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RESPONSE OF FERTILITY LEVELS, FYM AND BIOINOCULANTS ON YIELD ATTRIBUTES, YIELD AND QUALITY OF WHEAT

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ABSTRACT

The field experiment was conducted during two consecutive *rabi* seasons of 2009-10 and 2010-11 to study the effect of levels of NPK fertilizers, FYM and bio-inoculants (PGPR + VAM) on growth and yield of wheat in an Inceptisol of Varanasi. The results showed that, the application of 100% NPK, FYM and bio-inoculants significantly increased grain, straw yield and quality parameter of wheat. 100% and 75% NPK level increased the yield of wheat over 50% NPK which in turn was significantly superior over control. In case of yield, combination of farmyard manure (10 t/ha) along with 75% NPK showed statistically at par with 100% NPK alone. All treatments greatly increased growth, yield and yield attributes wheat. Based on our results, we recommend using PGPR and/or FYM in combination with NPK to minimize chemical fertilizer dose under intensive cropping system. Crop yield values showed significant difference between 100% and 50% NPK levels. Application of FYM showed increased yield over the control. PGPR and VAM helped in significant increase of the grain and straw yield of wheat. The interaction of these components registered better performance, thus inferring the importance of integrated nutrient supply system. The results revealed that application of optimum doses of NPK in combination with FYM @ 10 t/ha recorded highest grain and straw yields followed by 100% NPK. However, the yield responses were high with the balanced application of NPK with FYM and bio-inoculants in comparison to sub optimal and super optimal doses of NPK.

Keywords:
FYM, NPK, PGPR, Wheat, Yield

INTRODUCTION

Wheat (*Triticum aestivum* L.) is second most important cereal crops of India. Its rank first in the world cereal production with the productivity of 2.98 million tons/ha and is a staple food of about one third of the world's population. India is the second largest producer of wheat (94.90 million tons) next only to China (125.60 million tons) and cover the largest area under its cultivation (29.80 m ha), which is about 13.53 % of the world wheat area (217 m ha) (FAOSTAT, 2014). In recent year the food grain production have been stagnated or even declined for both rice and wheat crops (Dawe and Dobermann, 1999) and there has been a wide gap between the target and actual production (Pathak *et al.*, 2003). There are many reasons of low productivity of wheat out of which imbalance and excess fertilizer application is major one and changes in physico-chemical composition of the soil, a depletion and diminution in bioavailability of soil nutrients, a scarcity of good groundwater, build up of pests and attack of various diseases of wheat greatly affected its yield and quality (Timsina and Connor, 2001; Rush *et al.*, 2005). Excessive use of chemical fertilizers not only harms the biological power of soil but also decreases the soil fertility and crop productivity.

An optimum soil biota population must be maintained in the soil for higher nutrient use efficiency. No single source of plant nutrients can meet the entire nutrient need of crops in modern agriculture; rather they need to be used in an integrated manner following a management technology that is appropriate, economically viable, eco-friendly (Finck, 1998). FYM are the source of energy to the soil micro-flora and organic carbon content is considered to be an index of the soil health (Chand, 2008). Introduction of efficient strains of PGPR in soils may help in boosting up production through increased microbial population and consequently fixation of more atmospheric nitrogen and more solubilization of insoluble phosphorus from the soil. Hence present study was undertaken to know the effect of NPK fertilizer levels, FYM and bio-inoculants on the yield and quality of wheat crop.

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The integrated nutrient management advocates balanced and conjoint use of inorganic fertilizer, organic manure, green manure and PGPR in order to maintenance or adjustment of soil fertility and plant nutrient supply to an optimum level for sustaining desired crop productivity. Fertilizers are very important sources of plant nutrients for increasing agricultural production. The inorganic fertilizer could supply only one, two or three nutrients but integrated use of inorganic fertilizers, FYM and PGPR would provide macro and micronutrients to plant and soil and resist occurrence of multiple nutrient deficiencies. If sufficient quantity of organic manures is added along with inorganic fertilizers then perhaps there would be no need of adding micronutrients (Parsad, 1999). There is a great need for more research on biological nitrogen fixation and phosphorus solubilization for energy conservation. Most soils of Uttar Pradesh are low in organic matter content and poor in nitrogen and phosphorus. Hence introduction of efficient strains of PGPR in such soil may help in boosting up production through fixation of more atmospheric nitrogen and solubilization of insoluble phosphorus in soils. Farmyard manure favorably improves the physical, chemical and biological environment (Chand *et al.*, 2004).

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of 2009-10 and 2010-2011 at Agricultural Research Farm, Banaras Hindu University, Varanasi (Uttar Pradesh). The soil of experimental field was sandy loam in texture having low soil organic carbon (0.43%), low available N (208 kg/ha), medium available P (18.0 kg/ha) and K (237 kg/ha) and contents with neutral pH 7.3 (Table-1). A total of 32 treatments combinations comprising of four levels of fertilizer (0, 50, 75 and 100% NPK/ha), two levels of FYM (0 and 10 t/ha) and four plant growth promoting rhizobacteria (PGPR) strains used included no PGPR, two strain belonged to N_2-fixing (*Azotobacter chroococcum* W5 and *Azospirillum brasilense* Cd), one strain *Pseudomonas fluorescen*s BHUPSB06 belonged to promoting of root growth and antibiotic agent and P-solubilizing (*Bacillus megaterium* BHUPSB14), vesicular arbuscular mycorrhiza (*Glomus fasciculatum*) and PGPR + VAM, were replicated thrice under spilt-split plot design and assigned in main plots, sub plot and sub-sub plots, respectively. The 100% NPK recommended dose of fertilizer for wheat was 120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha, respectively. The farmyard manure (FYM) was obtained from dairy farm of Banaras Hindu University. The FYM @ 10 t/ha was incorporated one month before sowing as per treatments. Total N, P and K contents of the FYM were 0.47, 0.24, and 0.46 %, respectively. Half dose of N and full dose of P and K were applied as basal in the form of urea, di-ammonium phosphate and muriate of potash manually by placement method into open furrows, respectively.

The remaining N was applied in two equal splits at tillering and flower initiation stages, respectively during both the years. Seeds were inoculated with *Azotobactor chroococum* W5 + *Azospirillum brasilence* Cd + *Pseudomonas fluorescens* BHU PSB06 + *Bacillus megaterium* BHU PSB14 in 1:1:1:1: ratio. Inoculum of VAM, *Glomus fasciculatum* was drilled below seeds in soil. Wheat var. HUW-234 @ 100 kg/ha was sown at 22.5 cm spacing. The pure culture of *A. chroococcum* W5, *A. brasilence* Cd and mycorrhiza were obtained from Division of Microbiology, Indian Agricultural Research Institute, New Delhi. *Bacillus megaterium* BHUPSB14 and *Pseudomonas fluorescens* BHUPSB06 were obtained from Department of Soil Science and Agricultural Sciences, Institute of Agricultural Sciences, Banaras Hindu University. PGPR producing bacterial inoculums was prepared in conical flasks and each flask containing 250 mL nutrient broth was inoculated with selected strains of bacteria and incubated for 4 days under shaking (120 rpm) conditions at 29 ± 1^oC.

RESULTS AND DISCUSSION

Fertilizer levels

Plant height and yield attributes of wheat crop showed apparent influence of the varying levels of fertilizers (Table1). The improvement in growth and yield parameters was might be due to the supply of available form of NPK fertilizers. Beside that plant processes *viz.* cell division and root elongation in merismatic tissues and constituent of ADP and ATP in plant followed by a large canopy development under the increased levels of fertilizer seems to have a greater absorption and utilization of radiant energy resulting in high growth and yield attributing characters by crop plants (Sharma *et al*., 2012).Application of fertilizer levels from control to 100 % NPK significantly increased the grain and straw yield of wheat during both the years (Table-1). The values of grain yield (49.29 and 51.16 q/ha respectively) and straw yield (69.23 and 72.13 q/ha, respectively) during both years were significantly higher in treatment 100 % NPK which in turn was statistically superior to the rest of the treatment. The increase in yield could be attributed to profound influence of N, P and K fertilization on vegetative and reproductive growth; and their translocation towards the yield formation (Patidar and Mali, 2004).

Application of increasing levels of NPK fertilizer, FYM and bio-inoculants significantly increased the uptake of N, P and K by wheat (Table-2). The significant improvement in uptake of these nutrients was might be due to extra amount of nutrients supplied by fertilizer and FYM, which ultimately providing conductive physical environment facilitating better root growth and absorption of nutrients from the native as well as applied sources which favored the highest nutrient uptake (Bharadwaj *et al*., 1994; Singh and Singh, 2012).

Table 1 Effect of fertility levels, FYM and bio-inoculants on growth, yield attributes and yield of wheat

Treatment	Plant height (cm)		No. of ear head/m row		No. of grains/ear		Ear head length (cm)		Test weight (g)		Grain yield (q/ha)		Straw yield (q/ha)	
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Fertility levels (kg N, P_2O_5, and K_2O/ha)														
Control	73.20	74.30	62.83	63.88	30.18	30.79	6.86	6.92	35.20	35.31	16.25	16.55	25.27	25.77
NPK 50%	79.76	81.37	74.46	76.00	34.46	35.33	7.78	7.93	39.01	40.17	25.42	27.11	39.40	41.27
NPK 75%	96.64	98.27	84.33	86.08	37.55	38.50	8.19	8.42	41.38	41.80	40.29	41.75	58.12	60.22
NPK 100%	101.65	102.42	94.33	96.67	39.87	41.29	8.68	8.93	42.14	42.51	49.29	51.16	69.23	72.13
CD (*P*=0.05)	1.381	1.445	2.368	2.615	1.370	1.494	0.140	0.146	0.259	0.281	0.944	1.223	1.425	1.710
FYM levels (t/ha)														
FYM0	84.67	85.87	77.23	78.25	34.68	35.08	7.61	7.77	38.79	39.23	29.01	30.14	43.36	45.00
FYM10	90.96	92.31	80.75	83.06	36.35	37.88	8.15	8.33	40.07	40.67	36.60	38.14	52.65	54.69
CD (*P*=0.05)	0.753	0.869	1.837	1.866	0.550	0.977	0.101	0.106	0.248	0.255	0.339	0.551	0.483	0.697
Bio-inoculants														
Uninoculated	86.24	87.56	75.29	75.67	34.00	34.79	7.64	7.78	39.30	39.83	31.09	32.15	46.12	47.66
PGPR	87.64	88.94	79.21	81.00	35.51	36.33	7.89	8.06	39.48	39.99	32.95	34.66	48.04	49.88
VAM	88.23	89.24	78.88	81.67	35.85	36.21	7.94	8.07	39.38	39.90	32.45	33.87	47.61	49.30
PGPR + VAM	89.15	90.62	82.58	84.29	36.70	38.58	8.05	8.28	39.57	40.07	34.74	35.88	50.24	52.55
CD (*P*=0.05)	1.119	1.054	2.043	2.075	0.664	1.007	0.119	0.117	NS	NS	0.518	0.610	0.574	0.625

Significant increase in protein and carbohydrate content of grain was recorded upto 100% NPK during both the years. The increase in quality parameter was might be due to stimulating effect of NPK nutrients on chlorophyll formation and consequently photosynthesis. Similarly, the vital role of K in carbohydrate synthesis and its translocation to storage organs of grain (Agamy *et al*., 2012; Diacono *et al*., 2013; Sharma *et al*., 2013).

Farmyard manure (FYM)

The results indicate that FYM @ 10 t/ha significantly influenced the plant height, yield attributes, grain and straw yield and nutrient uptake over control both year of experiment (Table-1and 2). Application of FYM @ 10 t/ha significantly increased plant height (90.96 and 92.31 cm), number of ear head/m (80.75 and 83.06), number of grains/ear (36.35 and 37.88), ear head length (8.15 and 8.33 cm), test weight (40.07 and 40.67 g), grain yield (36.60 and 38.14 q ha^{-1}), straw yield (52.65 and 54.69 q ha^{-1}) and similarly other parameters during both the years, respectively. The result revealed that increasing application of FYM increased all the above parameters as compare to control (no FYM) might be due to its successive decomposition enabled the wheat crop to ensure an almost continuous supply of nutrients efficiently throughout the growth period of crop (Patil *et al*., 1998) and besides this it improved the soil physical, chemical and biological properties. Similar results were also reported by Kumar and Singh, (2010).

Bio-inoculants

The investigation result could be revealed that seed inoculation of wheat with bio-inoculants encourages the plant height and yield attributes. Seed inoculation with PGPR + VAM recorded significantly higher plant height, number of ear head, number of grain ear^{-1} head, ear head length and test weight over control. This may be due to the effect of PGPR + VAM which plays an important role in the nutrient acquisition, stimulation of growth by producing growth hormone, so that wheat plants reflected on enhance in the growth and yield characteristic. Phytohormones like, IAA and GA which promote the plant growth, cell division, breaking the special dominances, hence encouraging the photosynthesis and assimilates accumulation (El-Khawas and Adachi, 1999). Such improvements in yield attributes have also been observed by Namvar and Khandan (2013) and Lavakush *et al.* (2014).

Table 2 Effect of fertilizers levels, FYM and PGPR on total nutrients uptake of wheat

Treatment	Nitrogen (kg/ha)		Phosphorous (kg/ha)		Potassium (kg/ha)	
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Fertility levels (kg N, P_2O_5, and K_2O/ ha)						
Control	29.67	30.29	4.25	4.33	34.54	35.33
NPK 50%	52.06	55.72	7.71	8.43	57.94	61.18
NPK 75%	88.05	91.26	13.47	14.36	92.07	96.00
NPK 100%	110.06	114.94	17.53	18.92	118.50	123.91
CD (*P*=0.05)	2.95	3.48	0.676	0.282	1.811	2.058
FYM levels (t/ha)						
FYM0	60.78	63.31	9.19	9.95	67.36	70.17
FYM10	79.15	82.79	12.29	13.06	84.46	88.04
CD (*P*=0.05)	1.317	0.982	0.298	0.277	0.617	1.039
Bio-inoculants						
Uninoculated	65.62	68.17	9.89	10.51	72.48	75.28
PGPR	70.40	73.84	10.76	11.53	75.82	79.35
VAM	69.37	72.64	10.72	11.53	75.14	78.30
PGPR+VAM	74.46	77.56	11.58	12.46	79.61	83.49
CD (*P*=0.05)	1.523	1.852	0.247	0.554	0.817	0.922

Inoculation of composite PGPR + VAM significantly increased grain and straw yield (Table-1). Use of nitrogen fixing and phosphate solubilizing and mobilizing microorganism increased grain yield by 11.74 and 11.60% and straw yield by 8.93 and10.26% over no inoculation during 2009-10 and 2010-11, respectively. Combined use of PGPR + VAM showed highest value of grain yield (34.74 and 35.88 q/ha) and straw yield (50.24 and 52.55 q/ha), respectively, over no inoculation because these PGPR supply a part of nutrient demand of crop by fixing the atmospheric nitrogen or mobilizing fixed form of phosphorus and production of plant growth promoting substances such as IAA, GA and cytokinins-like substances (Wu *et al*., 2005).

Seed treatments with bio-inoculants have also shown significantly increase in total N, P and K uptake by wheat during both the years as compared to no inoculation. The use of composite cultures of PGPR + VAM significantly increased the total N (74.46 and 77.56 kg/ha), P (11.58 and 12.46 kg/ha) and K (79.61 and 83.49 kg/ha) uptake, which were significantly higher over no inoculation as well as over individual treatments of PGPR or VAM during 2009-10 and 2010-11, respectively.

Interaction effect of fertilizers and farm yard manures

Combined application of inorganic fertilizer and FYM produced significantly higher plant height, yield attributes, grain and straw yield, nutrient uptake in wheat than application of individuals. The data (Table-3) have clearly shown that combined application of 75% NPK + FYM @ 10 t/ha gave significantly higher plant height during both the years and test weight during 2010-11 as compared to 100% NPK fertilizer alone without application of FYM. Moreover, ear head length were found at par with application of 75% NPK + FYM @ 10 t/ha as compared to 100% NPK application alone during both the years. Similarly, the Combined application of 75% NPK and FYM @ 10 t/ha recorded grain and straw yield and N and P uptake at par that recorded by application of 100% NPK alone without FYM application during both the years.

Table 3 Interaction effect of fertilizer levels and FYM on plant height (cm) of wheat during 2009-10 and 2010-11

Treatment	2009-10											
	Plant height				Ear head length (cm)				Test weight (g)			
	Control	$NPK_{50\%}$	$NPK_{75\%}$	$NPK_{100\%}$	Control	$NPK_{50\%}$	$NPK_{75\%}$	$NPK_{100\%}$	Control	$NPK_{50\%}$	$NPK_{75\%}$	$NPK_{100\%}$
FYM_0	71.42	76.84	91.88	98.53	6.36	7.58	8.15	8.35	34.45	38.22	41.11	41.38
FYM_{10}	74.99	82.68	101.41	104.77	7.36	7.98	8.23	9.01	35.95	39.79	41.64	42.91
	CD (*P*=0.05)= 1.506				CD (*P*=0.05)= 0.203				CD (*P*=0.05)= 0.496			
	2010-11											
	Plant height				Ear head length (cm)				Test weight (g)			
FYM_0	72.56	78.07	93.01	99.82	6.47	7.78	8.36	8.45	34.46	39.44	41.40	41.61
FYM_{10}	76.03	84.67	103.52	105.02	7.37	8.07	8.47	9.41	36.16	40.90	42.20	43.41
	CD (*P*=0.05)= 1.738				CD (*P*=0.05)= 0.212				CD (*P*=0.05)= 0.511			

CONCLUSION

Increasing cost chemically fertilizers and unstable crop production call for substituting part of the inorganic fertilizers by using as locally available low cost organic sources *viz.*, manures, and bio-inoculants *etc* in an integrated manner to sustain production and soil health. It is recognized that neither organic manure nor chemical fertilizers alone can maintain yield sustainability under modern farming where nutrient turnover is quite high. However, due to paucity of organic sources and their inability to meet total nutrient requirement in sustaining high level productivity, to meet the demands of fast growing population of the country and to safe guard the soil health, their integrated use with chemical fertilizers is essential. Keeping this in view, the present investigation was conducted to monitor the effect of integrated application of inorganic, organic sources and bio-inoculants on yield and quality of wheat.

REFERENCES

Agamy, R.A., Mohamed, G.F. and Rady, M.M. 2012. 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* **6**(3): 561-570.

Bharadwaj, V., Omanwar, P.K., Sharma, R.A. and Vishwanath, 1994. Long-term effects of continuous rotation of cropping and fertilization on crop yield and soil properties-I, Effect on crop yield and nutrient uptake. *Journal of the Indian Society of Soil Science* **42**(2):247-253.

Chand, S., Somani, L.L. and Pabbi, S. 2004. Biofertilizers: a green way to soil fertility through IPNS. Abstracts of the Interactive workshop on biofertilizers organized by Division of Microbiology and Center for Conservation and Utilization of Blue Green Alagae, New Delhi, p 57-58.

Chand, T.K. 2008. Analysis of fertilizer use by crops. *Indian Journal of Fertilizers* 4: 11-16.

Dawe, D. and Dobermann, A. 1999. Defining productivity and yield, In: IRRI Discussion paper series no. 33 Manila Philippines, pp 13, 1999.

Diacono, M., Rubino, P. and Montemurro, F. 2013. Precision nitrogen management of wheat: a review. *Agronomy for Sustainable Development* **33**(1): 219-241.

El-Khawas, H. and Adachi, K. 1999. Identification and quantification of auxins in culture media of *Azospirillum* and *Klebsiella* and their effect on rice roots. *Biology and Fertility of Soils* 28:377-381

FAOSTAT, 2014. Food and Agriculture Organization of the United Nations, FAOSTAT database. Available at *http://faostat.fao.org*

Finck, A. 1998. Integrated nutrient management an overview of priencpals, probles and possibilities. *Annals of Arid Zone* 37: 1-24.

Kumar, V. and Singh, A.P. 2010. Long-term effect of green manuring and farmyard manure on yield and soil fertility status in rice-wheat cropping system. *Journal of the Indian Society of Soil Science* **58**(4): 409-412.

Lavakush, Yadav, J., Verma, J.P., Jaiswal, D.K. and Kumar, A. 2014. Evaluation of PGPR and different concentration of phosphorus level on plant growth, yield and nutrient content of rice (*Oryza sativa*). *Ecological Engineering*, 62: 123-128.

Namvar, A. and Khandan, T. 2013. Response of wheat to mineral nitrogen fertilizer and biofertilizer (*Azotobacter* sp. and *Azospirillum* sp.) inoculation

under different levels of weed interference. *Ekologia*, **59**(2): 85-94.

Pathak, H., Ladha, J.K., Aggarwal, P.K., Peng, S., Das, S., Singh, Y. Singh, B., Kamra, S.K., Mishra, B., Sastri, A.S.R.A.S., Aggarwal, H.P., Das, D.K. and Gupta, R.K. 2003. Climatic potential and on-farm yield trends of rice and wheat in the Indo-Gangetic Plains. *Field Crops Research.* **80**(3): 223-234.

Patidar, M. and Mali, A. 2004. Effect of farmyard manure, fertility levels and bio-fertilizers on growth, yield and quality of sorghum (*Sorghum bicolor*). *Indian Journal of Agronomy*. **49**(2): 117-120.

Patil, R.B. and Varade, P.A. 1998. Microbial population in rhizosphere as influenced by high input rates of fertilizer application to sorghum on a Vertisol. *Journal of the Indian Society of Soil Science*. **46**(2): 223-227.

Prasad, B., 1999. Conjoint use of fertilizers with organics, crop residues and green manuring for their efficient use in sustainable crop production. *Fertilizer News*, 44: 67-73.

Rush, C.M., Stein, J.M., Bowden, R.L., Riemenschneiden, R., Boratynski, T. and Royer, M.H. 2005. Status of karnal bunt of wheat in the United States 1996-2004. *Plant Disease* 89, 212-223.

Sharma, A., Rawat, U.S. and Yadav, B.K.2012. 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* 1-9.

Sharma, G.D., Thakur, R., Som raj, Kauraw, D.L. and Kulhare, P.S. 2013. Impact of integrated nutrient management on yield, Nutrient uptake, protein content of wheat (*Triticum astivam*) and soil fertility in a typic haplustert, *The Bioscan* **8**(4), 1159-1164.

Singh, S. and Singh, J.P. 2012. Effect of organic and inorganic nutrient sources on some soil properties and wheat yield. *Journal of the Indian Society of Soil Science* **60**(3): 237-240.

Timsina, J. and Connor, D.J. 2001. Productivity and management of rice-wheat cropping systems: issues and challenges. *Field Crops Research* 69: 93-132.

Wu, S.C., Cao, Z.H., Li, Z.G. and Cheung, K.C. 2005. Effect of biofertilizer containing N-fixer, P and K solubilizers and AM fungi on maize growth: a greenhouse trial. *Geoderma*, 125: 155-166.