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RESEARCH ARTICLE

EFFECT OF AZOTOBACTOR, PSB AND FYM ON PRODUCTIVITY AND SOIL FERTILITY IN WHEAT CROP (*Triticum aestivum* L.)

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ABSTRACT

The present study was conducted during 2021-22 to evaluate the organic and Bio-fertilizers at the technology Farmer field of district Shravasti with nine treatment viz., control (T_1), 100% RDF (T_2), 100% RDF+Azotobactor+PSB (T_3), 75% RDF+5 t FYM ha^{-1} (T_4), 75% RDF+5 t FYM ha^{-1} + Azotobacter + PSB+10 kg ZnSO4+2 % urea spraying (T_5), 75 % RDF+Azotobactor + PSB (T_6), 50% RDF+5 t FYM ha^{-1} (T_7), 50% RDF+5 t FYM ha^{-1} + 10kg $ZnSo_4$+2% Urea Spraying (T_8), 50% RDF+5 t FYM ha^{-1}+Azotobacter + PSB+10 kg ZnSO4+2 % urea spraying (T_9).The findings indicated that application of FYM, Azotobactor and PSB provide higher growth and yield attributes of wheat. The maximum grain yield (39.82 q ha^{-1}) recorded with treatment (T_5) 75% RDF+5 t FYM ha^{-1} + 10kg $ZnSo_4$+2% Urea Spraying closely followed 100% RDF+Azotobactor seed Treatment + PSB Seed treatment (T_3) with 39.00 qha^{-1} grain yield. Application of organic manure 75% RDF+5 t FYM ha^{-1} + 10kg $ZnSo_4$+2% higher as protein content and yield as compared to control (T_1) alone treatment. The results of experiment showed higher grain yield obtained through yield contributing characters. Thus combination of organic, inorganic and Bio-fertilizer not only sustains the yield and increases the soil fertility in long term, but it also enhances the nutrient use efficiency. Therefore to maintain the soil sustainability and increase wheat productivity in long term, a balanced and integrated use of organic and inorganic fertilizer is the best option.

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second most important staple food crop of the world after rice and cultivated in almost all countries. In India, it is one of the most important staple food crops and occupies a notable position among the food grain crops not only in area and production but also in its versatility in adaptation to a wide range of agro-climatic conditions. Its productivity has played a key role in making the country self-sufficient in food grain. In India total wheat area was accounted for 296.51 lakh ha with production of 998.70 lack tons with average yield of 3368 kg ha^{-1}. (*Anonymous,* 2021). Increased use of chemical fertilizers in an unbalanced manner has created problem of multiple nutrient deficiencies, particularly micronutrients, diminishing soil fertility and unsustainable crop yields. In addition of organic manures along with chemical fertilizers sustained the yield through increased nutrients availability and nutrient use efficiency. Azotobacter as a nitrogen fixer and PSB as a phosphate solubilizer have grown in popularity among biofertilizers and Azotobacter is a type of bacteria that lives on its own. It has been reported that it fixes 20 kg N ha^{-1} in non-legume crop fields and secretes growth-promoting substances. Azotobacter produces thiomin, riboflavin, nicotine, indolacitic acid and giberalin in addition to nitrogen fixation. When Azotobacter is applied to seed germination is improve a considerable extent so also it controls plant diseases due to the above substances produced by Azotobacter. Seeds with a low germination rate can be inoculated with Azotobacter to boost germination by 20–30%. Azotobacter-inoculated seeds aid in the uptake of N, P, K and micronutrients like Mn, Bo, S and Zn in wheat. The application of farm yard manure results in improved crop yields, microbial activity, physical properties and chemical Properties soil (*Gayatri et al*. 2022). Bio fertilizers are commonly called microbial inoculants which are capable of mobilizing important nutritional elements in the soil from non-usable to usable form by the crop plants through their biological processes. Bio fertilizers due to its renewable, cheap and eco-friendly nature has gained increasing popularity in the past one decade in the field of agriculture and food production.

Bio fertilizers will help to solve such problems as increased salinity of soil and chemical run off from the agricultural field. It has been found to minimize the use of chemical fertilizers, improved soil fertility status and enhancing the crop production by their biological activity in the rhizosphere. Extensive research were carried out on the use of bacteria (Azotobacter, Azospirillum, Rhizobium, phosphobacteria) and VAM fungi as Bio fertilizers to supplement nitrogen and phosphorus fertilizers (*Rai et al.* 2014). These displayed considerable improvement in the growth of several crop plants. Microbiological fertilizers are an important part of environment friendly sustainable agricultural practices. Bio fertilizers include mainly the nitrogen fixing, phosphate solubilizing and plant growth-promoting microorganisms. Among, biofertilizers benefiting the crop production are Azotobacter, Azospirillum, blue green algae, Azolla, P-solubilizing microorganisms, mycorrhizae and sinorhizobium. Although, in this field, many experiments were conducted in various crops to study the effect of biofertilizers alone or in combination with other chemical fertilizers but the study of the same in wheat is lacking even if it is one of the major cereal crop around the world. Thus, the present study here aims to find out the effects of Azotobacter and Phosphobacteria on the yield of wheat (*Davari et al*. 2012 and *Kaur et al.* 2019).

MATERIALS AND METHODS

The present investigation was conducted at technology Farmer field of district Shravasti during *kharif* (November- April 2021-22) to explore the possibility of substituting fertilizer with FYM, PSB, Azotobactor, Zn and 2% Urea Spraying is an integrated manner for the crop. The treatment consisting of chemical fertilizer with different combination of organics (FYM, PSB, and Azotobator) viz., control (T_1), 100% RDF (T_2), 100% RDF + Azotobactor seed Treatment + PSB Seed Treatment (T_3), 75% RDF+5 t FYM ha^{-1} (T_4), 75% RDF + 5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying (T_5), 75 % RDF+Azotobactor seed Treatment + PSB Seed Treatment (T_6), 50% RDF+5 t FYM ha^{-1} (T_7), 50% RDF+5 t FYM ha^{-1} + 10kg $ZnSo_4$+2% Urea Spraying (T_8), 50% RDF +5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying (T_9). were comprised in Randomized Block replicated as thrice. The experimental field soil was sandy loam in initial properties of soil pH (1:25) (7.80) EC (0.82) dSm^{-1}, Organic Carbon (2.67) g kg^{-1}, Available Nitrogen (143.52) kg ha^{-1}, Phosphorus (22.50) kg ha^{-1}, Potassium (185.85) kg ha^{-1}, Sulphur (09.02) kg ha^{-1} and Zinc (0.342) ppm, Boron (0.615) ppm and Mn (0.338) ppm. The nitrogen, Phosphorus and potassium were applied through urea, DAP and MOP. The full dose of phosphorus, potassium and one third dose of nitrogen were given below the seed at the time of sowing as basal. Whereas, the remaining half dose of nitrogen was top-dressed after first irrigation and second half dose before flowering stage. In manure treatments FYM were applied before field preparation or before sowing of crop and PSB and Azotobacter were used in both liquid and powder forms equally for seed and soil treatment. The doses of PSB and Azotobacter were equally fixed for both soil and seed treatment in powder as well as liquid form. The doses of application were equally proportional for both the microbiological fertilizers i.e. PSB and Azotobacter. The soil samples were collected as initial before and after harvest of the crop and analyzed for chemical properties by following standard methods (*Jackson et al.* 1973). The experimental data were statistically analyzed using by MSTA for further observations and finding.

RESULT AND DISCUSSION

Plant growth and yield: The combination of 75% RDF+FYM+10kg ZnSo4+ 2% Urea Spraying gave maximum plant height at maturity stage 98.41 cm. The best performance variety DBW-252 was observed in treated plot FYM+Zn+ 2% Urea spraying. Highest grain yield was recorded in T_5 (75% RDF + 5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying) 39.82 qha^{-1} followed by T_3 (100% RDF+Azotobacter + PSB). The bio-fertilizer treatments of Azotobacter and PSB with inorganic fertilizer performed better than those without Azotobacter and PSB treatments. Foliar application of 2% urea resulted in maximum number of effective tillers, spikelet's $spike^{-1}$ and grain yield**.** The application of chemical fertilizers with 2 % Urea spaying had a stimulatory effect on the survival of direct effect on the growth changing the growth rate and metabolic activities of the crop plant, resulting in the secretion of more root exudates and thereby creating a favorable habitat for the growth and development (*Singh et al.* 2017). The results revealed the utmost Gross Return Rs. 91305 was recorded under with T_5 (FYM+10kg ZnSo4+ 2% Urea Spraying) which was statistically significant over all-remaining treatments (*Kannoj et al.* 2022). The application of Azotobacter and PSB on germination then Azotobacter is known to produce plant growth hormones such as gibberilic acid, Indole acetic acid, and cytokinin, which might have favoured the growth of wheat. The use of effective strains of bio- fertilizers (PSB+Azotobactor) is an environmentally benign, low-cost agricultural input that plays an essential role in enhancing nutrient availability of crops while also lowering production costs (*Kumar et al.* 2014, *Chaudhary et al.* 2013 and *Singh et al*. 2021).

Protein content : The maximum protein content (11.91%) was observed 75% RDF + 5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying (T_5) which was statistically at par with all the treatments. It is clear from results (Table-2) that application of organic manure along with 75% RDF + 5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying recorded significantly higher as protein content. This might be due to that application of FYM +Zn+ 2% Urea Spraying increased N-metabolism which enhanced accumulation of amino acids and drastically increased the rate of protein synthesis and consequently protein content in grain. FYM + Zn application in soil enhanced the Zn concentration in the plant which associated with ribosome induction (*Sharma et al*., 2013 and *Choudhary et al.*2027)

Soil properties: The results revealed that Improved soil physical conditions reflected by lower bulk density of soil, when applied organic and inorganic sources of nutrients continuously. Integration of organic sources with inorganic fertilizer and Biofertilizer was found more effective as compared to single application of FYM in buildup of fertility and improving physical status of soil. The maximum reduction in pH was observed with the application of T_7. However, differences in pH and EC were found non-significant.

Table 1. Effect of Chemical fertilizer, FYM, PSB, Azotobactor, Zn and 2% urea spraying on Wheat Crop in grain yield, straw yield (2021-2022)

Treatment	Plant Height (cm)	Length of spike (cm)	Number of grain per spike	Test weight (g)	Grain yield (qha^{-1})
T_1-Control	85.51	7.04	36.21	34.05	35.05
T_2- 100% RDF (NPK)	92.83	8.78	46.26	38.58	54.21
T_3-100% RDF + Azotobacter seed treatment + PSB seed treatment	97.21	9.24	48.48	38.42	55.43
T_4- 75 % RDF + 5 t FYM ha^{-1}	95.52	8.89	46.92	37.95	54.81
T_5- 75% RDF + 5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying	98.41	9.58	49.06	38.94	55.82
T_6-75% RDF + Azotobacter seed+ PSB seed treatment	94.01	8.42	45.86	ss37.86	53.96
T_7- 50% RDF + 5 t FYM ha^{-1}	93.54	8.70	46.10	38.02	53.03
T_8- 50% RDF + 5 t FYM ha^{-1} + 10 kg ZnSO4 + 2 % urea spraying	94.20	8.98	47.04	38.12	53.98
T_9-50% RDF +5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying	92.04	8.08	45.01	37.10	52.83
SEm±	3.02	0.334	2.065	1.56	2.194
C.D. at 5%	8.83	0.97	6.56	4.59	6.436

Table 2. Effect of Chemical fertilizer, FYM, PSB, Azotobactor, Zn and 2% urea spraying on Wheat Crop in B:C Ratio and Protein Content (2021-2022)

Treatment	Straw Yield (qha^{-1})	Cost of Cultivation ($Rs.ha^{-1}$)	Gross Income ($Rs.ha^{-1}$)	B:C Ratio ($Rs.Rupee^{-1}$ invested)	Protein content in Grain (%)
T_1-Control	44.86	22821	60543	2.65	10.52
T_2- 100% RDF (NPK)	65.58	29771	87562	2.94	11.30
T_3-100% RDF + Azotobacter seed treatment + PSB seed treatment	66.52	31171	89385	2.87	11.86
T_4- 75 % RDF + 5 t FYM ha^{-1}	65.77	29201	78077	2.67	11.85
T_5- 75% RDF + 5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying	69.75	29964	91305	3.05	11.87
T_6-75% RDF + Azotobacter seed+ PSB seed treatment	64.75	28960	79833	2.76	11.81
T_7- 50% RDF + 5 t FYM ha^{-1}	64.70	26640	77548	2.91	11.80
T_8- 50% RDF + 5 t FYM ha^{-1} + 10 kg ZnSO4 + 2 % urea spraying	64.78	27842	86504	3.11	11.84
T_9-50% RDF +5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying	63.89	26481	82511	3.12	11.76
SEm±	2.40	-	-	-	-
C.D. at 5%	7.0	-	-	-	-

Table 3. Effect of Chemical fertilizer, FYM, PSB, Azotobactor, Zn and 2% urea spraying on Wheat Crop in Chemical Properties of soil (2021-2022)

Treatment	pH	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	N ($kg\ ha^{-1}$)	P ($kg\ ha^{-1}$)
T_1-Control	7.79	1.01	2.68	148.20	32.80
T_2- 100% RDF (NPK)	7.85	1.12	2.70	167.80	35.80
T_3-100% RDF + Azotobacter seed treatment + PSB seed treatment	7.83	1.05	2.82	169.13	35.96
T_4- 75 % RDF + 5 t FYM ha^{-1}	7.76	0.97	3.86	171.96	36.51
T_5- 75% RDF + 5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying	7.80	1.08	3.90	174.81	36.79
T_6-75% RDF + Azotobacter seed+ PSB seed treatment	7.78	0.99	3.80	168.14	36.18
T_7- 50% RDF + 5 t FYM ha^{-1}	7.72	0.94	3.86	168.21	35.80
T_8- 50% RDF + 5 t FYM ha^{-1} + 10 kg ZnSO4 + 2 % urea spraying	7.55	0.95	3.95	170.34	36.90
T_9-50% RDF +5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying	7.74	0.98	3.25	164.89	35.83
SEm±	0.26	0.042	0.14	2.70	1.56
C.D. at 5%	0.77	0.12	0.42	7.94	4.565

These results might be due to continuous production of organic acids on decomposition of organic matter resulting into lowering of soil pH and EC (*Balu et al.* 2014). The buildup of neutral soil organic carbon were recorded as compared to treatment (T_9) The higher availability of nutrient N, P, K, S, B, Mn and Zn in soil, increased with the application of 50% RDF +5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying alone or in combination.

The application of PSB stimulates the nodulation bacteria for more fixation of atmospheric nitrogen which result an increase nutrient availability of soil. Application of chemical fertilizer alone or their combined use with 50% RDF +5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying increased all treatment. The higher availability of nutrient N, P, K, S, B, Mn and Zn in soil after harvest was recorded under modules as compared to inorganic fertilizer application treatments.

Table 4. Effect of Chemical fertilizer, FYM, PSB, Azotobactor, Zn and 2% urea spraying on Wheat Crop in Chemical Properties of soil (2021-2022)

Treatment	K (kg ha^{-1})	Sulphur (kg ha^{-1})	Zn (ppm)	B (ppm)	Mn (ppm)
T_1-Control	190.28	8.08	0.352	0.62	3.49
T_2- 100% RDF (NPK)	230.14	12.06	0.372	0.75	3.63
T_3-100% RDF + Azotobacter seed treatment + PSB seed treatment	234.80	13.62	0.409	0.88	3.84
T_4- 75 % RDF + 5 t FYM ha^{-1}	240.81	13.98	0. 420	0.94	3.92
T_5- 75% RDF + 5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying	243.08	14.05	0.415	0.96	3.96
T_6-75% RDF + Azotobacter seed+ PSB seed treatment	238.86	13.78	0.398	0.90	3.89
T_7- 50% RDF + 5 t FYM ha^{-1}	238.14	13.86	0.416	0.83	3.90
T_8- 50% RDF + 5 t FYM ha^{-1} + 10 kg ZnSO4 + 2 % urea spraying	240.04	13.97	0.410	0.87	3.94
T_9-50% RDF +5 t FYM ha^{-1} + Azotobacter seed treatment + PSB seed treatment + 10 kg ZnSO4 + 2 % urea spraying	236.81	13.50	0.396	0.78	3.84
SEm±	3.78	0.42	0.051	0.036	0.15
C.D. at 5%	11.11	1.25	0.12	1.05	0.44

Whereas the maximum availability of N, K, S, B, Mn and Zn were estimated under the treatment having T_4 which was closely followed by T_5 and T_7 (*Jackson et al. 1973*). Long term application and better soil health was observed with FYM treated plots might be due to the improvement of physical and chemical properties of the soil and providing good soil environment.

CONCLUSION

It is concluded from the present study that the application of 5 tons ha^{-1} FYM + Bio fertilizer not only produced the higher yield of Wheat but also improved the soil fertility as compared to application major nutrients (N, P, K and Zinc) alone. Thus, optimum mineral nutrition in conjunction with biofertilizers can play a vital role in exploiting high yield potential of Wheat through the favorable effect on nutrient supply and soil properties.

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