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Effect of bio-fertilizer and seaweed extract on yield attribute, yield and economics of wheat (*Triticum aestivum* L.)

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Abstract
The field experiment was conducted at crop research farm during Rabi season 2021-2022, Department of Agronomy, SHUATS, Prayagraj (UP), to adjudge the influence of bio- fertilizer and seaweed extract on yield and economics of wheat. The experiment was conducted in Randomized Block Design consisting of 9 treatments combinations with 3 replications and was laid out with the different treatments allocated randomly in each replication viz., seed inoculation with *Azotobacter (ASI)* 20g/kg seed and 0% application of seaweed extract (SWE) (T_1), *(ASI)* 20g/kg seed and 5% application of (SWE) (T_2), *(ASI)* 20g/kg seed and 7.5% (SWE) (T_3), seed inoculation with phosphorus solubilizing bacteria (PSB) 20g/kg seed and 0% (SWE) (T_4), seed inoculation with PSB 20g/kg seed and 5% application of (SWE) (T_5), seed inoculation with PSB 20g/kg seed and 7.5% application of (SWE) (T_6), seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 0% (SWE) (T_7), seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 5% (SWE) (T_8), seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 7.5% (SWE) (T_9). The results showed that seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 7.5% (SWE) found more productive as it attained the superior values of yield attributing (traits), spikes/m^2, grains/spikes, test weight (g), grain yield (t/ha), straw yield (t/ha) and proved significantly superior over seed inoculation alone with *Azotobacter* or PSB without foliar application of (SWE). Though the former treatment fetched the higher values of net monitory return (117048.00 INR/ha) and final cost of cultivation (49594.00 INR/ha), but plots receiving seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed alone with foliar application of 5% (SWE) found more remunerative due to proportionate increase in benefit/over cost investment (2.46).

Keywords: Seaweed, economics, wheat, Azotobacter, PSB, *Triticum aestivum* L.

Introduction
Generally, recommended dose of major nutrients i.e., nitrogen, phosphorus and potassium, is given through inorganic fertilizer like DAP/urea, single super phosphate and muriate of potash. The continuous application of major nutrients through said fertilizers not only attained the yield plateau in wheat but causing multi nutritional deficiency of Sulphur, zinc, molybdenum etc. As a consequence, the soil fertility and productivity are deteriorating in many parts of the country including Uttar Pradesh. Therefore, there is an urgent need to rectify the fertility imbalance fertilization in wheat growing areas to cope up the problem of multiple nutrient deficiency in soil including low yield levels of wheat. As wheat crop needs more nitrogen which is applied through inorganic fertilizers as a basal and top dressing at various growth stages. Nitrogen fixing bacteria have been tried in cereal crops with considerable success. These microorganisms serve as a viable substitute for nitrogen fertilizers and are comparatively cost effective. Several workers have reported significant increase in yield in various crops through the use of *Azotobacter* (Allison, 1947; Rangaswami *et al*., 1976). Poor P availability in agricultural soils is also an important issue (Oberson *et al*., 2001). Only 20-25% of the total quantity of phosphorus applied through phosphatic fertilizers is subjected to fixation and become unavailable to plants (Kondracka and Rychter, 1997). However, the fixed form of phosphate can be revert back to available form (H_2PO_4- and HPO_4--) with the use of phosphorus solubilizing bacteria (PSB) containing bacteria like Bacillus polymyxa and Bacillus megaterium. Conjunctive use of PSB along with sub-optimal dose of phosphatic fertilizer, gave similar yield to that of 100% dose of phosphatic fertilizer. Liquid extracts obtained from seaweeds have also gained importance in the recent past as foliar spray in many crops including wheat. Application of *Kappaphycus alvarezii* extract has been reported to

Application of Kappaphycus alvarezii and Gracilaria edulis extracts has been reported to enhance nutrient uptake by wheat (Shah *et al*., 2013) [5], which may be due to presence of many organic compounds and natural chelating compound (i.e. manitol) in sap, which mobilize the fixed nutrients to the plant in available form. Seaweed sap is also a rich source of potassium and phosphorus. When applied through foliar spray, it is directly assimilated by crop foliage within few hours after application. Shah *et al*., (2013) [5] reported that application of Kappaphycus alvarezii enhance yield of wheat by 20% including its quality. Since very little information is available in the literature on the conjunctive use of bio-fertilizers, seaweed and chemical fertilizers in wheat for Prayagraj district of Utter Pradesh. It is, therefore, a comprehensive study entitled "Effect of bio-fertilizer and seaweed extract on growth and yield of wheat" have been done to findout the suitable combination of Azotobacter, PSB and seaweed extract for getting the higher yields of wheat.

Material and Method

The experiment was carried out during *rabi* season of 2021-22 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P), India, which is located at 25o 39' 42" N latitude, 81o 67' 56" E longitude and 98 m altitude above the mean sea level. Soil of experimental plot was sandy loam, having nearly neutral soil reaction (pH 6.9), electrical conductivity (0.29 dS/m), available nitrogen (278.93 kg/ha), available phosphorous (10.8 kg/ha) and available potassium (206.4 kg/ha). The experiment was conducted in Randomized Block Design consisting of 9 treatment combinations with 3 replications and was laid out with the different treatments allocated randomly in each replication viz., seed inoculation with *Azotobacter (ASI)* 20g/kg seed and 0% application of seaweed extract (SWE) (T_1), *(ASI)* 20g/kg seed + 5% (SWE) (T_2), *(ASI)* 20g/kg seed and 7.5% (SWE) (T_3), seed inoculation with phosphorus solubilizing bacteria (PSB) 20g/kg seed and 0% (SWE) (T_4), seed inoculation with PSB 20g/kg seed and 5% application of (SWE) (T_5), seed inoculation with PSB 20g/kg seed and 7.5% application of (SWE) (T_6), seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 0% (SWE) (T_7), seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 5% (SWE) (T_8), seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 7.5% (SWE) (T_9), Test variety (SS-303) was sown on 4th week of November 2021 with a spacing of 22.5 x 5 cm. Fertilizers were applied as band placement, for which 4-5 cm deep furrows were made along the seed rows with a hand hoe. The nutrient sources were urea, single super phosphate (SSP), and murate of potash (MOP). The recommended dose of fertilizers in the ratio of 120:60:40 kg N:P:K/ha was applied according to the treatment details. After germination, the gaps were filled up by dibbling of seed at 10 days after sowing. Seedlings were thinned out in order to maintain spacing of 22.5 x 5 cm. Manual weeding was done with the help of khurpi at 28 and 45 days after sowing to minimize the crop weed competition. Seed was treated with bio-fertilizers (*Azotobacter* + PSB) and seaweed extract was applied two times through foliar spray at tillering and booting stages. The field was maintained in a moist condition and for this, four irrigations were provided, one as pre-sowing and other at CRI, spike initiation and milking stages. The crop was harvested separately from each plot taking 1.0 m^2 area on March 29th 2022, i.e., 120 days after sowing. The yield attributes and yield were recorded at harvest. The economics of the treatments was computed based on cost of inputs applied in respective plots and value of produce obtained as per (grain and straw) prevailing price in the market. Statistical analysis was done and mean were compared at 5% probability level of significant results.

Results and Discussion

Effect on yield attributes

It is obvious from the data given in Table 1 that application of bio-fertilizers and seaweed extract significantly affected the yield attributes namely number of spikes m^2, number of grains/spike, Test weight, except harvest index. The values of above yield attributing traits were inferior in plots receiving seed inoculation with PSB 20g/kg seed and 0% application of seaweed extract (T_4) or seed innaculation with Azotobacter 20g/kg seed and 0% application of seaweed extract (T_1). But these traits were improved and attained the maximum values in plots receiving seed innaculation with both Azotobacter and PSB 10+10 g/kg seed and foliar application of 7.5% seaweed extract (T_9) and proved significantly superior over other treatments being at par to treatment 8 receiving both Azotobacter and PSB 10+10 g/kg seed and foliar application of 5% seaweed extract. Optimal availability of nitrogen and phosphorus due to non-symbiotic fixation of nitrogen by Azotobacter and solubilisation of unavailable phosphate to available form by PSB, respectively, as well as direct assimilation of major, secondary and micro nutrients along with cytokinins and auxins after foliar application of k- sap, enhanced the growth and development of wheat plants. As a consequence attained superior values of yield attributing traits. However, reverse was true in case of other treatments, therefore, attained the inferior values of yield attributing traits. These results are in close conformity with the findings of Singh *et al*., (2015) [6, 10].

Effect on yield

Data presented in Table 1 showed that grain and straw yields were influenced by bio-fertilizer and seaweed extract. The plots receiving seed inoculation with phosphorus solubilizing bacteria (PSB) 20g/kg seed and 0% application of seaweed extract (SWE) (T_4) or seed inoculation with *Azotobacter (ASI)* 20g/kg seed and 0% application of (SWE) (T_1) had poor grain and straw yield. But these were increased to maximum level in plots receiving seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 7.5% (SWE) (T_9) and proved significantly superior over other treatments but at par to (T_8) receiving both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 5% (SWE). The superior yield attributes under treatment 9 and treatment 8 could be the reason for higher yields in treatment 9 receiving *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 7.5% (SWE) and treatment 8 receiving *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 5% (SWE), Whereas, reverse was true in plots receiving *(ASI)* + 0% (SWE) and plots receiving seed inoculation with PSB + 0% (SWE). Similar yield was also endorsed by Zodape *et al*., (2009) and Khandare *et al*., (2020).

Table 1: Effect of bio-fertilizer and seaweed extract on yield attributes and yield of wheat

S. No	Treatments	Spikes/m2	Grains/spike	Test weight (g)	Grain yield	Straw yield	Harvest Index (%)
1.	Azotobacter 20g/kg seed + 0% seaweed extract	307.00	45.64	37.10	4.01	6.81	37.04
2.	Azotobacter 20g/kg seed + 5% seaweed extract	339.00	47.59	38.20	5.04	8.06	38.27
3.	Azotobacter 20g/kg seed + 7.5% seaweed extract	341.00	48.24	37.83	5.11	8.68	37.10
4.	PSB 20g/kg seed + 0% seaweed extract	304.33	45.36	36.46	4.01	6.81	37.02
5.	PSB 20g/kg seed + 5% seaweed extract	313.33	47.42	37.00	5.09	8.65	36.97
6.	PSB 20g/kg seed + 7.5% seaweed extract	320.00	47.47	37.20	5.1	8.67	37.09
7.	Azotobacter + PSB 10+10g/kg seed + 0% seaweed extract	351.66	51.34	37.93	4.89	7.82	38.44
8.	Azotobacter + PSB 10+10g/kg seed + 5% seaweed extract	359.33	52.37	38.83	6.32	10.10	38.47
9.	Azotobacter + PSB 10+10 g/kg seed + 7.5% seaweed extract	391.66	53.78	40.00	6.68	10.68	38.49
	F-tes	S	S	S	S	S	NS
	S.Em+	10.86	0.99	0.64	0.32	0.39	1.42
	CD (P= 0.05)	32.58	2.99	1.92	0.97	1.19	-

Effect of economics

It is evident from data given in Table 2 that the gross monetary returns, net monetary returns and Benefit-cost ratio varied due to application of bio-fertilizer and seaweed extract in wheat. The values of these parameter were less in plots receiving seed inoculation with phosphorus solubilizing bacteria (PSB) 20g/kg seed and 0% application of seaweed extract (SWE) (T_4) and seed inoculation with *Azotobacter (ASI)* 20g/kg seed and 0% application of (SWE) (T_1). But these indices fetched maximum value in plots receiving (T_9) seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 7.5% (SWE) due to higher grain and straw yields but plots receiving (T_8) seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 5% (SWE), had maximum benefit over cost due to proportionate increase in benefit per rupee of investment on bio-fertilizer and seaweed extract. Similar results have been reported by Pramanick *et al*., (2014) and Singh *et al*., (2015).

Table 2: Effect of biofertilizer and seaweed extract on economics of wheat

S. No.	Treatment	Cost of cultivation (INR/ha)	Gross returns (1NR/ha)	Net returns (INR/ha)	B:C Ratio (B:C)
1.	Azotobacter 20g/kg seed + 0% seaweed extract	37594.00	101231.50	63637.50	1.69
2.	Azotobacter 20g/kg seed + 5% seaweed extract	45594.00	125736.01	80142.01	1.75
3.	Azotobacter 20g/kg seed + 7.5% seaweed extract	49594.00	129006.50	79412.50	1.60
4.	PSB 20g/kg seed + 0% seaweed extract	37594.00	101231.50	63637.50	1.69
5.	PSB 20g/kg seed + 5% seaweed extract	45594.00	128513.50	82919.50	1.81
6.	PSB 20g/kg seed + 7.5% seaweed extract	49594.00	128775.01	79181.01	1.59
7.	Azotobacter + PSB 10+10g/kg seed + 0% seaweed extract	37594.00	121993.50	84399.50	2.24
8.	Azotobacter + PSB 10+10g/kg seed + 5% seaweed extract	45594.00	157648.01	112054.01	2.45
9.	Azotobacter + PSB 10+10g/kg seed + 7.5% seaweed extract	49594.00	166642.01	117048.01	2.36

Conclusion

It is concluded that (T_8) seed inoculation with both *Azotobacter* and PSB 10+10 g/kg seed and foliar application of 5% (SWE), found more productive and remunerative.

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