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Efficacy of Salt Tolerant Plant Growth Promoting Bacterial Liquid Consortium on Growth and Yield of Wheat (*Triticum aestivum* L.)

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ABSTRACT: Feeding an overgrowing population with limited availability of fertile land is the burning issue for sustainable agriculture. To provide more production but not at the cost of pollution and soil fertility degradation is the real challenge for the future. Plant growth promoting bacteria are nature's gift to mankind to overcome this situation. Looking to this aspect, the present study has been designed. The field experiment for consecutive 2 years were conducted to evaluate the efficacy of native ST-PGPB consortium Bio NP liquid formulation on growth and yield attributes of wheat. The experiments were conducted in randomized block design during the Rabi 2018-19 and 2019-20, respectively. There was significant difference observed in plant height at harvest and in yield attributing characters like, number of total tillers and effective tillers per meter row length, grains per spike, straw and grain yield. However, the results were non-significant differences in plant population, plant height at 30 DAS and on test weight of wheat under field condition. Treatment T_4 (50 % RDF + 25 % N by Castor cake + Bio NP) found superior to other treatments for all growth and yield attributing parameters, grain yield (2500 kg/ha) and straw yield (4997 kg/ha) and remained at par with treatments T_1(100 % RDF) followed by T_3(75 % RDF + Bio NP) and T_5(50 % RDF + 25 % N by Vermicompost + Bio NP), respectively. Treatment T_2 (75 % RDF) found inferior for growth parameters and yield attributes of wheat.

Keywords: Plant growth promoting bacterial consortium, Bio NP, Salt tolerant bacteria, Growth, Yield, Wheat.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a key cereal and life sustaining crop in India and also cultivated in rain-fed areas. Wheat is considered one of the most important staple foods for human (Parlak, 2016). The wheat flour is commonly used for making bread, chapattis, biscuits, cakes, pastry, etc. Globally, wheat is widely grown followed by rice and corn utilizing major land resources. Being the second largest in population, India is also ahead in wheat consumption after China. In India, the total area under the wheat cultivation is about 29.8 million hectares with an average productivity of 3140 kg/ha. Wheat production is about 70 million tonnes per year in India and counts for approximately 12 per cent of world production (FAO, 2017). Major wheat growing states in India are Uttar Pradesh, Punjab, Haryana, Rajasthan, Madhya Pradesh, Gujarat and Bihar.

In Gujarat, total cultivated area under irrigated wheat cultivation is about 13547.5 ha with an average productivity of 45199.1 MT and having an average yield of 3336.3 kg/ha (Anonymous, 2020). Wheat is an excellent source of protein, carbohydrates and dietary fibers when eaten as the whole grain. Nutritionally, wheat supplies high content of carbohydrates, proteins, minerals, iron and some of the important vitamins for human (Olaniyan, 2015). Wheat is the leading source of vegetable protein in human food, having a protein content of about 13%, which is relatively high compared to other major cereals (Arzani and Ashraf 2017; Shewry and Hey 2015). A balanced food containing enough calories, balanced proteins and micro nutrients with low anti nutritional components is needed for the proper growth and development of human being (Singh *et al*., 2010).

Like other agricultural crops, wheat production is also affected by salinity stress. Salinity is one of the major constraints to wheat growth, which hampers production, causing a yield loss up to 65% in saline soils (Shafi *et al*., 2010). Saline soil increasing day by day that limits available land for cultivation all around the world and becomes serious threat in arid and semi-arid regions (Mandhania *et al*., 2006). Interest in the beneficial rhizobacteria associated with cereals and especially wheat has increased in recent era under variable ecological conditions (Chaudhary *et al*., 2023). Soil inoculation of PGPB may be considered a promising tool of integrated management system (Aruna *et al*., 2023). The use of PGPB is a prime agricultural approach for salinity susceptible crops to tolerant and maintains an appropriate level of productivity (Singh *et* *al*., 2011; Nadeem *et al.*, 2012; Manva *et al*., 2019; Patel *et al*., 2022).

MATERIAL AND METHODS

Experimental Site. The field experiment was conducted at college farm, College of Agriculture, Vaso during the *rabi* season of the year 2018-19 and 2019-20, respectively. The soil of college farm was sandy loam and low saline having pH 8.2. Geographically, Vaso college farm is situated at 22° 67′ N latitudes, 72°77′ E longitudes with an elevation of 33.0 m above the mean sea level.

Experimental Design and Treatments. The field experiment was conducted on Randomized Block Design (RBD) technique with four replications. The treatments comprised of all possible combinations of recommended dose of fertilizer in wheat crop and Bio NP consortium (Table 1). The RDF (recommended dose of fertilizers) for wheat crop was provided through inorganic chemicals only. An application of 10 tones FYM per hectare was applied to reclaim saline condition of soil. Bio NP consortium was applied in 2 phases *viz.*, first seed treatment of Bio NP consortium applied @ 5 ml / kg of seeds prior to sowing and secondly; application of Bio NP consortium along with irrigation water @ 1 lit / ha at second irrigation.

Table 1: Details of field experiment.

Experimental Design		**Randomized Block Design (RBD)**
Treatments		Five (5)
Replications		Four (4)
Season		*Rabi*
Crop & Variety		Wheat *var* GW 451
Method of sowing		Drilling
Spacing		22.5 cm row spacing
Plot size		Gross: 3.6 m × 5.0 m; Net: 2.7 m × 4.0 m
Duration of research (2 seasons)		Rabi (2018-19)&Rabi (2019-20)
Detail of treatments-		
T1	RDF (120-60-60 N-P_2O_5-K_2O kg ha^{-1})	
T2	75 % RDF	
T3	75 % RDF + Bio NP	
T4	50 % RDF + 25 % N by Castor cake + 25 % N by Bio NP	
T5	50 % RDF + 25 % N by Vermicompost + 25 % N by Bio NP	

For recording the observations of wheat, five plants were selected at random from each plot. These selected plants were labeled with necessary notations. All the observations of wheat attributes were recorded form all four replications.

Growth attributes

Plant population. For recording plant population, observations on number of plants per meter raw length from net plots were recorded after 20 days of sowing.

Plant height. The plant height was recorded at 30 DAS and at harvest of previously selected and tagged five plants in each net plot and average height was calculated(cm) and recorded.

Yield attributes

Number of total tillers. The number of total tillers per meter row length was recorded at harvest from each net plot.

Number of effective tillers. The number of effective tillers per meter row length was recorded at harvest from each net plot.

Number of grains per spike. The total number of grains per spike from previously tagged five plants at the time of harvest was counted and their average value per plant was worked out and recorded for each treatment.

Test weight (g). From the composite samples of seeds drawn from the produce of each net plot, 1000 seeds were counted and the total weight was recorded in gram for each experimental plot.

Grain yield (kg/ha). The grains of each net plot area were threshed separately, cleaned and the seed yield was recorded in kg per net plot and then computed on hectare basis for all treatments.

Straw yield (kg/ ha). Straw yield was obtained by subtracting the grain yield of each net plot from their respective total dry matter (above ground) or biological yield and computed in terms of kg per net plot and then on hectare basis.

Chemical analysis of soil. Soil analyses of samples were carried out at 0-15 cm soil depth before sowing and after harvest of wheat crop for the years 2018-19 and 2019-20, respectively. Collected soil samples were air-dried at room temperature and were sieved to remove stones and plant debris. Respective fine powdered soil was mixed thoroughly to obtain a representative sample (100 g) and preceded for analysis of various parameters *viz.*, pH by potentiometry method (Jackson, 1973), EC by conductometry method (Jackson, 1973), Organic Carbon by walkley and black method (Walkley and Black, (1934), available nitrogen by kjeldhal method (Kjeldahl, 1883) and available Phosphorus by spectrophotometry method (Olsen *et al.*, 1954).

RESULTS AND DISCUSSION

Growth Attributing Characters

Plant population per meter row length. Data pertaining to plant population per meter row length of wheat as influenced by different treatments at 20 DAS for the year 2018-19 and 2019-20 and in pooled analysis are presented in Table 2. It was seen from the data that plant population at 20 DAS was found non-significant during the year 2018-19, 2019-20 as well as on pooled basis indicating equal and uniform distribution of crop in all the experimental plots and whatever impact was seen on growth, yield attributes and yield was purely the treatment effect.

Table 2: Growth attributes of wheat as influenced by Bio NP treatment combinations.

Treatments	Plant population per meter row length at 20 DAS			Plant height (cm) at 30 DAS			Plant height (cm) at harvest		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
T_1	23.33	22.68	23.00	27.88	28.23	28.05	66.30	68.74	67.52
T_2	21.15	20.70	20.93	26.80	26.85	26.83	62.08	60.93	61.50
T_3	22.20	22.30	22.25	27.35	27.65	27.50	67.85	68.10	67.98
T_4	23.43	23.75	23.59	27.90	28.70	28.30	70.98	71.55	71.26
T_5	21.60	22.20	21.90	27.65	27.63	27.64	67.38	68.25	67.81
S. Em. ±	1.12	1.11	0.79	1.31	1.81	1.12	2.73	2.84	1.97
CD (p= 0.05)	NS	NS	NS	NS	NS	NS	8.41	8.74	5.75
Y	—	—	NS	—	—	NS	8.16	8.40	8.28
Y X T	—	—	NS	—	—	NS	—	—	NS
CV %	10.00	9.98	9.99	9.52	13.05	11.44	8.16	8.40	8.28

Plant height. The mean data on plant height (cm) of wheat as influenced by different treatments at 30 DAS and at harvest during the year 2018-19 and 2019-20 and in pooled analysis are presented in Table 2.

Result revealed that plant height at 30 DAS was not affected significantly due to different treatments during both the years and in pooled analysis. However, result pertaining to plant height at harvest presented in Table 2 manifested significant impact of different treatments on plant during the year 2018-19, 2019-20 and on pooled basis. Treatment T_4(70.9, 71.55 and 71.26) having 50 % RDF + 25 % N by Castor cake + Bio NP recorded significantly higher results which was found at par with treatment T_3 (67.85, 68.10 and 67.98 cm) having 75 % RDF + Bio NP, treatment T_5 (67.38, 68.25 and 67.81cm) having 50 % RDF + 25 % N by Vermicompost + Bio NP and treatment T_1 (66.30, 68.74 and 67.52 cm) having RDF during the year 2018-19, 2019-20 and in pooled analysis, respectively.

The increase in plant height at later growth stage might be attributed to the incremental use of chemical fertilizer (RDF), particularly, split application of nitrogen, along with application of bio NP consortium were found to encourage the growth and the row distance of T_2 and best treatment T_4 is also indicative for plants development (Fig. 1). Adequate nitrogen in the soil might supply adequate nutrition which might help in cell elongation and cell division. The results are in close conformity with those of (Islam *et al.*, 2008; Zaheen *et al.*, 2006; Panda *et al.*, 1995).

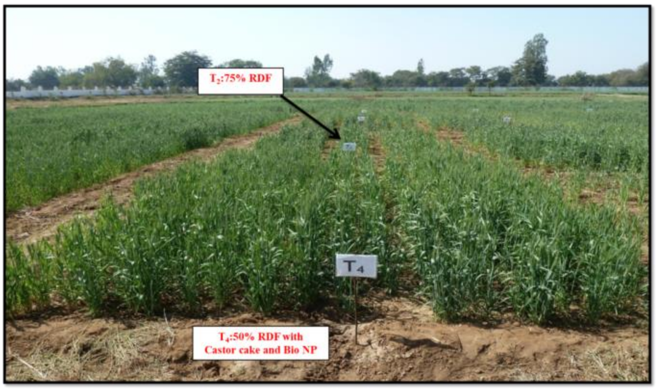

Fig. 1. Effect of key treatments (T_4 *vs* T_2) on growth of wheat.

Yield Attributing Characters

Number of total tillers. The data pertaining to number of total tillers per meter row length at harvest as influenced by different treatments during the year 2018-19, 2019-20 and pooled analysis are presented in Table 3.

The statistical analysis of the data revealed that treatment T_4 (50 % RDF + 25 % N by Castor cake + Bio NP) recorded significantly higher number of total tillers per meter row length (125.83 and 126.10) at harvest which was found at par with treatment T_1 having 100 % RDF (119.08 and 120.10) followed by treatment T_5 with 50 % RDF + 25 % N by Vermicompost + Bio NP (117.50 and 119.50) and treatment T_3 with 75% RDF + Bio NP (116.75 and 119.25) for the year 2018-19 and 2019-20, respectively. Similar trend was followed for pooled analysis and T_4 (50 % RDF + 25 % N by Castor cake + Bio NP) being at par with T_1 (119.59), T_3 (118.00) and T_5 (118.50) observed significantly higher values for number of total tillers per meter row length at harvest (125.96).

An increase in number of tillers might be due to the activity of ST-PGPB which improved the availability of different plant nutrients, which may reflect in growth of crop and increased the number of total tillers at harvest. Research shows that application of salt tolerant PGPB in cereals may increase germination, promote seedling growth, induce antioxidative enzymes against ROS, favor osmolyte accumulation and modulate expression of genes related to salt stress (Rima *et al*., 2018; Sarkar *et al*., 2018; Paul and Lade, 2014).

Number of effective tillers. The mean data on number of effective tillers of wheat per meter row length as influenced by different treatments during the year 2018-19 and 2019-20 and in pooled analysis are presented in **Table 3.**

The statistical analysis during the years 2018-19 and 2019-20, showed significant response of different treatments on number of effective tillers per meter row length of wheat at harvest and revealed that treatment T_4 (50 % RDF + 25 % N by Castor cake + Bio NP) recorded significantly higher number of effective tillers per meter row length (117.23 and 118.80) at harvest which was found at par with treatment T_3 (110.75 and 108.05), T_1 (108.38 and 108.63) and treatment T_5 (106.85 and 110.35), respectively. Similar trend was observed in pooled analysis and treatment T_4 produced significantly higher number of effective tillers per meter row length (118.01). However, it was found at par with treatment T_3 (109.40), T_5 (108.60) and treatment T_1 (108.00). Significantly lower value pertaining to numbers of effective tillers per meter row length was recorded in treatment T_2 (97.43).

Singh *et al*. (2011)also reported significant increase in tillering in wheat due to application of bio-fertilizers either alone or in combination. Greater tillering was noticed when the crop received combined treatments than other treatments. They have also reported significant response of bio-fertilizers (N-fixer and P-solubilizer) on growth and productivity of wheat under field experiment.

Grains per spike. The mean data of number of grains per spike of wheat at harvest as influenced by different treatments during the year 2018-19, 2019-20 and on pooled basis are presented in Table 3.

Table 3: Yield attributes of wheat as influenced by Bio NP treatment combinations.

Treatments	Number of total tillers per meter row length			Number of effective tillers per meter row length			Number of Grains per spike		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	119.08	120.10	119.59	108.38	107.63	108.00	45.75	45.90	45.83
T_2	105.70	106.88	106.29	96.25	98.60	97.43	35.13	35.48	35.30
T_3	116.75	119.25	118.00	110.75	108.05	109.40	44.30	45.73	45.01
T_4	125.83	126.10	125.96	117.23	118.80	118.01	46.25	47.95	47.10
T_5	117.50	119.50	118.50	106.85	110.35	108.60	44.38	45.70	45.04
S. Em. ±	4.85	5.71	3.75	6.04	6.13	4.30	2.91	3.17	2.15
CD (p= 0.05)	14.93	17.60	10.93	18.62	18.90	12.57	8.97	9.76	6.28
Y	—	—	NS	—	—	NS	—	—	NS
Y X T	—	—	NS	—	—	NS	—	—	NS
CV %	8.29	9.65	9.00	11.20	11.29	11.24	13.49	14.35	13.94

It is obvious from the data that treatment T_4(50 % RDF + 25 % N by Castor cake + Bio NP) recorded significantly higher number of grains per spike (46.25 and 47.95), which was found at par with treatment T_1 (45.75 and 45.90), treatment T_5 (44.38 and 45.70) and treatment T_3 (44.30 and 45.73) during the year 2018-19 and 2019-20, respectively. The data on pooled analysis showed that, treatment T_4 had highest number of grains per spike (47.10) followed by treatment T_1 (45.83) and treatment T_5 (45.04) and treatment T_3 (45.01). The lowest value for number of grains per spike was recorded in treatment T_2 (35.30) having 75 % RDF.

All the treatments barring T_2 (75% RDF) obtained adequate and timely supply of nutrients, especially nitrogen through chemical fertilizer or through organic sources like castor cake or vermicompost along with bio NP. Increase in availability due to the activity of ST-PGPB consortium might improve the availability of different plant nutrients which might be resulted in to synergistic source to sink ratio and translocated more photolytes from vegetative to reproductive phase. Supply of nutrients through organic sources like castor cake and vermicompost also synchronized with the demand-supply equilibrium and resulted in to higher yield attributing characters like number of effective tillers as well as number of grains per spike. The results obtained are in accordance with those reported by Singh *et al*. (2009); Ahmad *et al*. (2008).

Test weight. The mean data of test weight (g) of wheat at harvest as influenced by different treatments during the year 2018-19, 2019-20 and on pooled basis are presented in Table 4. The statistical analysis of data revealed that test weight (g) of wheat grains was found non-significant for the year 2018-19, 2019-20 and in pooled basis.

Table 4: Yield attributes of wheat as influenced by Bio NP treatment combinations.

Treatments	Test weight (g)			Grain yield (kg/ha)			Straw yield (kg/ha)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	51.08	51.13	51.10	2357	2425	2391	4540	4667	4604
T_2	48.95	48.75	48.85	1844	1897	1870	3714	3896	3805
T_3	50.39	49.10	49.74	2292	2328	2310	4200	4503	4351
T_4	52.20	52.03	52.11	2479	2500	2490	4855	4997	4926
T_5	50.51	50.93	50.72	2320	2328	2324	4386	4274	4330
S. Em. ±	2.20	2.27	1.58	143	159	107	287	254	192
CD (p= 0.05)	NS	NS	NS	440	491	312	884	784	560
Y	—	—	NS	—	—	NS	—	—	NS
Y X T	—	—	NS	—	—	NS	—	—	NS
CV %	8.71	9.03	8.87	12.66	13.88	13.29	13.23	11.38	12.32

Grain yield. The mean data of grain yield (kg/ha) of wheat at harvest as influenced by different treatments during the year 2018-19, 2019-20 and on pooled basis are presented in Table 4.

Perusal of data revealed that grain yield of wheat was found significantly affected by different treatments for both the years and in pooled analysis. Data revealed that during the year 2018-19 treatment T_4 (50 % RDF + 25 % N by Castor cake + Bio NP) recorded statistically superior grain yield (2479 kg/ha), which remained at par with the results of treatment T_1 (2357 kg/ha), treatment T_5 (2320 kg/ha) and treatment T_3 (2292 kg/ha). During the year 2019-20, same results had been reported and treatment T_4 (2500 kg/ha, being at par with treatments T_1 (2425 kg/ha), T_3 (2500 kg/ha) and T_5 (2328 kg/ha) respectively. During 2018-19 and 2019-20, treatment T_2 (75% RDF) produced significantly lower yield (1844 kg/ha and 1897 kg/ha), respectively.

The data on pooled analysis also reflected the similar trend and treatment T_4 recorded significantly higher grain yield (2490 kg/ha) which remained at par with the treatment T_1 (2391 kg/ha), T_3 (2310 kg/ha) and treatment T_5 (2324 kg/ha). The lowest value for grain yield of wheat was recorded in treatment T_2 (1870 kg/ha). The pooled results also indicated an increase of grain yield to the tune of 24.89%, 21.79%, 19.53% and 19.04 % for T_4, T_1, T_5 and T_3 over T_2, respectively.

Application of salt tolerant PGPB in salt-affected soil not only assisted in the survival of crop but also improved yield in a wide range of cereal crops (Singh and Jha 2016). Rajput *et al*. (2013) reported that *P. rifietoensis*, an alkaliphilic bacterium is reported to enhance growth and yield of wheat crop under salinity stress. Research shows that application of salt tolerant PGPB in may increase germination, promote seedling growth, induce antioxidative enzymes against ROS, favor osmolyte accumulation and modulate expression of genes related to salt stress that ultimately leads to higher yield in crops (Rima *et al*., 2018; Sarkar *et al*., 2018; Paul and Lade 2014). Singh and Jha (2016) reported better growth in wheat plants (*T. aestivum* L.) after inoculation of PGPB under salt stress condition. Ramadoss *et al.* (2013) revealed that bio-formulation of halotolerant bacterial strains can improve salinity stress (80, 160, and 320 mM) in wheat, resulting in a 70% improvement of root length comparatively to negative controls may be due to functional interactions between plants and microbes that lead to salt stress tolerance (Heidaryan and Feilinezhad 2015; Nazneen *et al*., 2022). Upadhyay and Singh (2015) reported that *B. subtilis* enhanced wheat yield by around 18% in salt-affected soil (EC 5.2 dSm^{-1}). Studies have confirmed that under salt stress yield loss in crops can be minimized by the application of phytohormone producing PGPB under saline conditions (Yao *et al.*, 2010). It has been realized that application of ST-PGPB in salt-affected soil not only assisted in the survival of crop but also improved yield in a wide range of cereal crops (Singh and Jha 2016).

Straw yield. The mean data of straw yield (kg/ha) of wheat at harvest as influenced by different treatments during the year 2018-19, 2019-20 and on pooled basis are presented in Table 4.

A critical view of the results indicated that straw yield of wheat was found significantly affected due to different treatments for the year 2018-19, 2019-20 and in pooled basis. Data revealed that treatment T_4 (50 % RDF + 25 % N by Castor cake + Bio NP) recorded significantly higher straw yield (4855 kg/ha), which remained at par with the treatment T_1 (4540 kg/ha), T_3 (4200 kg/ha) and treatment T_5 (4386 kg/ha) during the year 2018-19. During the year 2019-20, treatment T_4 recorded significantly superior straw yield (4997 kg/ha), which remained at par with treatment T_1 (4667 kg/ha), T_3 (4503 kg/ha) and T_5 (4274 kg/ha). The data on pooled analysis also followed the same trend and treatment T_4 recorded superior straw yield (4926 kg/ha) which remained at par with the results of treatment T_1 (4604 kg/ha) and treatment T_3 (4351 kg/ha). The lowest value for straw yield of wheat was recorded in treatment T_2 (3805 kg/ha) having 75 % RDF.

Majeed *et al.* (2018) conducted an experiment on wheat and found that plant inoculation with PGPB strains provided a significant increase in straw yield as well as shoot and root biomass. A significant increase in shoot N contents (76%) and root N contents (32%) was observed over the un-inoculated control.

Yield is the resultant effect of all the growth and yield attributing characters. In field study, polled data the outstanding treatment was T_4 (50% RDF + 25% N by Castor cake + Bio NP), which produced significantly highest grain and straw yield at harvest, better plant height, number of total and effective tillers per meter row length, number of grains per spike plus remained at par with T_1 (RDF) followed by T_3 and T_5. Contrarily treatment T_2 with 75% RDF had produced inferior growth and yield attributing parameters as reflected in lower grain yield of wheat (Fig. 2).

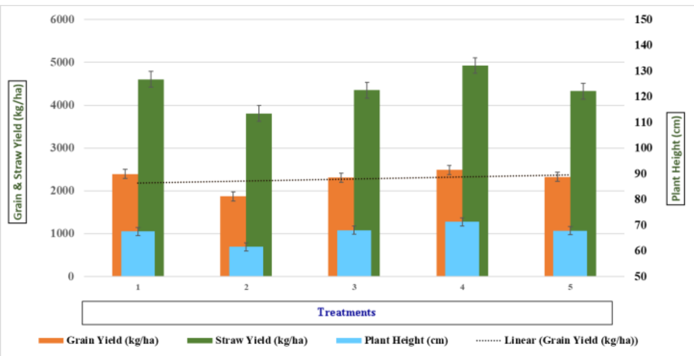

Fig. 2. Treatments effect in pooled data at harvest- plant height, grain and straw yield of wheat.

Chemical analysis of soil. The results pertaining to effect of bacterial inoculation on pH, EC (dsm^{-1}), organic carbon (%), available nitrogen content (kg/ha) and available phosphorous content (kg/ha) during the year 2018-19 and 2019-20, respectively are presented in Table 5.

Results showed that, EC of the soil was increased (0.45 dsm^{-1}) while pH was reduced for the successive years (7.70). It was also noted that organic carbon (%), available nitrogen content (kg/ha) and available phosphorous content (kg/ha) were showed better value for the year 2019-20 as compared to 2018-19. It indicates that inoculation of ST-PGPB increased soil organic carbon, total nitrogen which may provide an added advantage to the subsequent crop due to improved soil fertility. Similarly, Gomare *et al*. (2013) obtained higher percentage of NPK content of soil receiving N-fixer treatment compared to control. Similar results were obtained by (Ji *et al*., 2018; Das *et al*., 2016).

The effect of growth attributing characters like plant population at 20 DAS and plant height were measured at 30 DAS showed non-significant effect, while plant height at harvest was significantly affected by different treatments and treatment T_4, being at par with T_1, T_3 and T_5 reported significantly higher plant height (71.26 cm) at harvest on pooled basis.

Table 5: Chemical analysis of soil samples at harvest.

Sr. No.	Soil parameter	Initial (Before sowing)	2018-19	2019-20
1.	pH	7.50	7.90	7.70
2.	EC (dsm^{-1}) (1:2.5, S:W Ratio)	0.40	0.40	0.45
3.	Organic Carbon (%)	0.28	0.31	0.35
4.	Available Nitrogen (kg/ha)	285	313	415
5.	Available Phosphorous i.e P_2O_5 (kg/ha)	14.05	16.85	20.25
6.	Available Potash i.e. K_2O (kg/ha)	311	344	373

CONCLUSIONS

The effect of Bio NP formulation prepared from native salt tolerant PGPB were found helpful in improving grain and straw yield and remained at par with the RDF. Overall field study for two years clearly showed that ST Bio NP consortium helped in optimum growth and superior yield of wheat with saving of 25% fertilizers, was highly encouraging and unique research outcome in low saline soil (EC 0.4 dsm^{-1}) and under restricted irrigation conditions of saline water (TDS >3250 ppm). Furthermore, when native Bio NP consortium used with organic sources like castor cake or vermicompost in wheat, the 50 % of chemical load was observed to be curtailed, this may reduce deterioration of soil and keep agro-ecosystem sustainable in long run.

FUTURE SCOPE

Enhanced production with improved soil fertility in an eco-friendly manner is the need of the day. Isolation and identification of ST-PGPB from saline soil needs to be done at regional and global level. Salt tolerant plant growth promoting bacteria discussed in this study reduce chemical load and improving soil productivity on a long run that makes them a frontier tool for sustainable agriculture.

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Conflict of Interest. None.

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