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Comprehensive effect of PGPR and organic manure and plant growth, yield attributes in wheat (*Triticum aestivum* L.) under organic farming system

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Abstract
Plant growth-promoting rhizobacteria (PGPR) are the heterogeneous group of soil bacteria that are inhibiting in the rhizospheric, around/on the root surface, which improve the plant growth directly or indirectly via production and secretion of various regulatory substances. PGPR affect plant growth and development either by releasing phytohormones or other biologically active substances, altering endogenous levels of plant growth regulators (PGR), enhancing availability and uptake of nutrients through fixation and mobilization, reducing harmful effects of pathogenic microorganisms on plants and/or employing multiple mechanisms of action. Nowadays, PGPR have received more attention for its use as a bio fertilizer for sustainability of agro ecosystems. Numerous studies have suggested that PGPR in an integrated nutrient management (INM) system could be used as effective supplements to chemical fertilizers for promoting crop yields and soil health on sustainable basis. In prospect to healthy and sustainable agriculture PGPR approach revealed as one of the best alternatives.

Keywords: Farmyard manure, inorganic fertilizer, bio fertilizers, azotobactor, phosphate solubilizing bacteria

1. Introduction
Recently, there has been a resurgence of interest in environmental friendly sustainable agricultural practices. In the development and implementation of sustainable agriculture techniques, bio-fertilization is of great importance in order to alleviate deterioration of natural and environmental pollution. A considerable number of bacterial species are able to exert a beneficial effect on plant growth. Such bacteria are generally designated as PGPR (plant growth-promoting rhizobacteria). The beneficial effects of these rhizobacteria on plant growth can be direct or indirect. Several mechanisms by which PGPR can act beneficially on plant growth are described. With activities secretion of growth hormones including (a) bio fertilization, (b) stimulation of root growth, (c) rhizoremediation, and (d) plant stress control. Organic fertilization is very important in organic fruit production due to use of inorganic fertilizers is not possible. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. The use of organic manures *viz*. farmyard manure, vermicomposting forest litter and bio fertilizers *viz*. azotobactor, Phosphate solubilizing bacteria reduce the cost of cultivation and supplement the secondary and micronutrients to crops. Bio-fertilizers combined with organic manure influences the plant growth by enhancing root biomass; total root surface facilitates higher absorption of nutrients and increase in yield by reducing consumption of natural sources of energy. The organic fertilizers have proved that their application has the potential to increase the biomass and productivity of a wide range of crops

2. Materials and Methods
Field experiments were conducted during Kharif and Rabi seasons of 2008-09 on an Inceptisol at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.). It is located at South-East end of Varanasi city at 25º.18′ N latitude, 83º.30′ E longitude and at an altitude of 128.93 m above mean sea level. The experimental site lies approximately in the centre of North-Genetic alluvial plain, on the left bank of river Ganges.

The soil of experimental field was sandy loam in texture having mechanical separates sand 48.86%, silt 30.68% and clay 20.46%, low soil organic field was sandy loam in texture having mechanical separates sand carbon (0.39%), low available N (208 kg ha-1), medium available P (17.9 kg ha-1) and K (227.0 kg ha-1), bulk density (1.41 Mg M-3), particle density (2.62 Mg M-3), water holding capacity (45.7%), cation exchange capacity [18.70 Cmol (P+) kg-1 soil] with neutral pH 7.3 (1:2.5 soil: water ratio). The experiment consisted of thirty two treatment combinations of four levels of fertilizer (0, 50, 75 and 100% RDF), two levels of FYM (without FYM and 10 t FYM ha-1) and four levels of bio fertilizers [control, azotobacter chroococcum W5 + Azospirullum brasilense Cd + Pseudomonas fluorescens BHUPSB06 + Bacillus megaterium BHUPSB14, VAM. (Glomus fasciculatum) inoculation and azotobacter chroococcum W5 + Azospirullum brasilense Cd + Pseudomonas fluorescens BHUPSB06 + Bacillus megaterium BHUPSB14 + VAM (Glomus fasciculatum) inoculation were replicated thrice in a split plot design having fertilizer levels in main plots, organic manure in sub plot and biofertilizer in sub sub-plots. The levels of fertilizer and FYM were applied as per treatments. My corrhiza mixed with soil and pour in open furrow before sowing of the wheat seed as per the treatment. The different combination of fertilizer was applied through urea, Diammonium phosphate and muriate of potash, respectively. The half dose of nitrogen and full dose of phosphorus and potash were applied as basal dressing at the time of sowing and remaining half dose of nitrogen was applied in equal portion as top dressed after first and second irrigation. Wheat seeds were inoculated with different bio fertilizer culture as per treatments. Inoculated and uninoculated seed of wheat (HUW-234) was shown in the month of December in both the years using 100 kg seed/ha. Appropriate management practices were adopted to raise the crop. Growth and yield attribute were recorded at different growth stages of the crop.

2.1 Seed Inoculation with Inoculums

The mass culture of Azotobacter chroococcum W5, Azospirullum brasilense Cd and my corrhiza (Glomus fasciculatum) was obtained from Department of Microbiology, Indian Agricultural Research Institute, and New Delhi, India. The pure culture of Bacillus megaterium strain BHUPSB14 and Pseudomonas fluorescens strain BHUPSB06 were obtained from Department of Soil Science and Agricultural Sciences, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India. Healthy seeds weighed for each plot of 20 m^2 (@ 100 kg ha^{-1}) were separately inoculated as per treatments in plastic bags with 2 ml of each culture of 4 days old broth cultures grown in specific media of respective inoculants (mixed in 1:1:1:1 ratio for combined treatments) along with 10 ml of 1% (w/v) sticker solution of gum acacia to ensure bacterial population in the range of 107 to 108 cfu per seed. After drying for one hour in shade, uninoculated seeds were sown first followed by inoculated seeds just to avoid contamination. My corrhiza mixed with soil and pour in open furrow before sowing of the wheat seed as per the treatment.

3. Results and Discussion

The results obtained from the present investigation are summarized below in the following sub heads:

3.1 Effect of fertilizer levels on growth characters

Plant height, number of tillers and dry matter accumulation at different growth stages of wheat as influenced by fertilizer levels, FYM and bio fertilizer are presented in Table 1-3. Plant height was comparatively highest in second year than the first year of experimentation. Further, data revealed that all the factors, either of fertilizer, FYM or bio fertilizer, were able to increase plant height of wheat significantly over control during both the years. Plant height, number of tillers and dry matter accumulation at different growth stages of wheat were significantly increased with increasing application of fertilizer levels over no control (Table 1-3). Application of 100% RDF produced significantly taller plants, more number of tillers and dry matter than all other levels of fertilizer. The increase in plant height due to increase in fertilizer doses was might be due to an increase in nutrient availability and therefore, significant increase in vegetative growth of plants was obtained. Increasing fertilizer level increases the growth and yield attributes [12, 17, 21]. The results pertaining to the effect of fertilizer levels, FYM and biofertilizer on number of tillers m^{-1} row (Table 2) revealed that the increasing doses of fertilizer application increased the total number of tillers at the stages of tillering, ear emergence of wheat crop but at the harvesting stage, the number of tillers decreased. The lowest values of the number of tillers of wheat were 85.25, 85.75 at tillering, 90.13, 91.71 at ear emergence and 74.42, 75.46 at harvesting stage due to no application of fertilizers (control) whereas maximum values were 114.42, 115.83 at tillering, 116.75, 119.96 at ear emergence and 103.29, 105.75 at harvesting stage of the wheat due to application of 100% NPK during 1st and 2nd year of experiments, respectively. The increase in number of tillers was might be due to increased rate of fertilizer, which, led to greater stimulation of vegetative growth. All fertility levels significantly affected vegetative and reproductive growth of the plants depending upon the availability of needed nutrition which leads to proportional increase in tillers. Ineffective tillers died with the time of growth and only effective tillers are remained [19]. Therefore, decrease in number of tillers was observed at harvesting stage. Examination of data (Table 3) on fertilizer levels revealed that the dry matter production was significantly increased with increasing dose of fertilizer levels as compared to control. With 100% RDF, dry matter production increased from 39.20 to 47.12 g m-1 row, 84.73 to 101.78 g m-1 row at tillering and ear emergence, respectively on mean basis. The possible reason for increase in dry matter production could be correlated with the increased number of tillers, production and accumulation of more photo synthates under the influence of more nutrients availability which ultimately enhanced the dry matter production. These results are akin to the findings of many researchers on wheat crop [16, 18].

Table 1: Effect of recommended dose of fertilizer, FYM and bio fertilizers on plant height at various growth stages of wheat

Treatment	Plant height (cm)								
	Tillering stage			Ear emergence stage			Harvesting stage		
	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean
Recommended dose of fertilizer									
control	29.23	30.29	29.76	51.95	52.37	52.16	73.2	74.3	73.75
50%RDF	36.8	38.35	37.58	64.75	66.54	65.65	79.76	81.37	80.57

75%RDF	40.5	41.96	41.23	70.44	72.16	71.3	96.64	98.27	97.46
100%RDF	41.9	43.62	42.76	73.1	74.87	73.99	101.65	102.42	102.04
SE m+_	0.3	0.347		0.288	0.296		0.4	0.419	
CD 5%	1.034	1.119		0.996			1.381	1.445	
Fym Level(T Ha-1)									
No YM	35.47	36.72	36.1	62.18	63.34	62.76	84.67	85.87	85.27
FYM 10 t ha-1	38.75	40.39	39.57	67.93	69.63	68.78	90.96	92.31	91.64
SE m+_	0.253	0.251		0.174	0.271		0.231	0.267	
CD 5%	0.825	0.819		0.566	0.884		0.753	0.869	
Biofertilizer									
No incubation	36.00	37.35	36.68	63.41	64.95	64.18	86.24	87.56	86.9
PGPR	37.02	38.54	37.78	64.79	66.03	65.41	87.64	88.94	88.29
VAM	37.45	38.86	38.16	65.45	66.67	66.06	88.23	89.24	88.74
PGPR+VAM	37.98	39.46	38.72	66.58	68.2	67.39	89.15	90.62	89.89
SE m+_	0.21	0.21		0.366	0.345		0.393	0.371	
CD 5%	0.606	0.600		1.041	0.980			1.054	

Table 2: Effect of recommended dose of fertilizer, FYM and biofertilizer on numbers of tillers/m row at various growth stage of wheat

Treatment	Number of tillers/m row								
	Tillering stage			Ear emergence stage			Harvesting stage		
	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean
Recommended dose of fertilizer									
control	85.25	85.75	85.5	90.13	91.71	90.92	74.42	75.46	74.94
50%RDF	101.58	103.58	102.58	113.17	106.54	105.36	89.71	91.67	90.69
75%RDF	111.75	112.54	112.15	113.75	115.75	114.75	100.29	102.17	101.23
100%RDF	114.42	115.83	115.13	116.75	119.96	118.36	103.29	105.75	104.52
SE m+_	0.887	0.909		0.729	0.786		0.673	0.683	
CD 5%	3.06	3.136		2.515	2.712		2.322	2.356	
Fym level(t ha-1)									
No YM	98.73	99.33	99.03	101.29	103.48	102.39	88.6	89.83	89.22
FYM 10 t ha-1	107.77	109.52	108.65	111.1	113.5	112.3	95.25	97.69	96.47
SE m+_	0.618	0.67		0.359	0.424		0.393	0.4	
CD 5%	2.012	2.182		1.169	1.381		1.279	1.304	
Biofertilizer									
No incubation	100.21	101.33	100.77	102.29	104.46	103.38	86.92	88.5	87.71
PGPR	103.33	104.83	104.08	106.92	108.54	107.73	93.38	95.38	94.38
VAM	103.75	103.79	103.77	104.92	108	106.46	91.46	93.25	92.36
PGPR+VAM	105.71	107.75	106.73	110.67	112.96	111.82	95.96	97.92	96.94
SE m+_	0.74	0.54		0.558	0.8586		0.499	0.457	
CD 5%	2.114	1.542		1.587	1.668		1.419	1.3	

Table 3: Effect of recommended dose of fertilizer, FYM and biofertilizer on dry matter production at various growth stage of wheat

Treatment	Dry matter production (g m-1 row)					
	Tillering stage			Ear emergence stage		
	2009-10	2010-11	Mean	2009-10	2010-11	Mean
Recommended Dose of Fertilizer						
control	38.78	39.61	39.20	84.03	85.43	84.73
50%RDF	41.86	43.03	42.45	89.26	92.00	90.63
75%RDF	44.02	45.37	44.70	95.16	98.13	96.65
100%RDF	46.57	47.66	47.12	101.33	102.22	101.78
SE m+_	0.386	0.411		0.608	0.686	
CD 5%	1.331	1.418		2.097	2.366	
Fym level(t ha-1)						
No YM	41.49	42.16	41.83	90.6	92.7	91.65
FYM 10 t ha-1	44.13	45.68	44.91	94.29	96.19	95.24
SE m+_	0.312	0.332		0.51	0.518	
CD 5%	1.018	1.081		1.662	1.687	
Biofertilizers						
No incubation	40.65	41.67	41.16	87.57	91.07	89.32
PGPR	42.83	43.54	43.19	92.46	94.44	93.45
VAM	42.80	44.33	43.57	91.84	94.08	92.96
PGPR+VAM	44.95	46.13	45.54	97.92	98.2	98.06
SE m+_	0.363	0.402		0.828	0.848	
CD 5%	1.033	1.144		2.355	2.413	

3.2 Effect of FYM on growth characters

The growth parameters such as plant height, number of tillers and dry matter production were significantly higher with FYM application. The alone treatment of FYM @ 10 t ha^{-1} gave the values of plant height 38.75 cm and 40.39 cm at tillering stage; 67.93 cm and 69.63 cm at ear emergence and

90.96 cm and 92.31 cm at harvesting stage during 2009-10 and 2010-11, respectively (Table1). These values of plant height were significantly higher over the control treatment of FYM because application of FYM improved crop growth by improving physical, chemical and biological condition of soil [13]. Results of present investigation also corroborate with the findings of many researchers. They reported that application of FYM @10 t ha-1 supplies nutrients continuously to the crop plants and therefore, plant height could be increased [11,19]. Application of FYM @ 10 t ha-1 significantly increased the total number of tillers per meter row and dry matter production at all growth stages of the wheat during the year of investigation. Application of 10 tonnes FYM/ha produced more number of tillers (108.65, 112.3 and 96.47/m) which were 9.62, 9.91 and 7.25 tillers/m more than that recorded with the control, at tillering, ear emergence and harvesting state of wheat, respectively on mean basis (Table 2). Application of FYM increases the number of tillers [7]. The maximum dry matter production 44.13 and 45.68 g/m row at tillering and 94.29 and 96.19 g/m row at ear emergence due to incorporation of FYM @ 10 t ha-1 during 1st and 2nd years, respectively. The higher dry matter production in FYM applied treatment may be imputed to mineralized nutrients present in it and that can be easily utilizable by the plants during early stages of growth [22]. Plant height, number of tillers and dry matter production significantly enhanced with application of FYM [1].

3.3 Effect of PGPR on growth characters

Examination of data (Table 1) due to bio inoculants revealed that plant height at tillering stage was in the range of 36.0 to 37.98 cm and 37.35 to 39.46 cm at tillering stage, 63.41 to 66.54 cm and 64.95 to 68.20 cm at ear emergence; and 86.24 to 89.15cm and 87.56 to 90.62 cm at harvesting stage of the wheat during 2009-10 and 2010-2011, respectively. The plant height at tillering stage significantly increased with the inoculation of PGPR, VAM and PGPR +VAM to the extent of 2.83, 4.03 and 5.50% during 2009-10 and 3.19, 4.04 and 5.65% during 2010-11 over uninoculated treatment, respectively. The almost similar trends were also found at ear emergence and harvesting stages with the inoculation treatments of PGPR, VAM and PGPR+VAM during both the years. Application of PGPR+VAM together gave the significantly higher values of plant over the control and individual treatments. Plant height could be enhanced by PGPR due to secretion of phyto hormones and increasing the availability of nutrients in the root sphere [2]. The similar significant trends were also recorded in number of tillers and dry matter production of wheat at different growth stage during both the year of investigation. The significant effects on tillers and dry matter production of wheat was might be attributed due to increase in N and P availability through mineralization of organic N, N2 fixation and solubilization of insoluble inorganic phosphate, decomposition of phosphate rich organic compounds and production of plant growth promoting substances by the microbial inoculants or due to production of growth promoting substances such as indole acetic and gibberellic acids which positively affected plant growth [4, 8].

3.4 Interaction effect of fertilizer levels and FYM on plant growth

Significant interaction effect of different levels of fertilizer and FYM (Table 4) on plant height of wheat was observed. Data revealed that highest plant height i.e. 42.81, 74.01 and 104.77 cm was recorded with application of 100% RDF along with FYM @ 10 t ha-1 at all the stages of the wheat during 2009-10. The same trends were also recorded during 2010-11 at all the stages of the wheat growth. This trend was indicating that the use of fertilizers in addition to FYM improved the nutrients supplying power of soil to the plant and ultimately, improved the plant height of wheat. Combined use of FYM (10 t ha-1) and 75% RDF was significantly higher at harvesting stage of crop growth during 2009-10 and 2010-11, respectively. The results on plant height confirmed the trend observed earlier for the yield-contributing characters and upheld the need of supplementing the 100% RDF with 10 t FYM ha-1 [6].

Table 4: Interaction effect of recommended dose of fertilizer, FYM on plant height (cm) at various growth stage of wheat

2009-10												
Treatment	**Tillering stage**				**Ear emergence stage**				**Harvesting stage**			
	control	**50%RDF**	**75%RDF**	**100% RDF**	**control**	**50%RDF**	**75%RDF**	**100% RDF**	**control**	**50%RDF**	**75%RDF**	**100% RDF**
No YM	26.62	34.75	39.5	41.00	46.64	62.31	67.59	72.19	71.42	76.84	91.88	98.53
FYM 10 t ha-1	31.85	38.85	41.5	42.81	57.26	67.18	73.29	74.01	74.99	82.68	101.41	104.77
	S.Em+_ =0.507, CD (5%)=1.650				S.Em+_ =0.348, CD (5%)=1.133				S.Em+_ =0.462, CD (5%)=1.506			
2010-11												
Treatment	**Tillering stage**				**Ear emergence stage**				**Harvesting stage**			
	control	50%RDF	75%RDF	100% RDF	control	50%RDF	75%RDF	100% RDF	control	50%RDF	75%RDF	100% RDF
No YM	27.23	36.27	40.81	42.55	47.21	63.79	69.19	73.18	72.56	78.07	93.01	99.82
FYM 10 t ha-1	33.35	40.42	43.1	44.69	57.53	69.29	75.13	76.57	76.03	84.67	103.52	105.02
	S.Em+_ =0.503, CD (5%)=1.638				S.Em+_ =0.543, CD (5%)=1.768				S.Em+_ =0.534, CD (5%)=1.738			

3.5 Interaction effect of fertilizer levels and FYM on ear head length and test weight

The interaction effect of fertilizer levels and FYM presented in Table 5 revealed that the highest ear head length (9.01 and 9.41 cm) and test weight (42.9 and 43.41 g) were obtained due to combined use of 100% RDF and FYM @ 10 t ha-1 during both the years, respectively. The ear head length and test weight recorded by the combined application of 75% RDF and FYM @ 10 t ha-1 was at par with that recorded by the application of 100% RDF alone during both the years. The combined application of 100% RDF + 10 t FYM ha-1, improved the general soil environment, which helped to improve the wheat yield contributing characters [20]. The significant increase in the test weight was mainly owing to the improvement in growth as well as yield-attributing characters, as the application of FYM and fertilizer improves the fertility status which results in the better utilization of nutrients by the wheat crop. Adequate and gradual supply of nutrient might have increased the photosynthetic activity and uptake resulting thereby increase in test weight [23].

4. Conclusion
In conclusion, these results show that increasing levels of fertilizer, FYM and biofertilizers could stimulate growth and yield attributes of wheat. Fertilizer application with organic manure had the effect of improving the soil probably due to increasing its organic matter, mineralization and mineral absorption. Thus, integrated use of inorganic fertilizer and FYM (75% RDF + 10 t FYM/ha) was more effective in enhancing the growth and yield attributes.

5. References

1. Agamy RA, Mohamed GF, Rady MM. Influence of the application of fertilizer type on growth, yield, anatomical structure and some chemical components of wheat (*Triticum aestivum* L.) grown in newly reclaimed soil. Australian Journal of Basic and Applied Sciences. 2012; 6(3):561-570.
2. Burd GI, Dixon DG, Glick BR. PGPR that decrease heavy metal toxicity in plants. Canadian Journal of Microbiology. 2000; 3:237-245.
3. Das I, Singh AP. Effect of PGPR and organic manures on soil properties of organically cultivated mungbean. The Bioscan. 2014; 9(1):27-29.
4. Gaur AC, Sunita G. Phosphate solubilizing microorganisms-An overview, Current Trends in Life Science. 1999; 23:151-164.
5. Gaur AC, Neelketan S, Dargan KS. Organic manures. ICAR, New Delhi, 1990, 3.
6. Gawai PP, Pawar VS. Integrated nutrient management in sorghum (Sorghum bicolor)-chickpea (*Cicer arietinum*) cropping sequence under irrigated conditions. Indian Journal of Agronomy. 2006; 51(1):17-20.
7. Ghanshyam Kumar R, Jat RK. Productivity and soil fertility as effected by organic manures and inorganic fertilizers in greengram (Vigna radiata)-wheat (*Triticum aestivum*) system, Indian Journal of Agronomy. 2010; 55(1):16-21.
8. Ghulam R, Sajjad M, Farooq L, Kauser AM. Identification of plant growth hormones produced by bacterial isolates from rice, wheat and Kallar grass, In: Malik, KA, Sajjad, M, Mirza, JK and Ladha (Ed). Nitrogen fixation with Non-Legumes. Kluwer Academic Publishers, Dordrecht, Boston, London. 1998, 25-37.
9. Joseph B, Patra RR, Lawrence R. Characterization of plant growth promoting Rhizobacteria associated with chickpea (Cicer arietinum L). International Journal of Plant Production. 2007; 1:141-152.
10. Kloepper JW, Reddy SM, Rodreguez Kabana R, Kenney DS, Kokalis-Burelle N *et al*. Application for rhizobacteria in transplant production and yield enhancement. Acta Horticulturae. 2004; 631:217-229.
11. Konthoujam ND, Singh TB, Athokpam HS, Singh NB, Shamurailatpam D. Influence of inorganic, biological and organic manures on nodulation and yield of soybean (*Glycine max* L.) and soil properties. Australian Journal of Crop Science. 2013; 7(9):1407-1415.
12. Lavakush, Yadav J, Verma JP, Jaiswal DK, Kumar A. Evaluation of PGPR and different concentration of phosphorus level on plant growth, yield and nutrient content of rice (*Oryza sativa*). Ecological Engineering. 2014; 62:123-128.
13. Mehmood T, Azam F, Hussain F, Malik KA. Carbon availability and microbial biomass in soil under an irrigated wheat-maize cropping system receiving different treatment. Biology and Fertility of Soils. 1997; 25(1):63-68.
14. Parewa HP, Yadav J, Rakshit A. Effect of Fertilizer Levels, FYM and Bio inoculants on Soil Properties in Inceptisol of Varanasi, Uttar Pradesh, India, International Journal of Agriculture, Environment and Biotechnology. 2014; 7(3):517-525.
15. Rana A, Joshi M, Prasanna R, Shivay YS, Nain L. Bio fortification of wheat through inoculation of plant growth promoting rhizobacteria and cyanobacteria. European Journal of Soil Biology. 2012; 50:118-26.
16. Sharma A, Rawat US, Yadav BK. Influence of phosphorus levels and phosphorus solubilizing fungi on yield and nutrient uptake by wheat under sub-humid region of Rajasthan, India, International Scholarly Research Network Agronomy, 2012, 1-9.
17. Shivakumar BG, Ahlawat IPS. Integrated nutrient management in soybean (*Glycine max*)-wheat (*Triticum aestivum*) cropping system. Indian Journal of Agronomy. 2008; 53(4):273-278.
18. Singh KN, Prasad B, Prasad AK, Sinha RK. Integrated effects of organic manure, biofertilizers and chemical fertilizers in rice-wheat sequence, Journal of Research, Birsa Agricultural University. 1997; 9:23-29.
19. Singh RK, Singh SK, Singh LB. Integrated nitrogen management in wheat (*Triticum aestivum*). Indian Journal of Agronomy. 2007; 52(2):124-126.
20. Singh S, Singh JP. Effect of organic and inorganic nutrient sources on some soil properties and wheat yield. Journal of the Indian Society of Soil Science. 2012; 60(3):237-240.
21. Singh V, Singh SP, Singh S, Shivay YS. Growth, yield and nutrient uptake by wheat (*Triticum aestivum*) as affected by biofertilizers, FYM and nitrogen. Indian Journal of Agricultural Sciences. 2013; 83(3):331-334.
22. Srivastava OP. Role of organic matter in crop production. Indian Journal of Agricultural Chemistry. 1988; 31(1):1-12.
23. Tulasa R, Mir MS. Effect of integrated nutrient management on yield and yield-attributing characters of wheat (*Triticum aestivum*). Indian Journal of Agronomy.2006; 51(3):189-192.
24. Vance CP. Biological fixation of N2 for ecology and sustainable agriculture. Springer-Verlag, 1997, 179.