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PRODUCTIVITY AND ECONOMICS OF WHEAT AS INFLUENCED BY INORGANIC AND ORGANIC SOURCES OF NUTRIENTS

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ABSTRACT

A field experiment was conducted at Udaipur during rabi seasons to study the effect of sources of nutrients and biofertilizer and their combination on productivity and economics of wheat (Tritium aestivum L.). Application of 3.0 t vermicompost + 100 % RDF recorded higher plant height at harvest, DMA and LAI 30, 60 and 90 DAS, effective tillers / plant, grain /ear, test weight, grain (49.64 q ha^{-1}) and straw (64.56 q ha^{-1}) and net returns and B : C ratio over vermicompost alone (1.5 and 3.0 t ha^{-1}). Dual inoculation of Azospirillum + PSB significantly recorded higher growth parameters, yield attributes, grain (49.21 q ha^{-1}) and straw (63.81 q ha^{-1}), net returns and B / C ratio over Azospirillum and inoculated control. The combined application of 3.0 t vermicompost + RDF along with Azospirillum + PSB recorded significantly higher number of effective tillers plant^{-1} (4.92), grains ear^{-1} (49.05) grain (57.64 q ha^{-1}) and straw (74.46 q ha^{-1}) yields over vermicompost 1.5 and 3.0 t alongwith no inoculation.

Key words: Azospirillum, chemical fertilizer, economics, PSB, vermicompost, wheat

INTRODUCTION

Wheat (*Triticum aestivam* L.) being the second largest food crop of India, is grown over an area of around 29.25 mha with the total production of 85.93 mt in 2010-11 (Agriculture at a glance, Govt. of India, 2011). Wheat is responsible for the success story of 'Green Revolution' as its productivity increased many folds due to availability of inputs responsive high yielding varieties of the crop. Though, there are several inputs which made it possible to raise the productivity of wheat but a chemical fertilizer is the main contributor and responsible for about 40% of increased productivity of wheat. Plant nutrient management is one of the key components of intensive agriculture. The chemical fertilizers, no doubt, are the important source, which can meet the nutrients requirement but their imbalanced and continuous use lead to environmental pollution and deterioration of soil physico-chemical properties. It is well known that addition of organic manures has shown considerable increase in crop yield and exert significant influence on physical, chemical and biological properties of the soil. But its use alone is not sufficient to meet the requirements of nutrients. Therefore, there is a need to evaluate the utilization of organic as well as inorganic/ chemical sources in a rational way to achieve the desired production level. Biofertilizers can play an important role in meeting the nutrient requirement of crops because they can be produced at a low cost and can meet a part of nutrient requirements for increased crop production. They enhance soil fertility also crop productivity by fixing atmospheric nitrogen, mobilizing sparingly soluble P and by facilitating the release of nutrients through decomposition of crop residues. *Azotobacter* and phosphobacteria produce growth hormones *viz*., Indole acetic acid and Gibberellins. These hormones stimulate root growth and development. The use of growth stimulating seed inoculants helps to accelerate uptake of plant nutrients from applied chemical fertilizers by increasing the root growth. Furthermore, the availability of fertilizer at economic price is another problem for the country under these circumstances one should not depend on single source of plant nutrients like chemical fertilizers. The need of the hour is to evolve an integrated plant nutrient supply system, comprising balanced use of chemical fertilizer, organic manures and bio-fertilizers.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* seasons of 2003-04 and 2004-05 at the Instructional Farm, Rajasthan College of Agriculture, Udaipur using wheat (*Triticum* *aestivum* L.) as test crop. The soil of the experimental site was clay loam in texture having pH 8.4 and 8.2 and organic carbon 6.8 and 6.9 g kg^{-1}, during *rabi* 2003-04 and 2004-05, respectively. The corresponding available N, P_2O_5 and K_2O in soils were 289 and 278, 28.0 and 29.5 and 328 and 310 $kgha^{-1}$. The experiment comprised 27 treatment combinations, which consisted of nine fertilizer levels (RDF, vermicompost at 1.5 t ha^{-1}, vermicompost at 3.0 t ha^{-1}, vermicompost at 1.5 t ha^{-1} + 50 % RDF, vermicompost at 1.5 t ha^{-1} + 75 % RDF, vermicompost at 1.5 t ha^{-1} + RDF, vermicompost at 3.0 t ha^{-1} + 50% RDF, vermicompost at 3.0 t ha^{-1} + 75% RDF and vermicompost at 3.0 t ha^{-1} + RDF) and three biofertilizers inoculation (control, *Azospirillum* and *Azospirillum* + PSB). The experiment was carried out in split plot design taking fertility levels in main plots and biofertilizers in subplot treatments with three replications. Wheat variety Raj. 3765 was sown on 26th and 25th November during first and second year of experimentation. Furrows were opened at 22.5 cm apart using 125 kg seed ha^{-1}. Crop received no rains during both the years of experimentation and it was harvested at physiological maturity *viz*., 9th and 8th April during first and second years of the study. Plant height at harvest, dry matter $plant^{-1}$ and LAI at 30, 60 and 90 DAS after sowing, number of tillers and effective tillers $plant^{-1}$, grains ear^{-1}, test weight and grain as well as straw yield were recorded.

RESULTS AND DISCUSSION

Nutrient sources: Table 1 revealed that application of vermicompost at 3.0 t ha^{-1} + RDF significantly recorded the maximum plant height at harvest, dry matter accumulation at 30, 60 and 90 DAS, LAI at 30, 60 and 90 DAS, total and effective tillers $plant^{-1}$, grains ear^{-1}, 1000 grain weight, grain and straw yields, net monetary returns and B:C ratio. This treatment was statistically at par with RDF, vermicompost at 1.5 tha^{-1} + 75 and 100% RDF and vermicompost 3.0 t ha^{-1} + 75% RDF in dry matter accumulation and LAI at 30, 60 and 90 DAS, effective tillers $plant^{-1}$, grains ear^{-1}, test weight and net returns. The percent increases in grain and straw yields were 44.7 and 26.5 and 43.2 and 26.6 respectively over vermicompost 1.5 and 3.0 t ha^{-1} with application of vermicompost 3.0 t ha^{-1} + RDF. Treatment vermicompost 1.5 t ha^{-1} + 75% RDF recorded maximum net returns (Rs. 38639/ha) and B:C ratio (3.25) which was significantly higher over other treatments.

Table 1: Effect of fertilizer levels and biofertilizers on growth and yield attributing characters and yield of wheat (mean of two years)

Treatments	Plant height (cm)	DMA at DAS (g m^2)			LAI at DAS			Tillers $plant^{-1}$	Effective tillers $plant^{-1}$	Grains Ear^{-1}	Test weight (g)	Yield (qha^{-1})		Harvest index (%)	Net returns (Rs ha^{-1})	B/C ratio
		30	60	90	30	60	90					Grain	Straw			
Fertilizer levels																
RDF	89.15	41.52	292.11	568.23	2.45	3.42	3.81	6.4	4.43	40.1	42.52	45.78	61.84	42.5	35991	3.20
1.5 t VC ha^{-1}	63.08	30.34	208.68	411.37	1.80	2.52	2.80	5.6	3.74	29.4	30.67	33.20	44.48	42.8	23479	2.19
3.0 t VC ha^{-1}	73.59	33.77	233.75	462.92	1.95	2.95	3.37	5.9	4.01	33.6	34.70	38.82	51.05	43.2	28100	2.39
1.5 t VC ha^{-1} + 50 % RDF	76.25	34.68	240.46	469.42	2.02	3.04	3.42	5.9	4.16	34.8	35.50	39.92	52.47	43.2	29495	2.56
1.5 t VC ha^{-1} + 75 % RDF	93.77	41.34	290.78	566.63	2.43	3.40	3.82	6.5	4.38	42.2	42.63	49.36	63.59	43.8	38639	3.25
1.5 t VC ha^{-1} + RDF	94.64	41.63	292.78	570.17	2.46	3.44	3.85	6.5	4.5	42.4	43.21	49.50	64.36	43.4	38471	3.13
3.0 t VC ha^{-1} + 50 % RDF	83.15	37.21	262.40	524.09	2.20	3.20	3.60	6.1	4.31	37.5	38.61	43.49	56.67	43.4	32048	2.55
3.0 t VC ha^{-1} + 75 % RDF	94.19	42.22	291.94	568.15	2.47	3.46	3.85	6.5	4.49	42.5	43.31	49.56	63.96	43.6	37805	2.92
3.0 t VC ha^{-1} + RDF	94.84	42.20	293.88	573.47	2.47	3.47	3.88	6.6	4.57	42.6	43.93	49.64	64.56	43.4	37566	2.82
CD (P=0.05)	5.03	2.48	20.72	43.52	0.129	0.169	0.185	0.37	0.128	2.26	2.045	3.098	4.665	NS	2620	0.22
Biofertilizers																
Control	76.56	35.46	246.81	473.82	2.11	2.92	3.32	6.0	4.04	34.6	36.34	39.92	52.45	43.2	28992	2.42
Azospirillum	84.09	37.69	263.29	536.42	2.20	3.26	3.64	6.2	4.26	38	38.82	43.97	58.06	43.1	33166	2.75
Azospirillum + PSB	93.56	41.82	292.15	561.25	2.44	3.45	3.84	6.5	4.56	42.5	43.20	49.21	63.81	43.5	38374	3.17
CD (P=0.05)	2.53	1.21	8.33	17.98	0.059	0.081	0.081	0.095	0.061	1.09	1.300	1.484	1.932	NS	1337	0.11

VC= vermicompost

The positive response of nitrogen and phosphorus fertilization in combination with vermicompost on growth parameters *viz*., higher plant height and dry matter accumulation could be ascribed to better nutritional environment, enabling the plant to absorb more nutrients. The combined use of vermicompost and fertilizer not only found effective in maintaining higher productivity but also in providing stable crop yields. Significant improvement in grain and straw yield was also observed with combined application of 100% NPK + FYM 15 t ha^{-1} and biofertilizers, which sustained better growth, produced better yield attributes and ultimately higher grain yield of wheat (Mubarak and Singh, 2011) and maize (Tetarwal *et al.*,201l).

Biofertilizers: Data further revealed that seed inoculation with *Azospirillum* and *Azospirillum* + PSB significantly influenced all the growth and yield parameters over control. Co-inoculation was also found significantly higher in respect of all the parameters over *Azospirillum* alone inoculation. Inoculation of *Azospirillum* + PSB significantly recorded 23.2 and 11.9, 21.6 and 9.9, 32.3 and 15.7 percent higher grain and straw yield and net returns over control and *Azospirillum*, respectively. It is an established fact that micro-organism assimilate atmospheric nitrogen through enzyme nitrogenase in bacterial cells. The fixed organic nitrogen in becterioeds is dissociated and later on oxidized to nitrate (NO_3) form. The increased endogenous nitrogen content due to inoculation might have promoted crop growth. In addition to this *Azotobacter* has ability to produce antifungal, antibodies and similar compounds against pathogen like *Fusarium* and *Alternaria*. Thus, beneficial effects of *Azotobacter* inoculation could be attributed to their multiple action for synthesise growth promoting substances, antifungal and antibiotics which might have been utilized by the plants in synthesis of protein, carbohydrates, starch and other assimilates, thereby improving growth of plant. Inoculation with PSB enhances availability of P through solubilization of insoluble phosphorus carriers such as calcium and magnesium phosphate through production of organic acids like malic, glyoxalic, succinic, fumaric and citric acid. Under present investigation, distinct superiority of PSB and *Azospirllum* + PSB in improving growth could be ascribed to the better establishment of micro-organism population in the rhizosphere besides providing physical properties of soil and also ensured availability of nutrients through PSB, which enhanced availability of phosphorus from soil. It has been well emphasized that dual inoculation played vital role in improving three major aspects of yield determination i.e. formation of vegetative structure for higher photosynthesis, strong sink strength through development of reproductive structure and production of assimilates to fill economically important sink. The significant increase in straw yield under dual inoculation of *Azospirllum*+PSB seems to be due to their direct effect in improving biomass plant^{-1}, while indirect effect might be on account of increase in morphological parameters.

Table 2: Interaction effect of fertilizer levels and biofertilizers on yield attributes and yield (mean of two years)

Fertilizer levels	Biofertilizers		
	Control	*Azospirillum*	*Azospirillum* + PSB
(a) Number of effective tillers plant^{-1}			
RDF	4.05	4.42	4.84
1.5 t VC ha^{-1}	3.70	3.77	3.75
3.0 t VC ha^{-1}	3.85	4.05	4.12
1.5 tVC ha^{-1} + 50 % RDF	3.80	4.17	4.52
1.5 t VC ha^{-1} + 75 % RDF	4.14	4.25	4.75
1.5 t VC ha^{-1} + RDF	4.24	4.43	4.83
3.0 t VC ha^{-1} + 50 % RDF	4.14	4.35	4.45
3.0 t VC ha^{-1} + 75 % RDF	4.18	4.45	4.84
3.0 t VC ha^{-1} + RDF	4.30	4.50	4.92
CD (P=0.05)	0.18		
(b) Grains ear^{-1}			
RDF	35.25	39.67	45.53
1.5 t VC ha^{-1}	28.79	28.99	30.54
3.0 t VC ha^{-1}	31.80	33.95	35.22
1.5 tVC ha^{-1} + 50 % RDF	34.00	34.75	35.70
1.5 t VC ha^{-1} + 75 % RDF	36.57	41.35	48.69
1.5 t VC ha^{-1} + RDF	36.69	41.64	49.02
3.0 t VC ha^{-1} + 50 % RDF	34.90	38.02	39.70
3.0 t VC ha^{-1} + 75 % RDF	36.80	41.69	49.15
3.0 t VC ha^{-1} + RDF	36.82	41.94	49.05
CD (P=0.05)	3.28		
(c) Grain yield (q ha^{-1})			
RDF	39.06	45.30	52.98
1.5 t VC ha^{-1}	32.95	33.08	33.59
3.0 t VC ha^{-1}	37.82	39.19	39.48
1.5 tVC ha^{-1} + 50 % RDF	39.16	40.13	40.47
1.5 t VC ha^{-1} + 75 % RDF	42.43	48.24	57.42
1.5 t VC ha^{-1} + RDF	42.50	48.51	57.51
3.0 t VC ha^{-1} + 50 % RDF	40.43	43.88	46.17
3.0 t VC ha^{-1} + 75 % RDF	42.35	48.68	57.65
3.0 t VC ha^{-1} + RDF	42.57	48.73	57.64
CD (P=0.05)	4.45		
(e) Straw yield (q ha^{-1})			
RDF	54.17	61.10	70.25
1.5 t VC ha^{-1}	44.00	44.45	45.00
3.0 t VC ha^{-1}	50.24	51.10	51.80
1.5 tVC ha^{-1} + 50 % RDF	51.94	52.51	52.97
1.5 t VC ha^{-1} + 75 % RDF	53.64	63.55	73.59
1.5 t VC ha^{-1} + RDF	55.08	64.11	73.90
3.0 t VC ha^{-1} + 50 % RDF	53.63	57.68	58.70
3.0 t VC ha^{-1} + 75 % RDF	54.16	64.04	73.68
3.0 t VC ha^{-1} + RDF	55.19	64.02	74.46
CD (P=0.05)	5.80		

Interaction: Data presented in Table 2 reveal that application of vermicompost at 3.0 t ha^{-1} + RDF and 3.0 t ha^{-1} + 75 % RDF alongwith seed inoculation of *Azospirillum* + PSB remained at par with RDF, recorded the highest effective tillers per plant, grains ear^{-1}, grain and straw yield of wheat. Further data revealed that vermicompost at 1.5 t ha^{-1} alongwith all the biofertilizers recorded minimum values of the above said attributes on pooled basis. The positive response of vermicompost with chemical fertilizer in combination with biofertilizer could be ascribed to over all improvement in the crop growth due to better nutritional environment, enabling the plants to absorb more nutrients as is evident from the enhanced content and uptake of nutrients. The results of present investigation are in close conformity with the findings of Banerjee and Rai (2006) and Sarma *et al*. (2007).

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