Original Research Article

Growth and yield of wheat (*Triticum aestivum* L.) as affected by bio-fertilizer and seaweed extract

Abstract

The field experiment was conducted at crop research form during Rabi season 2021-2022 at Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P), to evaluate the influence of bio-fertiliser and seaweed extract on growth and yield of wheat. The 9 treatments consisting of Seed inoculation with Azotobacter 20g/kg seed and 0% application of seaweed extract (T_1), Seed inoculation with Azotobacter 20g/kg seed and 5% application of seaweed extract (T_2), Seed inoculation with Azotobacter 20g/kg seed and 7.5% application of seaweed extract (T_3), Seed inoculation with PSB 20g/kg seed and 0% application of seaweed extract (T_4), Seed inoculation with PSB 20g/kg seed and 5% application of seaweed extract (T_5), Seed inoculation with PSB 20g/kg seed and 7.5% application of seaweed extract (T_6), Seed inoculation with both Azotobacter and PSB 10+10g/kg seed and foliar application of 0% seaweed extract (T_7), Seed inoculation with both Azotobacter and PSB 10+10g/kg seed and foliar application of 5% seaweed extract (T_8), Seed inoculation with both Azotobacter and PSB 10+10g/kg seed and foliar application of 7.5% seaweed extract (T_9), were carried in Randomized Block Design and replicated thrice. The results showed that seed inoculation with both Azotobacter and PSB 10+10g/kg seed and foliar application of 7.5% seaweed extract at 30 and 60 DAS (T_9) had superior values of growth parameters i.e., plant height (35.39, 79.48, 84.45 cm) and dry weight (6.18, 16.61, 18.03 g) at 60, 90 DAS and harvest, respectively, and found more productive as it attained higher values of spikes/m^2 (391.66), grains/spike (53.78), test weight (40.00), as well as grain (6.68 t/ha) and straw yields (10.68 t/ha) and proved statistically superior over other treatments but found at par to seed inoculation with both Azotobacter and PSB 10+10 g/kg seed and foliar application of 5% seaweed extract (T_8).

Key words : Azotobacter, PSB, seaweed extract, growth, yield and wheat.

Introduction

Wheat is the most important cereal crop for the majority of the world's population (36%) as a staple food. It is the third most important cereal after maize and rice. India ranks second amongst the wheat growing countries of the world after China in terms of area and production. Wheat is grown mostly in Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Rajasthan and Bihar and these are the major wheat producing states and accounts for almost 91% of total production in India. It contains appreciable amount of nutrients including proteins, fiber and minor components including lipids, vitamins, minerals and phytochemicals, which contribute to a healthy diet. Azotobacter as a N fixer and PSB as a phosphate solubilizer have attained good popularity among bio-fertilizers, and there has been a positive response to Azotobacter and PSB inoculation. Bio-fertilizers are able to fix atmospheric nitrogen in the available form for plant and have beneficial effect on plant growth by production of antibiotic (Zahir et al., 2004). These non-conventional fertilizer sources are not only cheap, but they increase soil fertility and productivity appreciably. When Azotobacter and PSB are inoculated in seeds, seed germination is improved to a considerable extent and also control plant diseases due to production of anti-fungal substances. Seeds with a low germination are inoculated with Azotobacter to boost germination by 20–30%. The seed inoculation with Azotobacter inch up the uptake of N, P, and micronutrients like Fe and Zn in wheat. In addition to this, Azotobacter inoculation replaced upto 50% of the urea-N. Phosphate solubilizing bacteria (PSB) secrete organic acids that dissolve unavailable phosphate (PO_4^{3-}) to available forms such as HPO_4^{2-} and $H_2PO_4^{-}$. Besides making soluble P, P-solubilizing bacteria are involved in plant growth promotion by the production of beneficial metabolites, such as phytohormones like indole acetic acid (IAA), antibiotics or siderophores, aminocyclopropane-1-carboxylate deaminase (ACC), nitrogen fixation, zinc solubilization and antimicrobial activity against soil-borne plant pathogens (Olanrewaju et al., 2019; Chouyia et al., 2020; Kumawat et al., 2020 and Hakim et al., 2021). Application of *Kappaphycus alvarezii* extracts has been reported to enhance nutrient uptake by wheat (Shah et al., 2013), 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. Potassium helps in regulating the water status of the plants, control opening and closing of stomata and helps in increasing photosynthetic rate, whereas phosphorus helps in root growth, and its proliferation, thereby making the plants to feed on large volume of soil in a balanced proportion (Jackson, 1973 and Salat, 2004) and influences the crop maturity as a whole.

Besides, it also helps in photosystem to produce NADPH. In field crops, seaweed products are being used in many ways like foliar spray, soil amendments, seed primer etc. Through foliar spray, it is directly assimilated by crop foliage within few hours after application. As seed primer, it improves the establishment of the crop by can increasing the vigour and germination rate. Further, Shah et al., (2013) found that application of *Kappaphycus alvarezii* seaweed extract is an alternative nutrient source to enhance yield of wheat grain by 20 and 13% respectively as well as of better quality (Hakim et al., 2021). In light of the above, this experiment was conducted to investigate the effect of bio-fertilizer and seaweed extract on wheat growth and yield.

Materials and Methods

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), which is located at 25^o 39' 42" N latitude, 81^o 67' 56" E longitude and 98 m altitude above the mean sea level. Nine treatments comprising of, Azotobacter 20g/kg seed + 0% seaweed extract (T_1), Azotobacter 20g/kg seed + 5% Seaweed extract at 30, 60 DAS/ha (T_2), Azotobacter 20g/kg seed + 7.5% Seaweed extract at 30, 60DAS/ha (T_3), PSB 20g/kg seed + 0% Seaweed extract (T_4), PSB 20g/kg seed + 5% Seaweed extract at 30, 60DAS/ha (T_5), PSB 20g/kg seed + 7.5% Seaweed extract at 30, 60DAS/ha (T_6), Azotobacter + PSB 10+10g/kg seed + 0% Seaweed extract (T_7), Azotobacter + PSB 10+10g/kg seed + 5% Seaweed extract at 30, 60DAS/ha (T_8) and Azotobacter + PSB 10+10g/kg seed + 7.5% Seaweed extract at 30, 60DAS/ha (T_9), were laidout in Randomized Block Design with 3 replications. The uniform dose of major nutrients i.e., 120kg N, 60kg P, 60kg K was applied in all the plots. The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.7), low in organic carbon (0.57%), available N (203.7 kg/ha), medium in available P (17.2 kg/ha) but high in available K (346.0 kg/ha). The major nutrients were applied in soil through urea, single super phosphate (SSP) and muriate of potash (MOP). Halt dose of nitrogen and full dose of P and K was applied as basal dressing and remaining quantity of nitrogen was top dressed in equal quantity at 30 and 60 days after sowing. The growth parameters were recorded at different time intervals, whereas yield attributes and yield were recorded at harvest.

Results and discussion

Effect on growth

It is evident from the data given in Table 1 that application of bio-fertilizer and seaweed extract significantly affected the growth attributing characters of wheat such as plant height and dry weight, at all time intervals except at 30 DAS. The plant height and dry of plant were minimum during early period of growth (30 DAS) irrespective of treatments and it was increased with time being the maximum at 90 DAS in case of plant height and harvest in case of dry weight of plant. Differentiation of node and internodes during 60 to 90 DAS and gradual increase in leaf area upto flowering i.e. 90 DAS (Blunden et al., 1997) and better partitioning of photosynthates from source to sink is the reason of higher values of plant height and plant dry weight at 90 and harvest respectively. Plant height and dry weight of plant were inferior in plots receiving only seed inoculation with PSB 20 g/kg seed with 0% seaweed extract (T_4) and Azotobacter 20 g/kg seed with 0% seaweed extract (T_1) at 60 DAS due to availability of only phosphorus and nitrogen in aforesaid treatments. However, both the traits attained maximum values in plots receiving seed inoculation with Azotobacter + PSB 10+10 g/kg seed with foliar application of 7.5% seaweed extract (T_9) and proved statistically superior over other treatments except seed inoculation with Azotobacter + PSB 10+10 g/kg seed with foliar application of 5% seaweed extract (T_8). Optimum 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 essential major, secondary and micro nutrients along with cytokinins and auxins after foliar application of k-sap, enhanced the growth in meristematic region and consequently had superior values of growth characters. However, reverse was true in case of other treatments, therefore, they attained the inferior values of yield attributing traits. The positive effect of the application of Azotobacter and PSB on germination, germination percentage and plant height, has also been reported by Shaharoona et al. (2006).

Effect on yield attributes and yield

The perusal of data presented in Table 2 indicated that application of bio-fertilizers and seaweed extract significantly affected the growth attributing characters of wheat such as spikes/m^2, grains/spike, Test weight, grain and straw yields except harvest index. The values of attributing characters were less in plots receiving seed inoculation with PSB 20g/kg seed and 0% application of seaweed extract (T_4) and seed inoculation with Azotobacter 20g/kg seed and 0% application of seaweed extract (T_1) but these were enhanced and attained the top values in plots receiving seed inoculation 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 plot receiving both Azotobacter and PSB 10+10 g/kg seed and foliar application of 5% seaweed extract (T_8). Superior values of growth characters (plant height and plant dry weight) due to optiomal nutrition at different phenophases (Tillering, penicle initiation and grain filling stage) could be assigned the reason for superior yield attributes. These result are in close conformity to that of Murugalakshmi kumari et al. (2002),

Effect of yield

Data given in Table 3 showed that the grain and straw yields were affected by different levels of bio-fertilizer and seaweed extract. The values of both characters were minimum in plots receiving seed inoculation with PSB 20g/kg seed with no foliar application of seaweed extract followed by seed inoculation with Azotobacter 20g/kg seed with no foliar application of seaweed extract due to poor values of yield attributing traits. However, wheat grain and straw yield were increased by 39.9 and 36.2% when seed inoculation was done with both Azotobacter and PSB 10+10g/kg seed along with foliar application of 7.5% seaweed extract was done in wheat at 30 and 60 DAS (T_9) as compared to seed inoculation with PSB 20g/kg seed and 0% application of seaweed extract (T_4) being at par to seed inoculation with both Azotobacter and PSB 10+10g/kg seed along with foliar application of 5% seaweed extract in wheat at 30 and 60 DAS (T_8) but found significantly superior over other treatments. Superior values of yield attributing traits under former treatments could be assigned the reason of higher yields under seed inoculation was with both Azotobacter and PSB 10+10g/kg seed along with foliar application of 7.5% seaweed extract (T_9) and seed inoculation with both Azotobacter and PSB 10+10g/kg seed along with foliar application of 5% seaweed extract (T_8). Similar views have also been endorsed by Madhu et al. (2012). However, reverse was true in case of other treatments which received inoculation either with Azotobacter/PSB or both without any foliar application of seaweed extract.

Conclusion

It is concluded that seed inoculation with Azotobacter and PSB 10+10 g/kg seed and foliar application of 5% seaweed extract (T_8) found more productive as it attained the superior values of growth and yield attributing traits.

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Table 1 Effect of bio-fertilizer and seaweed extract on plant height of wheat

S. No.	Treatment	Plant height (cm)			
		30DAS	60DAS	90 DAS	At harvest
1.	Azotobacter 20g/kg seed + 0% seaweed extract	4.78	25.64	72.80	74.71
2.	Azotobacter 20g/kg seed + 5% seaweed extract	4.72	27.13	74.43	76.47
3.	Azotobacter 20g/kg seed + 7.5% seaweed extract	4.70	27.73	74.50	76.50
4.	PSB 20g/kg seed + 0% seaweed extract	4.81	23.84	71.70	73.37
5.	PSB 20g/kg seed + 5% seaweed extract	4.71	26.62	73.82	75.49
6.	PSB 20g/kg seed + 7.5% seaweed extract	4.84	27.08	74.02	76.04
7.	Azotobacter + PSB 10+10g/kg seed + 0% seaweed extract	4.77	28.06	78.50	80.44
8.	Azotobacter + PSB 10+10g/kg seed + 5% seaweed extract	5.23	29.64	74.43	81.45
9.	Azotobacter + PSB 10+10g/kg seed + 7.5% seaweed extract	4.90	35.39	79.48	84.45
	F tes	NS	S	S	S
	SEm±	0.50	1.05	1.07	1.06
	CD (P= 0.05)	-	3.15	3.20	3.18

Table 2 Effect of bio-fertilizer and seaweed extracton dry weight of wheat plant.

S. No.	Treatment	Dry weight (g plant^{-1})			
		30DAS	**60DAS**	**90 DAS**	**At harvest**
1.	Azotobacter 20g/kg seed + 0% seaweed extract	0.40	4.42	14.65	15.61
2.	Azotobacter 20g/kg seed + 5% seaweed extract	0.39	5.14	15.08	16.13
3.	Azotobacter 20g/kg seed + 7.5% seaweed extract	0.37	5.28	15.40	16.45
4.	PSB 20g/kg seed + 0% seaweed extract	0.36	4.38	14.52	15.52
5.	PSB 20g/kg seed + 5% seaweed extract	0.31	4.66	14.90	15.63
6.	PSB 20g/kg seed + 7.5% seaweed extract	0.34	4.67	14.96	15.99
7.	Azotobacter + PSB 10+10g/kg seed + 0% seaweed extract	0.38	5.31	15.67	16.72
8.	Azotobacter + PSB 10+10g/kg seed + 5% seaweed extract	0.34	5.32	15.86	17.19
9.	Azotobacter + PSB 10 + 10g/kg seed + 7.5% seaweed extract	0.45	6.18	16.61	18.03
	F tes	NS	S	S	S
	SEm$\pm$	0.02	0.24	0.28	0.28
	CD (P= 0.05)	-	0.72	0.85	0.85

Table-3 Effect of bio-fertilizer and seaweed extract on yield attributes and yield of wheat

S. No.	Treatment	Spikes/m^2	Grains/ spike	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
1.	Azotobacter 20g/kg seed + 0% seaweed extract	307.01	45.64	37.10	4.01	6.81	37.04
2.	Azotobacter 20g/kg seed + 5% seaweed extract	339.01	47.59	38.20	5.04	8.06	38.27
3.	Azotobacter 20g/kg seed + 7.5% seaweed extract	341.01	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	5.10	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 + 10g/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
	SEm±	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	-