}$ The lowest value of 0.27 meq 100 g^{-1} soil was found in the T_1 treatment. The increase in available K is due to the supply nutrients from PM throughout the growing season. A similar observation was made by Kingery et. al., (1993) who reported that using of poultry manure improves K content in soil.

4.2.6 Available sulphur in soil

The post-harvest soil which content available sulphur was significantly different for the different treatments. The available sulphur content in the studied soil ranged from 25.79 to 41.20 ppm (Table 4.4). The highest sulphur content (41.20 µg g^{-1} soils) was found in the treatment T_{11} which was statistically similar to those in T_9, T_{10} and T_{12} treatments. The lowest sulphur content (25.79 ppm) was observed in the treatment T_1.

4.2.7 Exchangeable magnesium in soil

The post-harvest soil which content exchangeable magnesium was different for the different treatments. The exchangeable magnesium content in the studied soil varied between 2.4 and 4.0 meq per 100 g soil. (Table 4.4). The highest magnesium content (4.0 meq per 100 g soil) was found in the treatment T_{12} which was statistically similar with T_4, T_7, T_8 and T_{11} treatments. The lowest magnesium (2.4 meq per 100 g soil) was recorded in the control treatment (T_1) which is statistically similar with T_5 and T_9 treatment.

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 February 2017. The experiment was laid out in a Randomized Complete Block Design (RCBD) with twelve treatments and three replications. The unit plot size was 10 m^2 (4 m × 2.5 m). Twelve fertilizer treatments were used and which were $T_1 = PM_0Mg_0$, $T_2 = PM_0Mg_{10}$, $T_3 = PM_0Mg_{15}$, $T_4 = PM_0Mg_{20}$, $T_5 = PM_5Mg_0$, $T_6 = PM_5Mg_{10}$, $T_7 = PM_5Mg_{15}$, $T_8 = PM_5Mg_{20}$, $T_9 = PM_{10}Mg_0$, $T_{10} = PM_{10}Mg_{10}$, $T_{11} = PM_{10}Mg_{15}$, $T_{12} = PM_{10}Mg_{20}$. Recommended doses of N, P, K, S and Zn were applied in all the treatments. They were distributed randomly in individual plots. The total numbers of plots were 36 (12×3). Magnesium was applied as magnesium sulphate and N, P, K was applied as urea, triple super phosphate and muriate of potash at the rate of 130, 80, and 40 kg ha^{-1} respectively. Seeds were sown on the 15^{th} November 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 25 th March, 2017. Plot wise yield and yield components were recorded.

Magnesium (Mg) and poultry manure (PM) fertilization significantly increased the plant height. The highest plant height (104.7 cm) was observed in the treatment combination of $PM_{10}Mg_{15}$ closely followed by treatment combination of PM_0Mg_{10} and $PM_{10}Mg_{20}$. The number of tillers $plant^{-1}$ varied significantly by the combination of PM and Mg. The maximum number of tillers was observed in T_{11} treatment and minimum in the control treatment T_1. The number of grain per spike also increased by PM and Mg fertilization and ranged from 20.20 to 41.60. The significant increased was obtained in T_{11} treatment. Spike length was also significantly influenced by Mg and PM application which varied between 17.46 and 18.42 cm.

1000-seed weight was found significant with different levels of Mg and PM fertilizer and was found maximum in the treatment T_{11} showing other treatment more or less same. Grain yield ranged from 2.9 to 5.3 t ha^{-1} due to the effect of different level of Mg and PM application. The lowest grain yield was observed in T_1 treatment and the highest was in T_{11}. Straw yield was also significantly positive as an effect of Mg and PM application. The rate of increased in straw yield continued to treatment combination of $PM_{10}Mg_{15}$. The different levels of Mg and PM application showed significant variation of biological yield of wheat. The highest biological yield of 10.0 t ha^{-1} was recorded in the treatment (T_{11}). On the other hand, the lowest biological yield of 5.4 t ha^{-1} was obtained in the control treatment (T_1).

The treatment of T_{11} followed by T_{10} and T_{12} of BARI Gom 25 produced higher values of yield, whereas the lowest was recorded in the treatment T_1. However, for maximizing the grain yield of wheat 10 t PM ha^{-1} with 15 kg Mg ha^{-1} could be applied.

Recommendation

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

- Further study may be needed to ensure the growth and yield performance of wheat in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.
- More inorganic and organic fertilizers may be needed to include for future study as sole or different combination to confirm in replacing chemical fertilizer doses.

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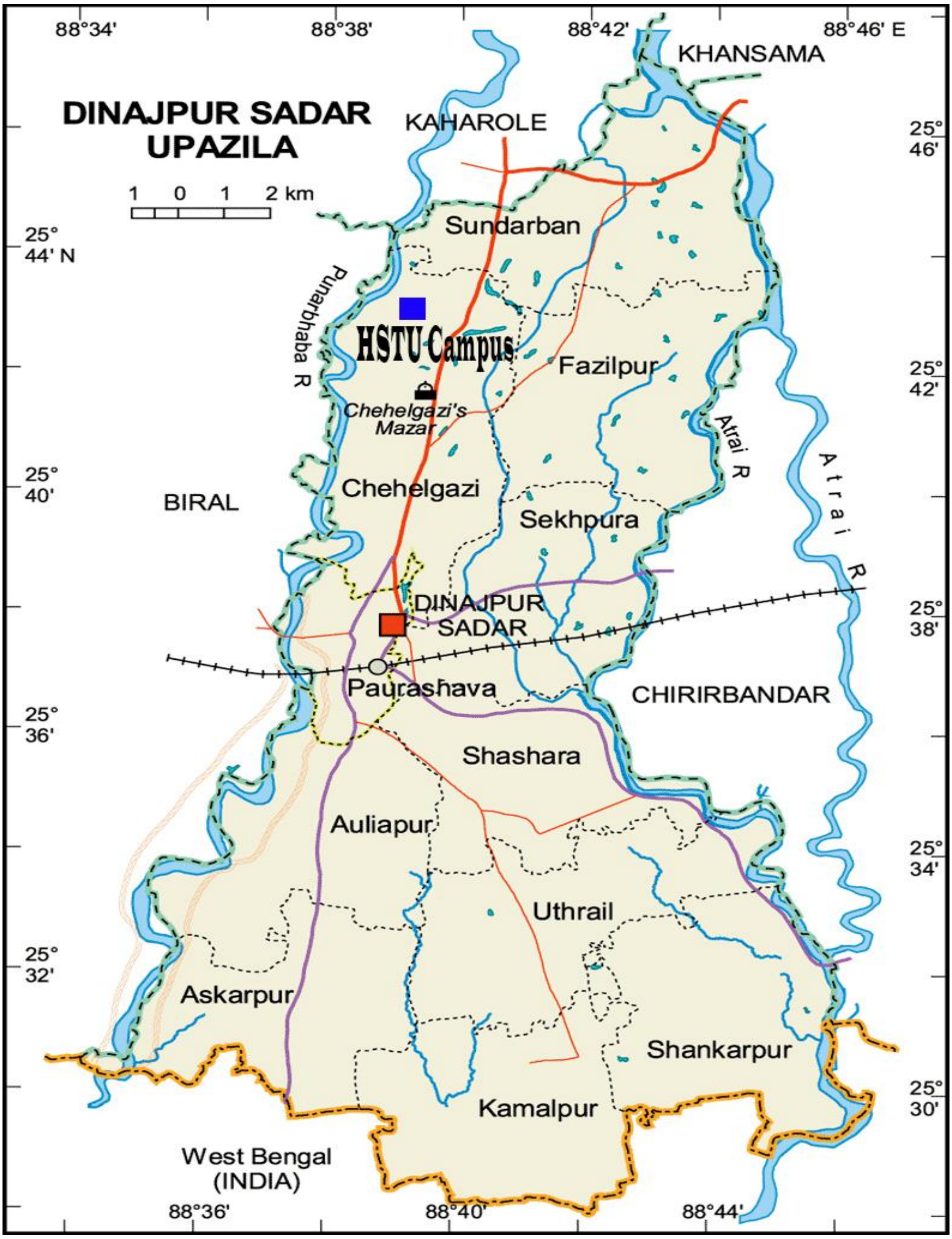
APPENDICES

Appendix I: Experimental site (Map of Dinajpur Sadar Upazila Showing the Research Field)



Appendix II: Monthly recorded air temperature, relative humidity and rainfall during November, 2016 to February, 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		81	4
	February	12.5	28.1		77	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	01.11.2016
2	Cross ploughing	01.11.2016
3	Breaking of clods, laddering	01.11.2016
4	Final land preparation	08.11.2016
5	Layout of experimental plot	09.11.2016
6	Fertilizer application	10.11.2016
7	Sowing of seed	15.11.2016
8	Thinning	11.12.2016
9	1st irrigation	15.12.2016
10	1st weeding	25.12.2016
11	Application of the 1/3rd doses of urea	27.12.2016
12	2nd weediong	04.01.2017
13	2nd irrigation	05.01.2017
14	3rd irrigation	02.02.2017
15	Harvesting	25.03 .2017
16	Threshing	30.03.2017
17	Weighing	30.03.2017

Appendix IV: Some photographs showing different treatments during research work

Plate 1: 15 days after sowing

Plate 2: 30 days after sowing

Plate 3: 60 days after sowing

Plate 4: 90 days after sowing