# Effect of integrated or alone use of inorganic, organic and inoculum sources on wheat (*Triticum aestivum* L)

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**Abstract**: Field experiments were conducted at Ishurdi and Rajshahi to evaluate the response of inorganic, organic and inoculum alone or integrated use of these sources on wheat. Treatment combinations were mineral fertilizer (M), cowdung (CD), phosphate solubilizing bacteria (PSB), CD + PSB, PSB + M, PSB + CD and PSB + CD + M including control. The trials were laid out in a randomized block design using three replications. Growth and yield performance of wheat was better in Ishurdi than Rajshahi location except for tiller per hill, 1000 seed weight and straw yield of wheat. PSB+CD+M fertilizer treated plots performed better growth of wheat than other treatments. Among the single fertilizer treatments, mineral fertilizer performed better results than CD and PSB except for tiller per hill and filled grain per ear. Integrated use of PSB + CD + M found the maximum grain and straw yield of wheat. Spike length, number of tillers per hill and filled grain per ear showed positive and significant correlation with grain yield of wheat. As a result, grain yield was increased with the increase of yield contributing parameters of wheat. From these results, it may be concluded that organic fertilizer in combination with inoculum increased the use efficiency of mineral fertilizer during crop production at Ishurdi.
**Key words**: Wheat, cowdung, mineral fertilizer, *Pseudomonas sp*, yield.

## Introduction

Bangladesh is an over populated country having the highest density in the world. On the other hand, the total cultivable land in Bangladesh is decreasing day by day. This brings into focus the need for efficient management of our limited land resources in order to increase and maintain crop production. Wheat is the second most important cereal crop next to rice on the basis of cultivated area and production in Bangladesh (BBS, 2008). Use of chemical fertilizers is an essential component of modern farming and about 50% of the world's crop production can be attributed to fertilizer use. Nevertheless, sustainable crop production cannot be maintained by using only chemical fertilizer and similarly it is not possible to obtain higher crop yield by using organic manure alone. Cowdung is the common manure of Bangladesh can play a vital role in soil fertility improvement as well as in supplying most of the macro and micronutrients for the crop production. On the other hand, nitrogen fertilizer use efficiency is very low due to it leaching and volatilization loss during crop production. Phosphorus is a non-renewable source and a major plant nutrient for higher crop yield. It limits the crop production because only about 20% of applied phosphorus is utilized by crop and remaining part is converted into insoluble forms in acid and alkaline soils (Rodriguez and Fraga, 1999). In Bangladesh, most of the soils are acidic or alkaline in nature and thus the availability of phosphorus for the nutrition of crops is very low due to its fixation. Adequate supply of phosphatic biofertilizer with less cost could play a vital role in improving the wheat yield. In this context, P-solubilization ability of micro-organisms is considered to be one of the most important traits associated with plant P nutrition (Chen *et al.,* 2006; Adesemoye and Kloepper, 2009). Several bacterial species are referred to as phosphate solubilizing bacteria and have been considered to have potential use as inoculants biofertilizer to improve the plant growth and yield (Vessey, 2003). Inorganic fertilizer contains large amount of specific plant nutrient in readily form. Therefore, inorganic fertilizer in combination with cowdung, PSB and cowdung + PSB may lead to better performance of wheat. Combination of inorganic, organic and inoculum sources of nutrients is necessary for sustainable agriculture that will provide food with good quality. However, not much research work has been done on the effect of mineral fertilizer, cowdung, inoculant alone and their combined effect on wheat in field conditions. Keeping these points in view, the present investigation was undertaken to evaluate the performance of inoculant along with cowdung and mineral fertilizer on growth and yield of wheat.

## Materials and Methods

Field experiments were conducted at Ishurdi and Rajshahi, Bangladesh to evaluate the response of inorganic, organic and inoculum alone or integrated use of these sources on yield and yield contributing traits of wheat. Soil samples were randomly collected at 0 – 15 cm depth during the time of land preparation from several spots of the experimental sites and composited it. Soil samples were air dried and passed through a 2 mm sieve for analyzing some important physicochemical properties. Initial soil characteristics results are presented (Table 1). The experimental treatments comprised of two locations (Ishurdi and Rajshahi) and eight fertilizer applications M (mineral fertilizers), M + CD (cowdung), CD, PSB (phosphate solubilizing bacteria: *Pseudomonas* sp), PSB + M, PSB + CD, PSB + CD + M including control. The trials were laid out in randomized block design using three replications having unit plot size of 4 m x 3 m=12m$^2$ and wheat was the test crop. One third of 90 kg N ha$^{-1}$ as urea, 42 kg $K_2O$ ha$^{-1}$ as muriate of potash, 20 kg P ha$^{-1}$ as triple super phosphate and 10 kg S ha$^{-1}$ as gypsum as per treatment were applied at the time of final land preparation. Cowdung (5.0 t ha$^{-1}$) also was applied at the time of final land preparation. All the above mentioned inorganic and organic fertilizers were mixed well with the soil by spading before sowing of seed. PSB application with seed coating at 7.5 kg ha$^{-1}$ of peat based carrier having a bacterial load of $10^8$ cells per gram. The rest 60 kg N as urea was applied in two splits at maximum vegetative phase and panicle initiation stage of wheat. Cultural practices were done whenever necessary. At harvesting stage, 10 plants were randomly selected and harvested from each unit plot to record yield contributing traits, grain and straw yield of wheat. Harvest index was

calculated by using the following formula: Harvest index = [{(Grain yield) ÷ (Biological yield)}× 100]. Data were statistically analyzed and Duncan's Multiple Range was applied to examine the significant differences between the treatment means (Gomez and Gomez, 1984).

## Results and Discussion

The results depicted in Table 2 indicated that location had significant effect on yield and yield contributing characters of wheat. At Ishurdi, growth parameters of wheat were statistically significant than Rajshahi location except for tiller per hill and 1000 seed weight. Plant height, spike length and filled grain per ear were significantly higher in Ishurdi than Rajshahi location. More plant height (70.85cm) was observed in Ishurdi compared to Rajshahi (63.01cm). The higher value (6.56cm) of spike length was found in Ishurdi and the lower (5.82cm) was obtained from Rajshahi. Maximum filled grain (24.06) was obtained from Ishurdi and the minimum filled grain per ear was observed in Rajshahi. Regarding location the highest mean 1000 grains weight (43.94g) was observed in Rajshahi as compared to Ishurdi (42.22g). Mean increase in 1000 seed weight of rice was 0.73% in Rajshahi compared to Ishurdi. The higher wheat yield (2.17 t $ha^{-1}$) was observed in Ishurdi compared to Rajshahi and it showed that increase in wheat yield at harvest of crop was 36.48 per cent in Ishurdi over Rajshahi location. On the other hand, maximum straw yield (4.05 t $ha^{-1}$) was observed in Rajshahi. Wheat gained maximum harvest index (40.57%) when grown in Ishurdi while minimum harvest index (27.34%) was observed in Rajshahi. More, harvest index in Ishurdi treated plots may be attributed to more individual grain size and grain yield.

**Table 1.** Initial soil properties of the selected locations

| Location | Soil type | pH | Organic matter (%) | Total nitrogen (%) | Available phosphorus (ppm) |
|---|---|---|---|---|---|
| Ishurdi | Sandy loam | 7.5 | 1.00 | 0.11 | 14.00 |
| Rajshahi | Clayey | 4.8 | 1.80 | 0.13 | 30.63 |

Results showed that PSB+CD+M application increased plant height, spike length, tiller per hill, filled grain per ear, 1000 seed weight, grain-straw yield and harvest index compared to control. Plant height, spike length, number of tillers per hill and filled grain per panicle ranged from 53.13 to 74.83cm, 5.00 to 6.76cm, 2.13 to 3.75, 14.88 to 24.25 were found in control and PSB + CD + M, respectively. The tallest plant height was observed in PSB + CD + M treatment followed by PSB + M, PSB + CD and M + CD treatments. Maximum spike length (6.76cm) was found in PSB + CD + M which were not statistically significant to other treatments. Maximum tiller (3.75) per hill was found in PSB + CD + M and PSB + CD treatments and the lowest (2.13) tiller per hill was obtained from control treatment. The second highest tiller per hill (3.63) was achieved in PSB + CD treatment. In respect of filled grain per ear, maximum result was found in PSB + CD + M treatment which was statistically significant to all other treatments except for cowdung and control treatments. The highest 1000 seed weight (43.96) was obtained from M + CD treatment which was not statistically significant to other treatments. Combined use of mineral, organic and inoculant was performed better results than alone use of these sources. In calcareous (Ishurdi) and acidic (Rajshahi) soil, microorganisms are enormous potential in providing soil phosphates for plant growth. Phosphatic biofertilizer in the form of microorganisms can help in increasing the availability of fixed phosphates for plant growth by solubilization. These results are in agreement with the findings of Ekin, 2010; Shah *et al.,* 2001; Richardson, 2001. *Pseudomonas* sp had a stimulatory effect on wheat, maize and cotton growth, yield, N, P uptake and soil P content (Egamberdiyeva *et al.,* 2004; Han and Lee, 2006).

Effects of different treatments on grain yields are presented (Table 2). Integrated application of phosphate solubilizing bacteria (*Pseudomonas* sp), cowdung and mineral fertilizer significantly influenced grain yield of wheat. Grain yield of wheat ranged from 1.52 to 2.83 t $ha^{-1}$ in control and PSB+CD+M treatments, respectively. Maximum grain yield was found in PSB + CD + M treatment which was statistically significant to other treatments. The lowest yield was observed in control treatment. The second highest grain yield was obtained from 2.19 t $ha^{-1}$ in PSB + M treatment. PSB alone performed better grain yield (1.88 t $ha^{-1}$) of wheat than control. Similar yield performance was found in M, M + CD and PSB + CD treatments. The data showed substantial effect of different treatments on wheat harvest index (Table 2). Harvest index ranged from 31.58 to 36.12 per cent in CD and control treatments. Maximum harvest index (36.12%) was observed in mineral treated plots followed by control treatment. Minimum harvest index (31.58%) was found in M+CD treated plots. The second highest harvest index was observed in control treatment (36.12%). The correlation coefficients of yield contributing traits were worked out (Table 3) in order to evaluate their influence on wheat yield. Spike length, number of tiller per hill and filled grain per panicle were showed positive and significant correlation with grain yield to indicate that grain yield increased with the increase of yield contributing parameters results. Filled grain had positive and significant correlation with number of tiller and spike length suggesting that higher number of filled grain was helped to increase wheat yield. Filled grains per ear were showed negative and significant correlation with 1000 seed weight of wheat because grains per ear increased with the decrease of grain size.

Interaction effects between location and fertilizer results are presented (Table 2). Plant height, spike length, filled grain per ear and 1000 seed weight were not statistically significant but the results were different among the fertilizer treatments. Maximum plant height, spike length and filled grain per ear (80.00cm, 8.02cm and 28.25) were found the treatment combination I × PSB+CD+M. Maximum tiller per hill was observed R × PSB treatment

followed by I × PSB+CD, I × PSB+CD+M, R × M+CD and R × PSB+CD+M treatments. The second highest filled grain (27.25) per ear was recorded in I × PSB treatment. The control treatment combination I × cont produced lower spike length, tiller per hill and 1000 seed weight in Ishurdi than Rajshahi. On the other hand, control treatment combination R × cont produced higher plant height, filled grain per ear and grain yield of wheat in Ishurdi than Rajshahi. Highest grain yield was observed from the treatment combination I × PSB+CD+M. On the other hand, maximum straw yield obtained from Rajshahi with PSB+CD+M treatment. Growth and yield performance was better in Ishurdi than Rajshahi location. Maximum harvest index (43.43%) was observed in I × control treated plots and minimum harvest index (23.19%) was found in R× PSB treated plots. Integrated use of inorganic and organic fertilizers in combination with phosphate solubilizing bacteria performed better results than the use of inorganic, organic and phosphate solubilizing bacteria alone in terms of improving crop yields of wheat. The probable reason for these findings could be related the better utilization of nutrients in plots receiving the combined use of inorganic, organic and PSB, which made plants more efficient in photosynthetic activity. Grain becomes a dominant sink at their maturity stage and the entire photo-assimilate deposited in the grains gave them weight and ultimately achieved more grain yield (Alam and Shah, 2003). Mineral fertilizer was unable to produce optimum yield of wheat compared to integrated use of organic, inorganic and PSM treatments. This has been attributed to the imbalanced use of mineral fertilizers that culminated in low efficiency of plant growth. According to Zia *et al.* (2000) reported that continuous use of chemical fertilizers even in balanced proportion did not able to sustain crop productivity due to deterioration in soil fertility.

**Table 2.** Effect of organic, inorganic fertilizers and their combination on yield contributing parameters of wheat

| Treatment | Plant height (cm) | Spike length (cm) | Tiller plant$^{-1}$ | Filled grain | 1000 seed wt. (g) | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|
| Location (L) | | | | | | | | |
| Ishurdi (I) | 70.85 | 6.56 | 3.13 | 24.06 | 42.22 | 2.17 | 3.21 | 40.57 |
| Rajshahi (R) | 63.01 | 5.82 | 3.34 | 16.88 | 43.94 | 1.59 | 4.05 | 27.34 |
| Fertilizer (F) | | | | | | | | |
| Cont | 53.13 | 5.00 | 2.13 | 14.88 | 41.36 | 1.27 | 2.25 | 36.02 |
| M | 67.73 | 6.38 | 3.13 | 19.38 | 43.29 | 2.02 | 3.61 | 36.12 |
| M + CD | 73.83 | 6.63 | 3.50 | 22.50 | 43.96 | 2.02 | 4.35 | 31.58 |
| CD | 63.62 | 5.73 | 3.00 | 18.63 | 42.54 | 1.48 | 3.02 | 32.97 |
| PSB | 61.06 | 6.34 | 3.50 | 22.00 | 42.65 | 1.70 | 2.77 | 33.06 |
| PSB + M | 71.65 | 6.40 | 3.25 | 21.38 | 43.27 | 2.16 | 4.41 | 33.51 |
| PSB + CD | 69.60 | 6.28 | 3.63 | 20.75 | 43.69 | 2.02 | 3.86 | 34.52 |
| PSB + CD + M | 74.83 | 6.76 | 3.75 | 24.25 | 43.89 | 2.39 | 4.75 | 33.87 |
| Interaction (L×F) | | | | | | | | |
| I × Cont | 57.50 | 4.90 | 2.00 | 18.75 | 41.17 | 1.52 | 1.98 | 43.43 |
| I × M | 68.35 | 6.40 | 3.00 | 21.00 | 42.19 | 2.35 | 3.09 | 43.21 |
| I × M+CD | 75.10 | 6.95 | 3.25 | 26.50 | 41.81 | 2.36 | 4.20 | 35.98 |
| I × CD | 68.15 | 5.90 | 3.00 | 19.50 | 42.00 | 1.54 | 2.76 | 35.81 |
| I × PSB | 68.06 | 6.73 | 3.00 | 27.25 | 42.27 | 1.88 | 2.50 | 42.92 |
| I × PSB+M | 75.35 | 6.80 | 3.25 | 26.25 | 41.71 | 2.49 | 3.57 | 41.16 |
| I × PSB+CD | 74.25 | 6.75 | 3.75 | 24.99 | 43.55 | 2.37 | 3.63 | 40.17 |
| I × PSB+CD+M | 80.00 | 8.02 | 3.75 | 28.25 | 43.04 | 2.83 | 3.93 | 41.86 |
| R × Cont | 48.75 | 5.10 | 2.25 | 11.00 | 41.54 | 1.01 | 2.52 | 28.61 |
| R × M | 67.12 | 6.35 | 3.25 | 17.75 | 44.38 | 1.70 | 4.13 | 29.04 |
| R × M+CD | 72.55 | 6.30 | 3.75 | 18.50 | 46.10 | 1.69 | 4.50 | 27.18 |
| R × CD | 59.09 | 5.55 | 3.00 | 17.75 | 43.08 | 1.41 | 3.27 | 30.12 |
| R × PSB | 54.06 | 5.95 | 4.00 | 16.75 | 43.02 | 1.51 | 3.04 | 23.19 |
| R × PSB+M | 67.95 | 6.00 | 3.25 | 16.50 | 44.82 | 1.83 | 5.25 | 25.85 |
| R × PSB+CD | 64.95 | 5.80 | 3.50 | 16.50 | 43.82 | 1.66 | 4.09 | 28.87 |
| R × PSB+CD+M | 69.65 | 5.50 | 3.75 | 20.25 | 44.74 | 1.94 | 5.56 | 25.87 |
| $LSD_{0.05}$ | | | | | | | | |
| L | 7.80 | 0.70 | 0.20 | 7.01 | 1.70 | 0.51 | 0.83 | 13.20 |
| F | 6.19 | NS | 0.31 | 5.27 | NS | 0.15 | 0.18 | 1.47 |
| L×F | NS | NS | 0.44 | NS | NS | 0.22 | 0.25 | 2.08 |

M-Mineral, CD-Cowdung, PSB-Phosphate solubilizing bacteria and means followed by same letter (s) in a column did not differ significantly at 5% level of probability and NS-Nonsignificant

In Ishurdi, yield performance was better than Rajshahi because Rashahi soils are acidic in nature. In acid soils the applied soluble phosphate fertilizer gets fixed through reaction with different soil constituents leading to phosphate deficiency. The important soil properties affecting P sorption are pH, organic carbon, oxalate extractable iron and aluminum, nature and content of clay, reactive aluminium and surface area of soil. The foregoing results suggest that in Rajshahi soils having low pH and higher organic matter compared to Ishurdi soil. Clay particles may be higher amount in Rajshahi as a result; extractable and reactive Fe & Al shared higher phosphate

fixation capacity (Sahrawat, 1991). In this regard, yield performance was not good at Rajshahi. On the other hand Ishurdi soils are calcareous in nature. Biswas *et al.* (1999) reported that P fixation decreased with high pH due to the effect of electrolytes with lower ionic strength. In this regard, pH was high in Ishurdi soil that is why phosphorus availability was higher than Rajshahi soil. In Rajshahi, straw yield of wheat was higher than Ishurdi due to imbalance use of N and P nutrients during wheat production. The correlation coefficients of all the above mentioned parameters (Table 3) helped to improve yield of wheat. Because yield of wheat increased with the increase of spike length, tiller per hill, filled grain per plant. The positive effects of phosphate solubilizing bacteria on yield and growth of crops such as sugarbeet, apple, raspberry and barley were explained by P-dissolving ability (Karlidag *et al.,* 2007). Last of all, our results showed that the possibility of integrated use of phosphate solubilizing bacteria in combination with cowdung and mineral fertilizers was enough to ensure the standard level of wheat yield. Therefore, these results indicated that the best management of integrated use of inorganic, organic and biofertilizer ensured good yield of wheat.

**Table 3.** Correlation coefficient among grain yield and yield contributing parameters of wheat

| Parameters | Grain yield | Plant height | Spike length | No. of tiller | Filled grain | 1000 seed weight |
|---|---|---|---|---|---|---|
| Grain yield | - | $0.693^{**}$ | $0.554^{**}$ | $0.399^{*}$ | $0.583^{**}$ | $0.033^{NS}$ |
| Plant height | | - | $0.634^{**}$ | $0.262^{NS}$ | $0.805^{**}$ | $0.032^{NS}$ |
| Spike length | | | - | $0.235^{NS}$ | $0.649^{**}$ | $0.162^{NS}$ |
| No. of tiller | | | | - | $-0.016^{NS}$ | $0.031^{NS}$ |
| Filled grain | | | | | - | $-0.455^{*}$ |
| 1000 seed weight | | | | | | - |

n=48; *, **-indicated significant at 5 and 1% level of significance and NS-Nonsignificant.

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