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# Effects of Municipal Solid Waste Compost, Fertilizers, *Rhizobium* and Flora on the Nutrient Content and Uptake of Wheat

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**Abstract:** The effect of municipal solid waste compost, fertilizers, *Rhizobium* and flora on the growth and yield of wheat was studied through a field experiment at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh. The soil was silty loam in texture having pH 6.94, organic matter 1.62%, total nitrogen 0.067%, available phosphorus 10.45 ppm, exchangeable K 0.08 me/100g soil, available sulphur 12.00 ppm and cation exchange capacity 15.0 me/100g soil. There were seven treatments such as $T_0$ = control, $T_1$ = 100% recommended doses of fertilizer (RDF), $T_2$ = 100% RDF + compost @ 3.5 t $ha^{-1}$, $T_3$ = 100% RDF + compost @ 3.5 t $ha^{-1}$ + *Rhizobium*, $T_4$ = 75% RDF + 25% N based compost, $T_5$ = 75% RDF + 25% N based compost + *Rhizobium*, $T_6$ = 100% RDF + Flora. The experiment was laid out in a Randomized Complete Block Design with three replications. Phosphorus, potassium, sulphur, zinc and boron were applied as basal dose from TSP, MOP, gypsum, zinc sulphate and boric acid @ 30 kg P, 135 kg K, 15 kg S, 2 kg Zn and 1 kg B, respectively. Nitrogen as urea was used @100 kg $ha^{-1}$ for the respective treatments. For $T_3$ and $T_5$, the seeds were inoculated with Rhizobial strains. The plants were harvested at maturity and the grain and straw yields were recorded. Wheat grain and straw samples were collected and analyzed for N,P,K and S. The nutrient uptake of wheat calculated. Application of municipal solid waste compost, fertilizers, *Rhizobium* and flora increased the N and S content both in grain and straw of wheat but decreased the P content as compared to control. The K content in wheat straw increased with different treatments but the effect was reverse in case of wheat grain. The N,P,K,and S uptake of wheat grain and straw as well as the total uptake increased significantly with all the treatments over control.

**Keywords:** Compost, Flora, Rhizobium, Wheat, Fertilizer.

## Introduction

Wheat (*Triticum aestivum L.*) is the world's leading cereal crop both in area and production and about two- third people of our planet live on it. In Bangladesh, it ranks next to rice (Razzaque and Hossain, 1991) and its popularity is increasing consistently. As compared to rice, wheat grains are richer in food value with 14.7% protein, 2.1 % fat, 78.1 % starch and 2.1 % mineral matter (Peterson, 1965). It has significant role in human nutrition as well as in industrial uses. In Bangladesh, about 0.84 million hectares of land is covered under wheat cultivation producing 1.84 million metric tons with an average yield of 2.16 t $ha^{-1}$ (BBS, 2004). The average yield of wheat in this country is quite low as compared to that of wheat growing countries of the world.

Fertilizer is a major input of modern farming with about 50% of the world's crop production being attributed to fertilizer use (Pradhan, 1992). The farmers of Bangladesh use only about 174 kg nutrients/ha annually (132 kg N, 17 kg P2O5, 17 kg K20, 4 kg S, 2 kg Zn + B + others), as against the crop removal of about 250 kg/ha (Islam *et al.,* 2002). The continuous imbalanced use of chemical fertilizers is creating complexity in our soils and the soil health has started deteriorating. Use of compost is an effective way to increase healthy plant production, help save money, reduce the use of chemical fertilizers, and conserve natural resources. Compost provides a stable organic matter that improves the physical, chemical, and biological properties of soils, thereby enhancing soil quality and crop production.

To reduce the use of costly inorganic N fertilizer input, *Rhizobium* could be the best alternative strategy. *Rhizobium* previously well known as a symbiotic $N_2$ fixer is also reported as asymbiotic (associative and endophytic) microorganisms in recent years (Biswas *et al*., 2000a, 2000b). *Rhizobium* spp. have the ability to release growth promoting substances and some are endophytes which can produce phytohormones, siderophores, HCN, solubilize sparingly soluble organic and inorganic phosphates and can colonize in the roots of many non-legumes (Antoun et al., 1998;). The association was found to increased plant growth at different growth stages such as enhanced seed germination, increased shoot length, leaf chlorophyll content, total dry matter, grain yield, N content and yield attributes (Biswas et al., 1997). Flora is a plant growth regulator. It is a new generation fertilizer containing 2.2% nitrogen in aromatic form derived from nitrobenzene 20%. The product contains 27% total solids and 73% aqueous media. Flora is a plant energizer and yield booster. It improves the root formation and prepares the plant to build a robust vegetative growth. It facilitates better anchorage of the plants and improves the nutrient uptake and nutrient use efficiency of the plants. A lot of works on wheat has been carried out in most of the wheat growing countries of the world but works in this field

are limited in Bangladesh. Therefore, the present study was conducted to evaluate the comparative effectiveness of fertilizers, municipal solid waste compost, *Rhizobium* and flora on the growth and yield of wheat and to study the effect of fertilizers, municipal solid waste compost, *Rhizobium* and flora on the nutrient content and uptake in wheat.

## Materials and Methods

The experiment was conducted at the Field Laboratory of the Department of Soil Science, Bangladesh Agricultural University, Mymensingh during the winter (Rabi) season from December, 2010 to March, 2011. The wheat variety Prodip was used as the test crop in the experiment. The experiment was laid out in a Randomized Complete Block Design with seven treatments and three replications. There were seven treatments including control. The treatments were - $T_o$ = Control (no fertilizer or compost), $T_1$ = 100% recommended doses of fertilizers (RDF= $N_{100}$, $P_{30}$, $K_{80}$, $S_{15}$, $Zn_2$, $B_1$), $T_2$ =100% RDF + compost @3.5 t $ha^{-1}$, $T_3$ = 100% RDF + compost @ 3.5 t $ha^{-1}$ + *Rhizobium*, $T_4$ = 75 RDF + compost 25% (N based), $T_5$ = 75% RDF + compost 25% (N based) + *Rhizobium*, $T_6$ = 100% RDF + Flora. Well decomposed compost was applied to the plots as per the treatments by mixing with the soil well before 7 days of sowing. Nitrogen fertilizer @100 kg $ha^{-1}$ from urea was applied in three equal splits. The *Rhizobium* inoculant was mixed with the seeds @ 50 g inoculums/kg seeds for $T_3$ and $T_5$ treatments. Flora was applied by hand sprayer for three times. Irrigation and weeding was done as and when necessary. Data on plant height, spike length, number of tillers $hill^{-1}$, number of spikelet $spike^{-1}$, filled grains $spike^{-1}$, 1000-grain weight, grain and straw yields were recorded. Soil samples were analyzed for total N (micro-kjeldahl method), available P (Olsen *et al.* (1954), available K , available S ( Page *et al.* (1989), particle size analysis of soil (Black, 1965), soil pH and CEC (Jackson,1962) and organic carbon Walkley and Black ,1934). NPKS determination

## Results and Discussion

Application of compost, chemical fertilizers, *Rhizobium* and flora in different combinations resulted a significant variation in nitrogen content of grain and straw of wheat (Table 1). The N content in wheat grain ranged from 1.310% to 1.870 % and the highest N content (1.870%) was observed in the treatment $T_2$ with the application of compost @ 3.5 t $ha^{-1}$ in combination with 100% of the recommended doses of fertilizers and it was statistically similar to the treatments $T_3$ (100% RDF + compost 3.5 t $ha^{-1}$ + *Rhizobium*). The effects of the treatments $T_1$, $T_3$ and $T_5$ on the N content of grain were statistically similar. The results indicated that compost when applied in combination with fertilizers and *Rhizobium* increased the N content of wheat grain over the application of chemical fertilizers. The lowest value of N content in grain of 1.310% was recorded in the treatment $T_0$ (control). The N content in wheat grain was comparatively higher than that of wheat straw. Application of 100% fertilizer with only flora resulted lower N content (1.347%) in grain as compared to the treatment $T_2$ (1.870%). On the other hand, the nitrogen content in wheat

straw varied from 0.186% to 0.610% (Table 1). All the treatments gave significantly higher N content in wheat straw as compared to the control. The maximum N content in wheat straw (0.6100%) was recorded in the treatment $T_1$ (100% RDF). Treatments $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$), $T_3$ (100% RDF + compost 3.5 t $ha^{-1}$ + *Rhizobium*), $T_4$ (75% RDF + compost 25%) and $T_6$ (100% RDF + Flora) was statistically similar. The minimum N content in wheat straw (0.1867%) was noted in the control treatment. It was also observed that application of 25% compost with 75%fertilizer and *Rhizobium* resulted lower N content in wheat straw as compared to the treatment $T_1$.

Phosphorus content in wheat grain and straw increased significantly due to the application compost, fertilizers, *Rhizobium* and flora (Table 1). The P content in wheat grain ranged from 0.265% to 0.358% and the highest P content (0.358%) was observed in the treatment $T_0$ which was statistically similar to treatments $T_1$ (100% RDF), $T_4$ (75% RDF + compost 25%), $T_5$ (75% RDF + compost 25% + *Rhizobium*) and $T_6$ (100% RDF + Flora). The second highest P content (0.352%) was observed in the treatment $T_5$ and it was statistically similar to the treatments $T_1$ (100% RDF), $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$) and $T_6$ (100% RDF + Flora). Application of 100% recommended chemical fertilizers ($T_1$) exerted the statistically similar effect to that of the treatments $T_2$ and $T_6$ on the P content of wheat grain The lowest value of P content in grain of 0.265% was recorded in the treatment $T_3$. The P content in wheat grain was comparatively higher than that of wheat straw. In case of wheat straw, P content also varied significantly due to the treatments with different combinations of MSW compost, fertilizers, *Rhizobium* and Flora. The P content in wheat straw ranged from 0.013% to 0.025% and the highest P content (0.025%) was observed in the treatment $T_0$. The second highest P content in wheat straw obtains in $T_4$ treatment. The effects of the treatments $T_1$, $T_2$ and $T_3$ on the P content of straw were statistically similar.

**Table 1**. Effects of MSW compost, fertilizers, *Rhizobium* and flora on N, P, K and S contents of wheat

| Treatment | Nitrogen (%) | | Phosphorus (%) | | potassium (%) | | Sulphur (%) | |
|---|---|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw | Grain | Straw |
| $T_0$ | 1.310 c | 0.186 d | 0.358 a | 0.025 a | 0.388 a | 0.855 d | 0.164 | 0.049 |
| $T_1$ | 1.617 bc | 0.610 a | 0.300 abc | 0.020 c | 0.308 e | 1.325 ab | 0.202 | 0.074 |
| $T_2$ | 1.870 a | 0.393 b | 0.292 bc | 0.020 c | 0.318 d | 1.257 abc | 0.207 | 0.062 |
| $T_3$ | 1.737 ab | 0.446 b | 0.265 c | 0.020 c | 0.309 c | 1.414 a | 0.220 | 0.058 |
| $T_4$ | 1.470 cd | 0.420 b | 0.353 a | 0.023 b | 0.340 c | 1.097 c | 0.157 | 0.054 |
| $T_5$ | 1.693 b | 0.306 c | 0.352 ab | 0.015 d | 0.343 b | 1.64 bc | 0.163 | 0.059 |
| $T_6$ | 1.347 de | 0.393 b | 0.302 abc | 0.013 e | 0.309 e | 1.264 abc | 0.193 | 0.061 |
| CV (%) | 5.36 | 7.52 | 8.22 | 14.53 | 3.16 | 3.39 | 12.52 | 28.98 |
| LSD | 0.1488 | 0.05626 | 0.05626 | 001779 | 0.00177 | 0.2028 | 0.05626 | - |
| SE (±) | 0.0488 | 0.0171 | 0.0151 | 0.0016 | 0.006 | 0.0649 | 0.0135 | 0.010 |

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

A significant variation in the potassium content in wheat grain and straw was recorded due to the application of MSW compost, fertilizers, *Rhizobium* and flora (Table 1). The K content in wheat grain ranged from 0.308% to 0.388% and the highest K content (0.3887%) was observed in the treatment $T_0$.The treatment $T_1$, $T_3$ and $T_6$ were statistically identical in K content of wheat grain with the values of 0.308%, 0.309% and 0.309%, respectively. The lowest value of K content in grain of 0.309 % was recorded in the treatment $T_1$ and $T_6$. The K content in wheat grain was comparatively lower than that of wheat straw. Application of MSW compost, fertilizers, *Rhizobium* and Flora in different combinations influenced the K content in wheat straw significantly and ranged from 0.855% to 1.414% (Table 1). All the treatments resulted significantly higher K content compared to the control. The maximum K content in wheat straw (1.414%) was recorded in the treatment $T_3$ which was statistically similar to the treatments $T_1$, $T_2$ and $T_6$. All the treatments increased the K content in wheat straw significantly over control. The treatments $T_1$, $T_2$, $T_5$ and $T_6$ influenced similarly on the K content of wheat straw. Again, K content of wheat straw recorded in $T_2$, $T_4$, $T_5$ and $T_6$ treatment were statistically similar. The results also indicate that application of compost with fertilizers shows significant effect in increasing the K content in wheat straw.

Sulphur content in wheat grain and straw increased significantly due to the application MSW compost, fertilizers, *Rhizobium* and Flora (Table 1). The S content in wheat grain ranged from 0.157 % to 0.207 %. S content varied insignificantly due to the treatments with different combinations of compost, fertilizers, *Rhizobium* and Flora. Sulphur content in wheat grain although varied insignificantly due to different treatments, may be ranked in the order of $T_3 > T_2 > T_1$ and $T_6 > T_0 > T_5 > T_4$. The variation in S content in wheat grain due to variable treatments was inconsistent. The S content in wheat straw varied from 0.074% to 0.049% due to different treatments. Sulphur content in wheat straw also varied insignificantly due to different treatments and may be ranked in the order of $T_1 > T_2 > T_6 > T_5 > T_3 > T_4 > T_0$.

The results presented in the Table 2 indicate that the N uptake by wheat grain, straw differed significantly due to the application of MSW compost, chemical fertilizers, *Rhizobium* and flora. Nitrogen uptake by wheat grain ranged from 10.35 kg $ha^{-1}$ to 92.17 kg $ha^{-1}$. The maximum N uptake of 92.17 kg $ha^{-1}$ by wheat grain observed in the treatment $T_3$ with the application of compost @ 3.5 t $ha^{-1}$ in combination with *Rhizobium* and 100% recommended doses of nitrogen fertilizer. The value was statistically identical to that obtained in the treatments $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$) and $T_5$ (75% RDF + compost 25% + *Rhizobium*) but significantly higher than all other treatments. The minimum N uptake of 10.35 kg $ha^{-1}$ was observed in the control treatment ($T_0$). The N uptake in the treatments $T_1$ (100% RFD) and $T_4$ (75% RDF + compost 25%) were statistically similar with the values of 66.50 kg $ha^{-1}$ and 58.73 kg $ha^{-1}$, respectively.

**Table 2**. Effects of MSW compost, fertilizers, *Rhizobium* and flora on N, P, K and S uptake by wheat (kg ha $^{-1}$)

| Treatment | Nitrogen | | | Phosphorus | | |
|---|---|---|---|---|---|---|
| | Grain | Straw | Total uptake | Grain | Straw | Total Uptake |
| $T_0$ | 13.10d | 2.53d | 15.63 e | 3.58c | 0.25d | 3.83c |
| $T_1$ | 56.33b | 17.57a | 73.9b | 10.46b | 0.762a | 11.22b |
| $T_2$ | 74.25a | 14.17abc | 88.42b | 11.59b | 0.727ab | 12.31b |
| $T_3$ | 74.44a | 16.28ab | 90.72a | 11.38b | 0.742a | 12.12b |
| $T_4$ | 46.15b | 10.53c | 56.68c | 11.10b | 0.531bc | 11.63b |
| $T_5$ | 69.19a | 12.53bc | 72.72b | 14.38a | 0.671ab | 15.05a |
| $T_6$ | 44.98c | 10.62c | 55.6d | 10.08b | 0.403cd | 10.48b |
| CV (%) | 7.59 | 17.69 | 7.04 | 8.48 | 18.87 | 8.21 |
| LSD | 8.594 | 3.779 | 9.604 | 1.940 | 0.1949 | 1.96 |
| SE (±) | 2.7908 | 1.2264 | 3.1169 | 0.6295 | 0.0637 | 0.638 |

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

All the treatments resulted significantly higher N uptake by wheat grain over the control. In case of wheat straw, N uptake ranged from 2.533 kg ha$^{-1}$ to 17.57 kg ha$^{-1}$. The maximum N uptake 17.57 kg ha$^{-1}$ by straw was obtained in the treatment $T_1$ with the application of NPKS fertilizers at recommended dose which was statistically similar to that obtained in the treatment $T_2$ (100% RDF + compost 3.5 t ha$^{-1}$) and $T_3$ (100% RDF + compost 3.5 t ha$^{-1}$ + Rhizobium). The minimum N uptake by wheat straw 2.533 kg ha$^{-1}$ was recorded in the control treatment ($T_0$). The statistically identical values were 14.17 kg ha$^{-1}$, 16.28 kg ha$^{-1}$ and 12.53 kg ha$^{-1}$ were noted in the treatments $T_2$, $T_3$ and $T_5$. Table 2 also shows that application of 100% RDF recorded more N uptake by wheat straw and the value was more as compared to the combined application of compost with fertilizers. Total Nitrogen uptake by wheat plants ranged from 13.18 kg ha$^{-1}$ to 108.4 kg ha$^{-1}$. The maximum N uptake of 108.4 kg ha$^{-1}$ by wheat observed in the treatment $T_3$ with the application of compost @ 3.5 t ha$^{-1}$ in combination with *Rhizobium* and 100% recommended doses of nitrogen fertilizer. The statistically identical values were obtained in the treatments $T_1$ (100% RDF), $T_2$ (100% RDF + compost 3.5 t ha$^{-1}$) and $T_5$ (75% RDF + compost 25% + *Rhizobium*). The minimum N uptake of 13.18 kg ha$^{-1}$ was observed in the control treatment ($T_0$).The maximum total Nitrogen uptake of wheat plants obtained in application of fertilizers at recommended dose in combination with compost and *Rhizobium*. Total uptake of N by wheat plants was significant by application of fertilizer at recommended dose with flora over control.

There was a significant variation in P uptake by wheat due to the various treatments (Table 2). Phosphorus uptake by wheat grain varied from 3.360 kg ha$^{-1}$ to 17.96 kg ha$^{-1}$. The highest P uptake by wheat grain 17.96 kg ha$^{-1}$ was found in treatment ($T_5$) with the application of 25% compost + 75% recommended doses of fertilizer + *Rhizobium*. The treatments $T_1$ (100% fertilizer), $T_2$ (100% RDF + compost 3.5 t ha$^{-1}$), $T_3$ (100% RDF + compost 3.5 t ha$^{-1}$ + *Rhizobium*), $T_4$ (75% RDF + compost 25%) and $T_6$ (100% RDF + Flora) with the values of 13.19 kg ha$^{-1}$, 14.44 kg ha$^{-1}$, 14.10 kg ha$^{-1}$, 14.12 kg ha$^{-1}$ and 12.79 kg ha$^{-1}$, respectively were statistically similar. The lowest P uptake by wheat grain of 3.360 kg ha$^{-1}$ was found in the treatment ($T_0$). It was further observed that application of 25% compost in combination with 75% N fertilizer and *Rhizobium* increased the P uptake by wheat grain considerably over the application of chemical fertilizers at recommended dose. The P uptake by wheat straw ranged from 0.254 kg ha$^{-1}$ to 0.762 kg ha$^{-1}$. The maximum P uptake 0.762 kg ha$^{-1}$ by wheat straw was obtained in the treatment $T_1$ with the application of chemical fertilizers at recommended dose which was statistically similar to the treatments $T_2$ (100% RDF + compost 3.5 t ha$^{-1}$), $T_3$ (100% RDF + compost 3.5 t ha$^{-1}$ + Rhizobium) and $T_5$ (75% RDF + compost 25% + *Rhizobium*). Again, the treatments $T_2$ (100% RDF + compost 3.5 t ha$^{-1}$), $T_4$ (75% RDF + compost 25%) and $T_5$ (75% RDF + compost 25% + *Rhizobium*) were statistically similar. The minimum P uptake by wheat straw 0.2547 kg ha$^{-1}$ was recorded in the control treatment ($T_0$) which was statistically similar to the treatment $T_6$ (100% RDF + Flora). Again, The treatments $T_4$ (75% RDF + compost 25%) and $T_6$ (100% RDF + Flora) exerted statistically similar effect on the P uptake by wheat straw with the value of 0.531 kg ha$^{-1}$ and 0.403 kg ha$^{-1}$. Total P uptake by wheat plant varied from 3.73 kg ha$^{-1}$ to 18.63 kg ha$^{-1}$. The highest total P uptake by wheat plant 18.63 kg ha$^{-1}$ was found in treatment ($T_5$) with the application of 25% compost + 75% recommended doses of fertilizer + *Rhizobium*. The treatments $T_1$ (100% fertilizer), $T_2$ (100% RDF + compost 3.5 t ha$^{-1}$), $T_3$ (100% RDF + compost 3.5 t ha$^{-1}$ + *Rhizobium*), $T_4$ (75% RDF + compost 25%) and $T_6$ (100% RDF + Flora) with the values of 13.95 kg ha$^{-1}$, 15.23 kg ha$^{-1}$, 14.87 kg ha$^{-1}$, 14.68 kg ha$^{-1}$ and 13.20 kg ha$^{-1}$, respectively were statistically similar.

The lowest P uptake by wheat plant of 3.73 kg ha$^{-1}$ was found in the treatment ($T_0$). Application of 25% compost in combination with 75% N fertilizer and *Rhizobium* increased the total P uptake by wheat plant considerably over the application of chemical fertilizers at recommended dose.

There was a significant variation in K uptake by wheat due to the various treatments Table 3). The K uptake by wheat grain ranged from 3.393 kg $ha^{-1}$ to 17.48 kg $ha^{-1}$. The maximum uptake of K (17.48 kg $ha^{-1}$) was observed in the treatment ($T_5$) due to application of 25% compost in combination with 75% recommended doses of N fertilizer and *Rhizobium* which was statistically similar to $T_3$ (100% RDF + compost 3.5 t $ha^{-1}$ + *Rhizobium*) and superior to all other treatments. The lowest K uptake of 3.393 kg $ha^{-1}$ was noted in the control treatment ($T_o$ ).The treatments $T_1$ (100% RDF), $T_4$ (75% RDF + compost 25%) and $T_6$ (100% fertilizer + flora) recorded statistically similar values of 13.58 kg, 13.59 kg and 13.08 kg $ha^{-1}$, respectively. All the treatments increased the K uptake by wheat grain significantly over the control. Again, the treatments $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$) and $T_3$ (100% RDF + compost 3.5 t $ha^{-1}$ + *Rhizobium*) statistically similar in K uptake of wheat. In case of wheat straw, K uptake ranged from 8.377 kg $ha^{-1}$ to 49.39 kg $ha^{-1}$. The maximum K uptake of 49.39 kg $ha^{-1}$ by straw was obtained in the treatment $T_3$ with the application of 100% RDF + compost 3.5 t $ha^{-1}$ + *Rhizobium* which was statistically identical to $T_1$ (100% RDF), $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$) and $T_5$ (75% RDF + compost 25% + *Rhizobium*). The minimum K uptake by wheat straw of 8.377 kg $ha^{-1}$ was recorded in the control treatment ($T_0$). Total K uptake by wheat plant ranged from 11.77 kg $ha^{-1}$ to 65.87 kg $ha^{-1}$. The maximum total K uptake of 65.87 kg $ha^{-1}$ by wheat plant was obtained in the treatment $T_3$ with the application of 100% RDF + compost 3.5 t $ha^{-1}$ + *Rhizobium* which was statistically identical to $T_1$ (100% RDF), $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$) and $T_5$ (75% RDF + compost 25% + *Rhizobium*). The minimum K uptake by wheat plant of 11.77 kg $ha^{-1}$ was recorded in the control treatment ($T_0$). Application of fertilizers at recommended dose in combination with compost and *Rhizobium* produced highest K uptake by wheat and application of fertilizers with flora increased K uptake by wheat significantly over control but the value was lower than all other treatments.

**Table 3.** Effects of MSW compost, fertilizer, *Rhizobium* and flora on K and S uptake by wheat (kg $ha^{-1}$)

| Treatment | Potassium | | | Sulphur | | |
|---|---|---|---|---|---|---|
| | Grain | Straw | Total uptake | Grain | Straw | Total uptake |
| $T_0$ | 3.88 d | 8.37d | 12.25d | 1.64 e | 0.53 c | 2.17 e |
| $T_1$ | 10.75 c | 47.27 a | 58.02 a | 7.04 bc | 2.68 a | 9.72 bc |
| $T_2$ | 12.62 b | 46.35 a | 58.97 a | 8.24 ab | 2.19 ab | 10.43 ab |
| $T_3$ | 13.24 ab | 49.39 a | 62.63 a | 9.42 a | 2.05 ab | 11.49 a |
| $T_4$ | 10.67 c | 27.04 c | 37.71 c | 4.93 d | 1.57 b | 6.5 d |
| $T_5$ | 14.02 a | 45.74 a | 59.76 a | 6.68 c | 2.29 ab | 8.97 bc |
| $T_6$ | 10.32 c | 36.14 b | 46.46 b | 6.45 c | 1.51 b | 7.96 cd |
| CV (%) | 6.68 | 7.77 | 5.64 | 13.27 | 29.52 | 11.98 |
| LSD | 1.586 | 5.140 | 5.071 | 1.861 | 0.964 | 2.072 |
| SE (±) | 0.514 | 1.668 | 1.645 | 0.603 | 0.312 | 0.672 |

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

There was a significant variation in S uptake by wheat due to the application of compost, fertilizer, *Rhizobium* and flora in different combinations (Table 3). The S uptake in wheat grain ranged from 1.430 kg $ha^{-1}$ to 11.73 kg $ha^{-1}$. The maximum uptake of S (11.73 kg $ha^{-1}$) by wheat grain was observed in the treatment $T_3$ with the application of compost @ 3.5 t $ha^{-1}$ in combination with *Rhizobium* and 100% recommended doses of chemical fertilizers which was statistically similar to the treatment $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$). The lowest S uptake of 1.430 kg $ha^{-1}$ was noted in the control treatment ($T_0$). The treatments $T_1$ (100% RDF) and $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$) were statistically identical in S uptake by wheat grain with the value 8.897 kg $ha^{-1}$ and 10.31 kg $ha^{-1}$, respectively. Again, the treatments $T_5$ (75% RDF + compost 25% + *Rhizobium*), $T_1$ (100% RDF) and $T_6$ (100% RDF + Flora) were statistically similar in S uptake by wheat grain with the value of 8.323 kg $ha^{-1}$, 8.897 kg $ha^{-1}$ and 8.237 kg $ha^{-1}$, respectively. Table 4.7 also suggests that combined application of compost, fertilizers and *Rhizobium* in more effective in producing the S uptake by wheat grain. Application of fertilizers with flora increased S uptake by wheat significantly over control. All the treatments increased the S uptake by wheat grain significantly over control. In case of wheat straw, S uptake ranged from 0.5333 kg $ha^{-1}$ to 2.683 kg $ha^{-1}$. The maximum S uptake 2.683 kg $ha^{-1}$ by wheat straw was obtained in the

treatment $T_1$ with the application of 100% fertilizers at recommended dose which was statistically similar to the treatment $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$), $T_3$ (100% RDF + compost 3.5 t $ha^{-1}$ + *Rhizobium*) and $T_5$ (75% RDF + compost 25% + *Rhizobium*).

The minimum S uptake by wheat straw 0.5333 kg $ha^{-1}$ was recorded in the control treatment ($T_0$). The treatments $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$), $T_3$ (100% RDF + compost 3.5 t $ha^{-1}$ + *Rhizobium*), $T_4$ (75% RDF + compost 25%), $T_5$ (75% RDF + compost 25% + *Rhizobium*) and $T_6$ (100% RDF + Flora) were statistically similar in S uptake by wheat straw with the values of 2.193 kg $ha^{-1}$, 2.053 kg $ha^{-1}$, 1.577 kg $ha^{-1}$, 2.297 kg $ha^{-1}$ and 1.513 kg $ha^{-1}$, respectively. The total S uptake in wheat plant ranged from 1.963 kg $ha^{-1}$ to 13.78 kg $ha^{-1}$. The maximum uptake of S (13.78 kg $ha^{-1}$) by wheat grain was observed in the treatment $T_3$ with the application of compost @ 3.5 t $ha^{-1}$ in combination with *Rhizobium* and 100% recommended doses of chemical fertilizers which was statistically similar to the treatment $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$). The lowest S uptake of 1.963 kg $ha^{-1}$ was noted in the control treatment ($T_0$). The treatments $T_1$ (100% RDF), $T_2$ (100% RDF + compost 3.5 t $ha^{-1}$) and $T_5$ (75% RDF + compost 25% + *Rhizobium*) were statistically identical in total S uptake by wheat plant with the value 11.58 kg $ha^{-1}$, 12.58 kg $ha^{-1}$ and 10.62 kg $ha^{-1}$, respectively. Again, the treatments $T_5$ (75% RDF + compost 25% + *Rhizobium*), $T_1$ (100% RDF) and $T_6$ (100% RDF + Flora) were statistically similar in S uptake by wheat grain with the value of 10.62 kg $ha^{-1}$, 11.58 kg $ha^{-1}$ and 9.75 kg $ha^{-1}$, respectively. Application of compost, fertilizers and *Rhizobium* is more effective in the S uptake by wheat grain. Again, application of fertilizers with flora increased S uptake by wheat significantly over fertilizer with compost and control. All the treatments increased the S uptake by wheat grain significantly over control.

The K uptake by wheat grain varied significantly due to different treatments and ranged from 3.88 kg $ha^{-1}$ to 14.02 kg $ha^{-1}$. The maximum uptake of K was observed in the treatment ($T_5$). All the treatments increased the K uptake by wheat grain significantly over the control. The K uptake by wheat straw ranged from 8.377.

## References


Antoun, Abril, A.; Zurdo, J. L.; Pineiro, Peix, A.; Rivas, R. and Velazquez, E. 1998. Solubilization of phosphate by a strain of *Rhizobium leguminosarum* bv. *Trifoli* isolated from *Phaseulus vulgaris* in El Chaco Arido soil.

BBS (Bangladesh Bureau of Statistics). 2004. Monthly Statistical Bulletin of Bangladesh. May, 2004. Stat. Div., Minis. Plan. Govt. People's Repub. Bangladesh, Dhaka.: 57.

Biswas, J. C. 1997. Effect of nitrogen fixing Bacteria on growth promotion of Lowland Rice (*Oryza sativa* L.). Ph. D thesis, Department of Soil Science, University of Phillipines, Los Banos.

Biswas, J. C.; Ladha, J. K. and Dazzo, F. B. 2000a. Rhizobia inoculation improves nutrient upkake and growth of low land rice. *Soil Sci. Soc. America J.*, 64: 1644-1650.

Biswas, J. C.; Ladha, J. K.; Dazzo, F. B.; Yanni, Y. G. and Rolfe, B. G. 2000b. Rhizobial inoculation influences seedling vigor and yield of rice. *Agron. J.*, 92: 880-886.

Black, C. A. 1965. Methods of Soil Analysis. Part I and II. Amer. Soc. Agron. Inc. Pub. Madison, Wisconsin, USA.

Islam, M. R. 2002. Effects of different levels of chemical and organic fertilizers on growth, yield and protein content of wheat. *Online J. Biol. Sci.*, 2(**5**): 304-306.

Jackson, M. L. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd. New Delhi, India: 10-44.

Olsen, S. R.; Cole, C. V.; Watanable, F. S. and Dean, L. A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Dept. Agril. Circ.: 929.

Page, A. L.; Millar, R. H. and Keeney, D. R. 1989. Methods of Soil Analysis. Part II, 2nd edn., Amer. Soc. Agron. Inc. Pub. Madison, Wisconsin, USA.

Peterson, R. F. 1965. Wheat-Botany, Cultivation and Utilization, Leonard Hill (books), London and Inter, Sci. Pub. Ino.; New York. 238.

Pradhan, S. B. 1992. Status of fertilizer use in developing countries of Asia and the Pacific regions, Proc. FADINAP Seminar, Chiang Mai, Thailand. 37-47.

Razzaque, M. A. and Hossain, A. B. S. 1991. The wheat development program Bangladesh. In: Proc. Wheat for non traditional warm area D. A. Saunders ed., UNDP/CYMMYT