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Improvement yield and nitrogen uptake of wheat through application of organic and inorganic fertilizers

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Abstract

An experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during winter (Rabi) season of 2013-14 to evaluate the effect of integrated use of organic and inorganic fertilizers on the growth, yield and nitrogen (N) uptake of wheat. There were six treatments such as T_0 (control), T_1 [STB-CF (HYG)], T_2 [STB-CF (HYG) + CD (5 t/ha)], T_3 [STB-CF (HYG) +PM (3 t/ha)], T_4 [STB-CF (HYG) COM (5 t/ha)] and T_5 [FP (Farmers' practice)]. The experiment was laid out in a Randomized Complete Block Design with four replications. Soil test based nitrogen, phosphorus, potassium, sulphur, zinc and boron were used @ 100, 20, 60, 10, 3 and 2 kg ha^{-1}, respectively. The integrated use of organic and inorganic fertilizers significantly increased the yield attributes as well as grain and straw yields of wheat. The treatment T_3 [STB-CF (HYG) + PM (3 tha^{-1})] produced the highest grain yield of 3554 kg ha^{-1} (69.67% increase over control) and straw yield of 3635 kg ha^{-1} (62.83% increase over control). The lowest grain yield (2094 kg ha^{-1}) and straw yield (2232 kg ha^{-1}) were found in control treatment. The N content and uptake by wheat were also markedly influenced by combined use of organic and inorganic fertilizers and the treatment T_3 demonstrated superior performance to other treatments. So, the applications of fertilizers in combination with poultry manure @ 3 t ha^{-1} can be used for the successful cultivation of wheat in Old Brahmaputra Floodplain soil.

Key words: Cowdung, poultry manure, compost, wheat yield, nitrogen uptake

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Introduction

Wheat (*Triticum spp*) is the most important cereal crop and ranks first both in acreage and production of the world (BBS, 2011). It has been established as the second most important staple food crop after rice in Bangladesh (Indira 2006). It is cultivated in different agro-ecological regions of the country. The production of wheat per unit area in Bangladesh is very low in comparison to that of agriculturally developed countries of the world due to paucity of agricultural inputs (Razzaque *et al.,* 1992). Bangladesh produces 14,53,000 metric tons of wheat per annum from 16,86,000 acres of land (BBS, 2011).It provides grains rich in food values containing 14.7% protein, 78.1% starch and 2.1% mineral matters (Peterson, 1965). Bangladesh is a small country with large population and its population is increasing day by day. So, the cereal crop like wheat should be increased to meet the demand of the escalating population.

The beneficial role of animal manure in crop production has long been recognized. The utilization of cattle manure as a soil amendment is an integral part of the tropical countries farmers. However, the information that is lacking to most of the farmers is the methods of manure management practices for optimal quality before field application and time of

application of animal manure for optimum crop production.

The use of inorganic chemical fertilizers is essential for crop nutrition in order to maximize productivity. The crop yields especially of wheat are stagnant for the last couple of years. The use of organic manures and composted organic materials along with chemical fertilizers may be effective for further increase in crop yield. The present investigation was, therefore, undertaken to study the effect of organic and inorganic fertilizers in IPNS (Integrated Plant Nutrient Management System) system on the growth, yield and nitrogen uptake of wheat.

Materials and Methods

The experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during the winter (Rabi) season of 2013-14. The soil of the experimental field belongs to Sonatala Series. The experimental soil was silt loam in texture having pH 6.94, organic matter 1.62%, total nitrogen 0.067%, available phosphorus 10.45 mg/kg, exchangeable K 0.08 me/100g soil, available sulphur 12.00 mg/kg and cation exchange capacity 15.0 me/100 g soil. The recommended high yielding wheat variety Kanchan was used as the test crop in this experiment. The experiment was laid out in a Randomized Complete Block Design (RCBD) with six treatments and four replications. The total numbers of plots were 24. The unit plot size was 5m x 4 m having spacing between plot to plot 0.5m and block to block 1m. There were six treatments; T_0 (Control), T_1 [STB-CF (HYG)], T_2 [STB-CF (HYG) + CD (5 t/ha)] on IPNS basis, T_3 [STB-CF (HYG) + PM (3 t/ha)] on IPNS basis, T_4 [STB-CF (HYG) + COM (5 t/ha)] on IPNS basis, T_5 [FP (Farmers practice)]. Here, [STB=Soil Test Basis, CF=Chemical fertilizer, CD=Cow dung, PM=Poultry manure, COM=Compost, FP=Farmers' practice, HYG=High yield goal].

Well decomposed cow dung, compost and poultry manure were applied to the plots as per the treatments by mixing with the soil well before 7 days of sowing. The nutrient content in cow dung, poultry manure and compost has been depicted in Table 1. The amount of nitrogen, phosphorus, potassium, sulphur and boron required for each plot was calculated and used as per requirement. One third of urea and the full amount of TSP, MOP, gypsum and boric acid were applied one day before transplanting. The rest of urea was applied in two equal splits; one at maximum tillering stage (30 days after sowing) and the other at spike initiation stage (60 days after sowing). Seeds of wheat were sown @ 150 kg ha^{-1} in lines and covered by soil with hand. The line to line distance was 20 cm and the depth of furrow was about 6 cm. A strip of wheat crop was established as border crops. Intercultural operations were done for ensuring and maintaining the normal growth of the crop. The crop was harvested at full maturity. Grain yield was recorded on 14% moisture basis and straw yield on sun dry basis. Five hills were randomly selected from each plot at maturity to record the growth and yield contributing characters. Grain and straw samples were analyzed for N content following the method outlined by Bremner and Mulvaney (1982). The N uptake by grain and straw was calculated from its content and yield data using the equation, Nitrogen uptake = [Nitrogen content (%) x Yield (kg ha^{-1})]/100. All the data were statistically analyzed by F-test and the mean differences were ranked by DMRT at 5% level (Gomez and Gomez, 1984).

Table 1. Nutrient content in cow dung, poultry manure and compost

Name of manure	Nutrient contents (%)			
	N	P	K	S
Cow dung	0.57	0.7	0.69	0.23
Poultry manure	1.8	1.13	0.81	o.35
Compost	2.9	0.05	1.55	0.165

Source: Islam *et al.* (2014)

Results and Discussion

Growth and yield contributing characters

Growth and yield contributing characters such as plant height, effective tillers $hill^{-1}$, spike length and spikelets $spike^{-1}$were influenced significantly due to application of organic and inorganic fertilizer in different combinations (Table 2). The tallest plant of 73.75 cm was observed in the treatment T_1 with the

application of chemical fertilizers at recommended dose and it was identical with T_2 [STB-CF (HYG) + CD (5 t/ha)], T_3 [STB-CF (HYG) +PM (3 t/ha)], T_4 [STB-CF (HYG) COM ((5 t/ha)] and T_5 [FP (Farmers' practice)]. The shortest plant of 57.40 cm was recorded in the control (To) treatment. The highest number of effective tillers hill^{-1} of 7.67 was found in both T_3 [STB-CF (HYG) + PM (3 t/ha)] and T_5 [FP (Farmers' practice)] treatments and they were identical. The lowest number of effective tillers hill^{-1} was observed in control treatment. The treatments T_1, T_2 and T_4 showed statistically similar effective tillers hill^{-1}. The highest spike length (12.07 cm) was found in T_1 [STB-CF (HYG)] with the application of chemical fertilizers. The treatments T_2, T_3, T_4, andT_5 showed statistically similar spike length of wheat with the values of 11.90, 11.83, 11.37 and 11.07 cm, respectively. The lowest value of 7.77 cm was obtained in control. The number of total grains spike^{-1} due to different treatments ranged from 65.00 to 83.00 and the maximum number was observed in T_3 [STB-CF (HYG) +PM (3 t/ha)]. The lowest number of grains spike^{-1} (65.00) was found in control. The 1000-grain weight did not show any significant variation due to the application of manures and fertilizer in different combinations. Many researchers reported that combined application of manures and fertilizers increased the plant height and tillers hill^{-1} (Khan *et al*., 2007), spike length, (Singh *et al*., 2001) and filled grains spike^{-1} (Satyannarayana *et al*., 2002).

Table 2. Effects of manures and fertilizers on the growth and yield components of wheat

Treatments	Plant height (cm)	Tillers hill^{-1} (No.)	Spike length (cm)	Spikelets spike^{-1} (No.)	1000-grain weight (g)
T_0 [control]	57.40b	3.67b	7.77b	65.00b	37.87
T_1 [STB-CF(HYG)]	73.75a	7.00a	12.07a	81.67a	42.90
T_2[STB-CF (HYG)+CD]	70.84a	7.00a	11.90a	78.00a	41.30
T_3 [STB-CF (HYG) +PM]	73.03a	7.67a	11.83a	83.00a	44.97
T_4[STB-CF (HYG) COM]	72.47a	6.00a	11.37a	78.33a	43.03
T_5 [FP]	72.40a	7.67a	11.07a	72.67ab	40.93
SE (±)	1.067	0.567	0.586	3.444	2.083
CV (%)	3.74	15.13	9.22	7.58	8.63
P Value	0.0001	0.004	0.003	0.030	0.321

The figure(s) having common letter(s) in a column do not differ significantly at 5% level of significance, STB = Soil Test Basis, CF = Chemical fertilizer, OM = Organic manure, CD = Cow dung, PM = Poultry manure, COM = Compost, FP = Farmers' practice, HYG = High yield goal, CV (%) = Coefficient of variation, SE (±) = Standard error of means, P=Probability

Grain yield

The integrated use of cow dung, poultry manure, compost and fertilizers showed a positive effect on grain yield of wheat (Table 3). The grain yield ranged from 2094 to 3554 kg ha^{-1}. The highest grain yield of 3554 kg ha^{-1} was observed in T_3 [STB -CF (HYG) +PM (3 t/ha)] and the lowest value of 2094 kg ha^{-1} was recorded in T_0 (Control). The grain yield produced by the treatments T_1, T_2, T_4 and T_5 was 3345, 3249, 3399 and 3171 kg ha^{-1}, respectively. Based on grain yield, the treatments may be ranked in order of T_3> T_4> T_1> T_2> T_5> T_0. With same recommended fertilizer doses poultry manure treated plots gave higher grain yield than cow dung and compost treated plots. This might be due to the presence of uric acids in poultry manure that hastens the release of nutrients from poultry manure than compost and cow dung. The increase in grain yield over control ranged from 51.44 to 69.72% where the highest increase was obtained in T_3 and the lowest one was obtained in T_5 FP [farmers' practices] as shown in Table 3. These results are in agreement with Islam *et al.* (2014) who reported that combined application of manures and fertilizers increased the grain and straw yield of wheat. Malika *et al.* (2015)

and Liza *et al.* (2014) also support the findings of the present study.

Straw yield

The straw yield of wheat also responded significantly due to combined use of manures and fertilizers (Table 3). The yields of straw ranged from 2232 to 3635 kg ha^{-1}. The maximum straw yield of 3636 kg ha^{-1} was found in T_3 [STB-CF (HYG) +PM (3 t/ha) and the minimum value of 2232 kg ha^{-1} was noted in T_0 (control). The treatment may be ranked in the order of $T_3 > T_2 > T_4 > T_1 > T_5 > T_0$ in terms of straw yield. Regarding the percent increase of straw yield, the highest increase (62.83%) was noted in T_3 and the lowest increase (41.92%) was observed in T_5 FP [Farmers' practices] as shown in Table 3.

These findings are well corroborated with that of Malika *et al.* (2015), Islam *et al.* (2014), and Akter *et al.* (2012) who reported that integrated use of manures and fertilizers increased the grain and straw yield of rice and wheat.

Table 3. Effects of manures and fertilizers on the grain and Straw yields of wheat

Treatments	Grain yield ($kgha^{-1}$)	% yield increase over control	Straw yield ($kgha^{-1}$)	%yield increase over control
T_0 [control]	2094e	-	2233e	-
T_1 [STB-CF(HYG)]	3345b	59.71	3444c	54.26
T_2[STB-CF (HYG)+CD]	3249c	55.13	3419c	53.12
T_3 [STB-CF (HYG) +PM]	3555a	69.72	3636a	62.83
T_4[STB-CF (HYG) COM]	3399b	62.29	3596b	61.07
T_5 [FP]	3172d	51.44	3169d	41.92
SE (±)	18.22	-	11.74	-
CV (%)	1.01	-	0.63	-
P Value	0.000	-	0.000	-

The figure(s) having common letter(s) in a column do not differ significantly at 5% level of significance

Nitrogen uptake by wheat

The results presented in the Table 4 indicate that the N uptake by wheat grain and straw differed significantly due to the application of manures and fertilizers. Nitrogen uptake by wheat grain ranged from 31.85 to 71.86 kg ha^{-1}. The maximum N uptake of 71.86 kg ha^{-1} by wheat grain was observed in the treatment T_3 [STB-CF (HYG) + PM (3 t/ha)] which was statistically similar with T_1, T_4 and T_5treatments. The minimum N uptake of 31.85 kg ha^{-1} was observed in the control (To). In case of wheat straw, N uptake ranged from 21.97 to 46.05 kg ha^{-1}.

Table 4. Effects of manures and fertilizers on nitrogen

Treatments	Nitrogen uptake (kg $ha^{-1)}$		
	Grain	Straw	Total
T_0 [Control]	31.85c	21.97b	53.82b
T_1 [STB-CF(HYG)]	71.34a	41.31a	112.45a
T_2[STB-CF (HYG)+CD]	56.86b	40.83a	97.69a
T_3 [STB-CF (HYG) +PM]	71.86a	46.05a	117.90a
T_4[STB-CF (HYG) COM]	69.57a	39.55a	109.11a
T_5 [FP]	63.95ab	39.08a	103.04a
SE (±)	3.85	3.32	5.96
CV (%)	10.96	15.06	10.41
P Value	0.0002	0.007	0.0002

The figure(s) having common letter(s) in a column do not differ significantly at 5% level of significance

The maximum N uptake of 46.05 kg ha^{-I} by straw was obtained in the treatment T_3 which was identical with T_1, T_2, T_4 and T_5. The minimum N uptake by wheat straw 21.97 kg ha^{-1} was recorded in the treatment T_0. Total N uptake by wheat ranged from 53.82 to 117.90 kg ha^{-1}. The maximum total N uptake of 117.90 kg ha^{-1} was observed in T_3 which was statistically similar with the value obtained in T_1, T_2, T_4 and T_5treatments. The minimum total N uptake of 53.82 kg ha^{-1} was observed in the control treatment. These results support the findings of Islam *et al.* (2014), Akter *et al.* (2012) and Parvez *et al*. (2008) who also observed an increase in N uptake by wheat and rice through combined application of manures and fertilizers.

Conclusion

The overall results indicate that the yield of wheat varied considerably among the treatments T_1, T_2, T_3 and T_4 although they received the same amount of nutrients but the sources of nutrients were different. Poultry manure in combination with chemical fertilizers (T_3) produced the highest grain and straw yield of wheat and it took superior position in all other parameters studied including yield components, N content and uptake. Therefore, it can be concluded that poultry manure in combination with chemical fertilizers can be used successfully in an integrated way using IPNS system for the successful cultivation of wheat.

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