

Effect of pgpr and organic manure and plant growth, yield attributes in wheat under organic farming system *Triticum aestivum* L

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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. There is an increasing need for the management of the traditional processes of nutrient management, to result in higher nutrient concentration in soil and also to reduce environmental pollution. A considerable number of bacterial species

are able to exert a beneficial effect on plant growth. Bio-fertilizers combined with organic manure influences the plant growth by enhancing biomass; total root surface facility at as. Higher absorption of nutrient's 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. Hence, the research findings pertaining to these aspects on wheat crop have been reviewed.

Key Words: Farmyard manure; Vermicomposting forest litter; Bio fertilizers; azotobacter; Phosphate solubilizing bacteria

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. Therefore N₂ fixing and phosphate solubilizing bacteria, including *Bacillus* sp., *Azotobacter* sp., *Azospirillum* sp., *Beijerinckia* sp., *Pseudomonas* sp. are widely used in organic plant growing. Organic farming is a new agricultural production system involves locally and naturally available organic materials or agro inputs to meet out the production system without endangering our precious natural resources. 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. *Azotobacter*, 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.

MATERIALS AND METHODS

Field experiments were conducted during Kharif and Rabi seasons of. 2008-09 on an Inceptiso! 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 25°18' N latitude, 83°30' E longitude and at an altitude of 128.93 m. above mean sea level. The experimental site lies approximately in the center 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 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%), c tidn 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 evils 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+ *Azospirillum* baselines Cd+ *Pseudomonas* fluorescents BHUPSB06+ *Bacillus megaterium* BHUPSB14, VAM (Glom us fasciculata) inoculation and *Azotobacter chroococcum* W5+ *Azospirillum* brasiliense 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 bio fertilizer in sub sub-plots. The levels of fertilizer and FYM were applied as. Per treatments. Mycorrhiza 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, respective. 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.

Seed inoculation with inoculums

The mass culture of *Azotobacter chroococcum* W5, *Azospirillum brasiliense* Cd and mycorrhiza (Glomus fasciculatum) was obtained from Department of Microbiology, Indian Agricultural Research Institute, and new Deihl, India. The pure culture f *Bacillus megaterium* strain BHUPSB14 and *Pseudomonas fluorescens* straih 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 m² (@ 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 du per seed. After drying for one hour in shade, inoculated seeds were sown first followed by

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inoculated seeds just to avoid contamination. Mycorrhiza mixed with soil and pour in open furrow before sowing of the wheat seed as per the treatment.

RESULTS AND DISCUSSION

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

Effect of fertilizer evels 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 biofertilizer are presented in Tables 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 eight, 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 (Tables 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 [1-3]. The results pertaining to the effect of fertilizer levels, FYM and bio fertilizer 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 c op 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 [4]. Therefore, decrease in number of tillers was observed at harvesting stage. Examination of data 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 product ion 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 nurnber of tillers, product ion and accumulation of more photosynthetic 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 [5,6].

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	
CDS%	1.034	1.119		0.996			1.381	1.445	
FYM LEVEL (t ha-1)									
NoYM	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	
CDS%	0.825	0.819		0.566	0.884		0.753	0.869	
Bio fertilizers									
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_S %	0.606	0.600		1.041	0.980			1.054	
P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05
P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05

TABLE 2

Effect of recommended dose of fertilizer, FYM and bio fertilizers 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	74.9
50%RDF	101.58	103.58	102.58	113.17	106.54	105.36	89.71	91.67	90.6
75%RDF	111.75	112.54	112.15	113.75	115.75	114.75	100.29	102.17	101.
100%RDF	114.42	115.83	115.13	116.75	119.96	118.36	103.29	105.75	104.
SE m+	0.887	0.909		0.729	0.786		0.673	0.683	
CDS%	3.06	3.136		2.515	2.712		2.322	2.356	
FYM LEVEL (t ha⁻¹)									
NoYM	98.73	99.33	99.03	101.29	103.48	102.39	88.6	89.83	89.2
FYM 10 t ha ⁻¹	107.77	109.52	108.65	111.1	113.5	112.3	95.25	97.69	96.4
SE m+	0.618	0.67		0.359	0.424		0.393	0.4	
CDS%	2.012	2.182		1.169	1.381		1.279	1.304	
Biofertilizers									
No incubation	100.21	101.33	100.77	102.29	104.46	103.38	86.92	88.5	87.7
PGPR	103.33	104.83	104.08	106.92	108.54	107.73	93.38	95.38	94.
VAM	103.75	103.79	103.77	104.92	108	106.46	91.46	93.25	92.3
PGP R+VAM	105.71	101.75	106.73	110.67	112.96	111.82	95.96	97.92	96.9
SE m+	0.74	0.54		0.558	0.8586		0.499	0.457	
• CD S%	2.114	1.542		1.587	1.668		1.419	1.3	

TABLE 3

Effect of recommended dose of fertilizer, FYM and bio fertilizers on dry matter-production at various growth stage of wheat

Treatment	Dry matter production (gm ⁻¹ row)					
	Tillering stage			Ear emergence stage		
	2009-10	2010-11	Mean	2009-10	2010-11	Mean
recommended dose of fertilizer						
	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	
CDS%	1.331	1.418		2.097	2.366	
FYM LEVEL (t ha⁻¹)						
NoYM	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	
CDS%	1.018	1.081		1.662	1.662	

Bio fertilizers						
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	
CDS%	1.033	1.144		2.355	2.413	

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%
NoYM	26.62	34.75	39.5	41	46.64	62.31	67.59	72.19	71.42	76.84	91.88	
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	
SEm+ =0.507, CO {5%}=1.650				SEm+ =0.348, CD {5%}=1.1-33				SEm+ =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%
NoYM	27.23	36.27	40.81	42.55	47.21	63.79	69.19	73.18	72.5li	78.07	93.01	
FYM10t ha ⁻¹	33.35	40.42	43.1	44.69	57.53	69.29	75.13	76.57	-76.03	84.67	103.52	

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 al one 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 (Table 1). These values of plant, height were significantly higher over the control treatment of FYM be a use application of FYM improve d crop growth by improving physical, chemical and biological condition of soil [7]. Results of present investigate <-> n 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 [8,9]. 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 [10]. The maximum dry matter production 44.13 and 45.68 g/m row at tillering and 94.29 and 96.19 g/m rowat 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 [11]. Plant height, number of tillers and dry matter production significantly enhanced with application of FYM [12].

Effect of PGPR on growth characters

Examination of data (Table 1) due to bioinoculants 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 89.15 cm and 87.56 to 90.62 cm at harvesting stage

of the wheat during 2009-10 and 010-2011, 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, \ (AM and PGPR+VAM during both the years. Application of PGPR+VA_M 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 [13]. The similar significant trend was 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 insole acetic and gibberellin acids which positively affected plant growth [14,15].

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 imp roved the nutrients supplying power of soil to the plant and ultimately, improved the plant height of wheat (Table 5). 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 [16].

TABLE 5

Interaction effect of recommended dose of fertilizer, FYM one Ear head length and test weight of wheat

Ear head length (cm)								
Treatment	2009-10				2010-11			
	control	50%RDF	75%RDF	100% RDF	control	50%RDF	75%RDF	100%RDF
NoYM	6.36	7.58	8.15	8.35	6.47	7.78	8.36	8.45
FYM 10 t ha ⁻¹	7.36	7.98	8.23	9.01	7.37	8.07	8.47	9.41
		SEm+	=0.062, CD (5%)=0.203		SEm+	=0.065, CD (5%)=0.212		
Test weight								
Treatment	2009-10				2010-11			
	control	50%RDF	75%RDF	100% RDF	control	50%RDF	75%RDF	100%RDF
NoYM	34.45	38.22	41.11	41.38	34.46	39.44	41.4	41.61
FYM 10 t ha ⁻¹	35.95	39.79	41.64	42.91	36.16	40.9	42.2	43.41
		SEm+	=0.152, CD (5%)=0.496		SEm+	=0.157, CD (5%)=0.511		

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

The interaction effect of fertilizer levels and FYM presented in 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 record d by the application of 100% RDF alone during both the years. The combined application of 100% RDF+10t FYMha⁻¹, 'improved the general soil environment, which helped to improve the wheat yield contributing characters [17-21]. 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, FVM 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 [22-24].

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 n enhancing the growth and yield attributes.

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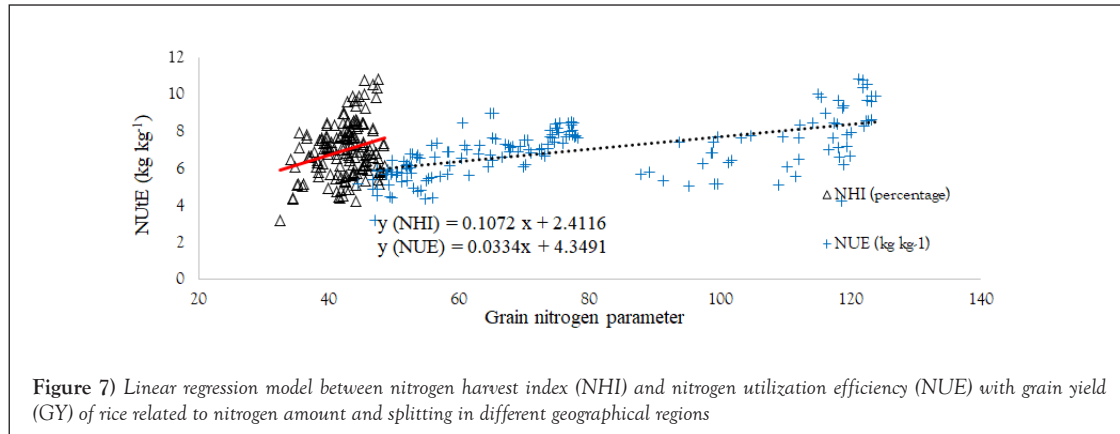


Figure 7) Linear regression model between nitrogen harvest index (NHI) and nitrogen utilization efficiency (NUE) with grain yield (GY) of rice related to nitrogen amount and splitting in different geographical regions

