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Effect of *Azospirillium* and phospho-solubilizing bacterial isolates on yield and nutrient uptake of rice in salt affected soil

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ABSTRACT : A pot experiment was conducted to investigate the effect of soil microbes (*Azospirillium* and PSB) with different dose of NPK on salt affected soil properties, grain yield, straw yield, nutrient contain (%), uptake etc. the experiment was carried out in Randomized Block Design with 21 treatment and three level of fertilizer (50, 75 and100% recommended dose of NPK ha^{-1}) with and without microbial isolates in three replication. The result indicate that the addition of microbial isolates to salt affected soil not only increase the yield of rice reduce use of fertilizer, improve the soil physico chemical properties like pH, EC, organic carbon, available N, available P and available K in the post-harvest soil as well enhance the rice quality.

KEY WORDS : *Azospirillium,* Phospho-solubilizing, Bacterial isolates, Nutrient uptake, Salt affected soil

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INTRODUCTION

Rice (*Oryza sativa* L.) is a stable food in India, providing 43 per cent of calorie requirement for more than 70 per cent of the Indian population. To meet the demands of increasing population and to maintain self-sufficiency, Hence, sustainable production of rice could be achieved only by maintaining a balance between demand and supply of nutrients by integration of inorganic and organic sources of nutrients like vermicompost, bio-compost, composted coir pith etc. At the same time India has a vast scope for reutilization of renewable agricultural industrial wastes like pressmud, coir pith and industrial by-product like gypsum. By the way of addition and to utilize the above waste as raw materials for crop production with suitable technologies is need of the hour. According to this concept several worker doing this work like Mathews *et al.* (2006) have worked on the effect of nutrients and biofertilizers on yield and yield components of rice in coastal alluvial soil of Karnataka. Isawa *et al.* (2010) worked on *Azospirillium* sp. strain B510 which enhances rice growth and yield. Chauhan *et al.* (2010) worked on the effect of nutrient management practices on the performance of upland rice (*Oryza sativa* L.) on terraced land under continuous cultivation. Chesti *et al.* (2005) had work on growth and yield of rice (*Oryza sativa* L.) which influenced by integration of flyash and fertilizers. Roul *et al.* (2005) worked on effect of integrated nitrogen nutrition techniques on yield, nutrient content (%) and uptake and use efficiency of rice (*Oryza sativa*). The aim of this study was the isolation and characterization of micro-organisms (*Azospirillium* and PSB)

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one of the most efforts in this way to not only increase the yield of rice also improve the soil physico-chemical properties like pH, EC, OC, available N, available P, available K in the post-harvest soil. Thirty five days old three seedling per hill and three hills per pot transplanted.

EXPERIMENTAL METHODS

The pot experiments with rice variety usardhan–3 were conducted in *Kharif* 2012 with 21(12 *Azospirillium* and 5 PSB) treatment in salt-affected soil. The treatments consist of four without inoculated, control, full dose of fertilizer 3/4th dose of NP+K half dose of NP+K. Twelve isolate of *Azospirillium* and five isolates of PSB tested with 1/2 NP+K fertilizer dose. The soil samples were collected from (0-0.15 depth) from the salt-affected soil of zone-1. The experimental soil was texture - Sandy loam, Bulk density - 1.58 Mg M^{-3}, Organic matter - 0.27 per cent, pH (1:2.5::Soil: Water suspension at 25°) - 8.72, EC (1:2.5::Soil: Water suspension at 25°) - 1.23 dSm^{-1}, ESP - 32 per cent, available nitrogen, available P_2O_5 and available K_2O were low. The experiment was laid out with Randomized Block Design having 3 replication thirty five days old three seedling per hill and three hill per pot transplanted. The recommended half dose nitrogen (60 kg ha^{-1}) through urea (0.58g pot^{-1}) and full dose of P_2O_5 (tricalcium phosphate 0.54g pot^{-1}) and K_2O (muriate of potash 0.29g pot^{-1}) were applied at the time of transplantation of rice seedlings. Remaining half amount of nitrogen was applied in two equal instalments after 20 days and 45 days after transplanting (DAT). The crop was harvested on physiological maturity and yield of grain and straw were recorded. At the same time post harvest soil samples were collected and processed for further chemical analysis following standard procedure. The grain and straw samples were analysed for total N, P, and K contain by digestion with sulphuric acid and diacid procedure and uptake were calculated.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present study have been discussed in detail under following heads and in Table 1 and 2.

Effect of different bacterial isolates on yield and nutrient content (%) of rice grain and straw :

Grain yield/pot affected by full dose, 3/4 dose and 1/2 dose of fertilizer with different isolates of *Azospirillium* and

Table 1 : Effect of *Azospirillum* and phosphate solubilizing bacterial isolates on yield and nutrient content of rice grain and straw

Treatments	Grain yield (g/pot)	Straw yield (g/pot)	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
			grain	Straw	Grain	Straw	Grain	Straw
$T_1(N_0\ P_0\ K_0)$ (control)	8.6	20.3	1.01	0.45	0.27	0.11	0.26	1.37
T_2 (N P K) (full dose)	12.6	22.6	1.19	0.52	0.35	0.14	0.35	1.44
$T_3\ (N_{3/4}\ P_{3/4}\ K)$	12.3	22.9	1.16	0.48	0.33	0.13	0.32	1.40
$T_4\ (N_{1/2}\ P_{1/2}\ K)$	12.0	21.9	1.12	0.47	0.28	0.11	0.30	1.39
$T_5\ (N_{1/2}\ P_{1/2}\ K + AzsSI_4)$	14.6	24.6	1.15	0.48	0.31	0.12	0.32	1.42
$T_6\ (N_{1/2}\ P_{1/2}\ K + AzsVA_1)$	13.0	22.0	1.14	0.50	0.31	0.12	0.31	1.42
$T_7\ (N_{1/2}\ P_{1/2}\ K + AzsVA_{15})$	13.6	25.8	1.14	0.48	0.31	0.12	0.32	1.42
$T_8\ (N_{1/2}\ P_{1/2}\ K + AzsMUZ_6)$	17.1	28.6	1.15	0.48	0.31	0.12	0.32	1.43
$T_9\ (N_{1/2}\ P_{1/2}\ K + AzsMUZ_7)$	19.0	29.5	1.18	0.52	0.33	0.13	0.33	1.43
$T_{10}\ (N_{1/2}\ P_{1/2}\ K + AzsMUZ_8)$	20.7	29.2	1.17	0.53	0.32	0.14	0.32	1.42
$T_{11}\ (N_{1/2}\ P_{1/2}\ K + AzsMUZ_{8B})$	18.8	30.2	1.16	0.48	0.32	0.12	0.33	1.42
$T_{12}\ (N_{1/2}\ P_{1/2}\ K + AzsMUZ_9)$	13.6	25.8	1.14	0.49	0.32	0.12	0.31	1.41
$T_{13}\ (N_{1/2}\ P_{1/2}\ K + AzsMUZ_{13})$	15.0	27.2	1.16	0.48	0.31	0.12	0.31	1.41
$T_{14}\ (N_{1/2}\ P_{1/2}\ K + AzsMUZ_{13B})$	17.8	30.2	1.15	0.48	0.31	0.12	0.31	1.41
$T_{15}\ (N_{1/2}\ P_{1/2}\ K + AzsEC_{11})$	19.8	30.8	1.17	0.52	0.32	0.13	0.33	1.42
$T_{16}\ (N_{1/2}\ P_{1/2}\ K + AzsEC_{11B})$	13.0	25.2	1.14	0.48	0.31	0.12	0.32	1.41
$T_{17}\ (N_{1/2}\ P_{1/2}\ K + PsbSI_4)$	13.0	25.6	1.14	0.48	0.32	0.12	0.31	1.41
$T_{18}\ (N_{1/2}\ P_{1/2}\ K + PsbVA_{15B})$	18.0	29.5	1.13	0.51	0.33	0.13	0.31	1.43
$T_{19}\ (N_{1/2}\ P_{1/2}\ K + PsbMUZ_{8B})$	13.6	25.8	1.14	0.49	0.31	0.12	0.31	1.41
$T_{20}\ (N_{1/2}\ P_{1/2}\ K + PsbEC_{11B})$	17.0	27.0	1.13	0.48	0.31	0.12	0.31	1.41
$T_{21}\ (N_{1/2}\ P_{1/2}\ K + PsbWC_{15})$	14.6	24.9	1.12	0.48	0.31	0.11	0.31	1.41
C.D. (P=0.05)	1.09	1.77	0.04	0.04	0.03	0.01	NS	NS
C.D. (P=0.01)	1.41	2.28	0.05	0.05	0.04	0.02		
C.V.	6.75	6.44	3.58	8.27	10.22	12.48		

NS= Non-significant

PSB over control was observed to have increased significantly. The highest grain yield (72.5%) being recorded with $AzsMUZ_8$ whereas, PSB isolates $PsbVA_{15B}$ caused 50.0 per cent increase in grain yield over without isolates.

Straw yield/pot affected by full dose, 3/4 dose, and 1/2 dose of fertilizer with different isolates of *Azospirillium* and PSB over control was studied. The straw yield increases significantly. The highest straw yield (40.63%) being recorded with $AzsEC_{11}$ whereas PSB isolates $PsbVA_{15B}$ caused 34.70 per cent increase in straw yield over without isolates.

As regard the nutrient contents (%) in grain and straw of rice the following observations have been remarkable.

Nitrogen content in rice grain and straw shows a great impact of fertilizer dose in microbial inoculants. The influenced the nitrogen contain in grain as well as straw significantly.

Phosphorus content also increased significantly in grain and as well as in straw :

Potassium content of rice grain and straw, however, indicate that the effect of different fertilizer dose and inoculation of selected *Azospirillium* and PSB isolate was in significant.

Effect of *Azospirillium* and phosphate solubilizing bacteria on nitrogen, phosphorus and potassium (mg pot^{-1}) uptake in grain and straw :

Uptake of nitrogen :

Nitrogen uptake (mg/pot) by grain, straw and total, increases significantly. The highest N uptake by grain was

Table 2 : Effect of *Azospirillum* and phosphate solubilizing bacterial isolates on nitrogen, phosphorus and potassium uptake (mg pot^{-1}) in rice

Treatments	Nitrogen			Phosphorus			Potassium		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
$T_1(N_0\ P_0\ K_0)$ (control)	0.087	0.091	0.178	0.023	0.022	0.045	0.022	0.278	0.301
T_2 (N P K) (Full dose)	0.150	0.118	0.268	0.044	0.032	0.076	0.044	0.325	0.370
T_3 ($N_{3/4}$ $P_{3/4}$ K)	0.143	0.110	0.253	0.041	0.030	0.070	0.039	0.321	0.360
T_4 ($N_{1/2}$ $P_{1/2}$ K)	0.134	0.103	0.237	0.034	0.024	0.058	0.036	0.304	0.340
T_5 ($N_{1/2}$ $P_{1/2}$ K + $AzsSI_4$)	0.168	0.117	0.285	0.046	0.030	0.075	0.047	0.350	0.396
T_6 ($N_{1/2}$ $P_{1/2}$ K + $AzsVA_1$)	0.148	0.110	0.258	0.040	0.026	0.067	0.040	0.312	0.353
T_7 ($N_{1/2}$ $P_{1/2}$ K + $AzsVA_{15}$)	0.155	0.124	0.279	0.042	0.031	0.073	0.043	0.367	0.410
T_8 ($N_{1/2}$ $P_{1/2}$ K + $AzsMUZ_6$)	0.197	0.138	0.335	0.053	0.034	0.087	0.054	0.407	0.462
T_9 ($N_{1/2}$ $P_{1/2}$ K + $AzsMUZ_7$)	0.224	0.154	0.379	0.063	0.039	0.102	0.063	0.422	0.485
T_{10}($N_{1/2}$ $P_{1/2}$ K + $AzsMUZ_8$)	0.242	0.155	0.397	0.066	0.041	0.107	0.066	0.414	0.481
T_{11}($N_{1/2}$ $P_{1/2}$ K + $AzsMUZ_{8B}$)	0.218	0.145	0.363	0.060	0.036	0.096	0.062	0.429	0.491
T_{12}($N_{1/2}$ $P_{1/2}$ K + $AzsMUZ_9$)	0.155	0.126	0.281	0.043	0.031	0.074	0.042	0.364	0.406
T_{13}($N_{1/2}$ $P_{1/2}$ K + $AzsMUZ_{13}$)	0.174	0.130	0.305	0.047	0.033	0.079	0.046	0.384	0.430
T_{14}($N_{1/2}$ $P_{1/2}$ K +$AzsMUZ_{13B}$)	0.205	0.145	0.350	0.055	0.036	0.091	0.055	0.426	0.481
T_{15}($N_{1/2}$ $P_{1/2}$ K + $AzsEC_{11}$)	0.232	0.160	0.392	0.063	0.040	0.103	0.065	0.437	0.503
T_{16}($N_{1/2}$ $P_{1/2}$ K + $AzsEC_{11B}$)	0.227	0.121	0.348	0.062	0.030	0.092	0.064	0.355	0.419
T_{17}($N_{1/2}$ $P_{1/2}$ K + $PsbSI_4$)	0.148	0.123	0.271	0.042	0.031	0.072	0.040	0.361	0.402
T_{18}($N_{1/2}$ $P_{1/2}$ K + $PsbVA_{15B}$)	0.203	0.150	0.354	0.059	0.038	0.098	0.056	0.422	0.478
T_{19}($N_{1/2}$ $P_{1/2}$ K + $PsbMUZ_{8B}$)	0.155	0.126	0.281	0.042	0.031	0.073	0.042	0.364	0.406
T_{20}($N_{1/2}$ $P_{1/2}$ K + $PsbEC_{11B}$)	0.192	0.129	0.321	0.053	0.032	0.085	0.053	0.381	0.433
T_{21}($N_{1/2}$ $P_{1/2}$ K + $PsbWC_{15}$)	0.163	0.118	0.281	0.045	0.028	0.073	0.045	0.352	0.397
C.D. (P=0.05)	0.014	0.010	0.020	0.006	0.005	0.008	0.005	0.027	0.027
C.D. (P=0.01)	0.018	0.016	0.025	0.008	0.007	0.011	0.006	0.035	0.035
C.V.	7.671	9.761	6.255	12.253	16.386	10.323	9.769	7.000	6.212

recorded in *Azospirillium* treatment (T_{10}) $AzsMUZ_8$. In case of N uptake in grain with *Azospirillium* and PSB all inoculant increase significantly except treatment (T_6) with $AzsVA_1$. The effect of different fertilizer dose with *Azospirillium* and PSB inoculant on nitrogen uptake by straw was increase significantly. The highest N uptake by straw was recorded in *Azospirillium* treatment (T_{15}) with $AzsEC_{11}$. Total uptake of nitrogen under different dose of fertilizers and microbial inoculants was significant. The effect of *Azospirillium* and PSB treatment all 17 inoculant was increase significantly. The highest total N uptake was recorded in treatment (T_{10}) with inoculant $AzsMUZ_8$.

Uptake of phosphorus :

Phosphorus uptake (mg/pot) by grain, straw and total increases significantly. The highest grain, straw and total P uptake was recorded in *Azospirillium* treatment (T_{10}) with inoculant $AzsMUZ_8$. In case of P uptake in grain the effect of *Azospirillium* and PSB all treatment was significant except treatment (T_6) $AzsVA_1$, but in case of P uptake in straw the effect of *Azospirillium* and PSB all treatment was significant except treatment (T_6) $AzsVA_1$ and (T_{21}) $PsbWC_{15}$.

Uptake of potassium :

Potassium uptake (mg/pot) by grain, straw and total with microbial inoculant of *Azospirillium* and PSB significantly increased. The highest K uptake by grain was recorded in *Azospirillium* treatment (T_{10}) with inoculant $AzsMUZ_8$. In case of P grain uptake all phosphate solubulizer bacteria inoculant was increase significantly. The effect of different fertilizer dose with *Azospirillium* and PSB inoculant on P uptake by straw was significant with all inoculant except treatment (T_6) with

Table 3 : Effect of *Azospirillum* and phosphate solubilizing bacterial isolates on physico-chemical properties of the post-harvest soil of the rice crop

Treatments	pH	EC	Available N (mg/kg)	Available P (mg/kg)	Available K (mg/kg)
$T_1(N_0\ P_0\ K_0)$ (control)	8.72	1.23	54.55	6.30	50.27
T_2 (N P K) (Full dose)	8.70	1.24	64.50	7.20	54.73
T_3 ($N_{¾}$ $P_{¾}$ K)	8.72	1.24	62.76	6.97	52.90
T_4 ($N_{½}$ $P_{½}$ K)	8.71	1.24	58.52	6.74	51.96
T_5 ($N_{½}$ $P_{½}$ K + $AzsSI_4$)	8.71	1.23	60.44	6.93	52.41
T_6 ($N_{½}$ $P_{½}$ K + $AzsVA_1$)	8.71	1.24	60.08	6.90	52.37
T_7 ($N_{½}$ $P_{½}$ K + $AzsVA_{15}$)	8.71	1.24	60.93	6.94	52.77
T_8 ($N_{½}$ $P_{½}$ K + $AzsMUZ_6$)	8.72	1.23	61.74	6.97	52.81
T_9 ($N_{½}$ $P_{½}$ K + $AzsMUZ_7$)	8.71	1.23	62.58	6.97	52.90
T_{10}($N_{½}$ $P_{½}$ K + $AzsMUZ_8$)	8.71	1.23	63.52	7.03	53.71
T_{11}($N_{½}$ $P_{½}$ K + $AzsMUZ_{8B}$)	8.72	1.23	63.12	7.02	53.26
T_{12}($N_{½}$ $P_{½}$ K + $AzsMUZ_9$)	8.72	1.23	61.87	6.95	52.81
T_{13}($N_{½}$ $P_{½}$ K + $AzsMUZ_{13}$)	8.72	1.24	62.00	6.94	52.86
T_{14}($N_{½}$ $P_{½}$ K + $AzsMUZ_{13B}$)	8.71	1.23	62.76	6.99	52.95
T_{15}($N_{½}$ $P_{½}$ K + $AzsEC_{11}$)	8.71	1.23	62.72	7.00	53.71
T_{16}($N_{½}$ $P_{½}$ K + $AzsEC_{11B}$)	8.71	1.23	60.89	6.92	52.95
T_{17}($N_{½}$ $P_{½}$ K + $PsbSI_4$)	8.62	1.23	59.06	7.34	52.81
T_{18}($N_{½}$ $P_{½}$ K + $PsbVA_{15B}$)	8.21	1.23	60.08	7.37	52.50
T_{19}($N_{½}$ $P_{½}$ K + $PsbMUZ_{8B}$)	8.51	1.23	60.13	7.33	50.71
T_{20}($N_{½}$ $P_{½}$ K + $PsbEC_{11B}$)	8.32	1.23	60.17	7.28	52.86
T_{21}($N_{½}$ $P_{½}$ K + $PsbWC_{15}$)	8.60	1.23	59.10	6.83	51.92
C.D. (P=0.05)	NS	NS	0.47	0.38	3.29
C.D. (P=0.01)			0.60	0.50	4.25
C.V.			0.73	5.29	5.95

inoculant $AzsVA_1$ and the highest K uptake by straw was recorded in *Azospirillium* treatment (T_{15}) $AzsEC_{11}$. Similarly in case of total uptake of potassium by different dose of fertilizers and microbial inoculant *Azospirillium* and PSB was significant. The highest total uptake of P was recorded in treatment (T_{15}) with $AzsEC_{11}$.

Effect of use of different bacterial inoculants on physico-chemical properties of post-harvest soil of rice :

Soil reaction (*pH*) :

The soil reaction in terms of pH (1:2.5::soil: water extract) of post-harvest soil presented in Table 3. The effect of different *Azospirillium* and PSB treatments on soil reaction was insignificant. Inoculation of phosphate solubilizing bacteria with half dose of N, P and full dose of P decrease the soil pH after harvest of paddy but the effect was insignificant. The decrease in soil pH in treatment with PSB isolates may be due to production of weak organic acids by PSB in the rhizosphere of paddy crop.

Electrical conductivity :

The electrical conductivity (dSm^{-1}) of post-harvest soil presented in Table 3 clearly indicates that the effect of different fertilizer dose alone and in combination with inoculation of selected *Azospirillium* and PSB at half dose of N, P and full dose of K was insignificant. However they vary from 1.23 to1.24 dSm^{-1} in different treatment.

Available N (mg/kg) :

Available nitrogen (mg/kg) of post harvest soil analyzed and presented in Table 3. The available nitrogen varies from 54.55 to 64.50 mg/kg due to different treatment. The effect of fertilizer dose alone and half dose of N, P and full dose of K with microbial inoculant of either *Azospirillium* or PSB significantly improved the available nitrogen content of the post-harvest soil. The highest available N was recorded in *Azospirillium* treatment T_{10} with inoculant $AzsMUZ_{8.}$ Increasing dose of fertilizer from control to 1/2 dose, 1/2 dose to 3/4th and 3/4th to full dose of fertilizer have significantly increased the available nitrogen in post harvest soil. The effects of selected *Azospirillium* inoculants at half dose of N, P and full dose of K have significantly improved the available nitrogen of post-harvest soil. This may be due to the fact that *Azospirillium* may fix atmospheric nitrogen in the rhizosphere and increased the available N significantly. The available nitrogen in post-harvest soil after the treatment with *Azospirillium* inoculant $AzsMUZ_7$, $AzsMUZ_8$, $AzsMUZ_{8B}$, $AzsMUZ_{13}$, $AzsMUZ_{13B}$ and $AzsEC_{11}$ were found to be almost equivalent to 3/4th dose of fertilizer. It means if these inoculants of *Azospirillium* are used in farm field, it may save 1/4th dose of nitrogen of paddy cultivation in salt-affected soil.

Available P (*mg/kg*) :

Available phosphorus (P_2O_5 mg/kg) of post-harvest soil presented in Table 3 the available phosphorus varies from 6.30 to 7.37 mg/kg due to different treatment in control and treatment T_{15} with inoculant $PsbVA_{15B}$ inoculant, respectively. The effect of fertilizer dose alone and half dose of N, P and full dose of K with microbial inoculant of either *Azospirillium* or PSB significantly improved the available phosphorus of the post-harvest soil. Increasing dose of fertilizer from control to 1/2 dose, 1/2 to 3/4th dose and 3/4th to full dose of N and P has significantly increased the available phosphorus of the post-harvest soil. The effect of selected *Azospirillium* inoculants at half dose of N, P and full dose of K has increased positively, but the available phosphorus due to *Azospirillium* inoculant was insignificant. All *Azospirillium* inoculants recorded available P at par with 3/4th dose of N, P and full dose of K. The effect of different isolates of PSB significantly increase the available phosphorus in post-harvest soil except the treatment with PSB inoculant $PsbWC_{15}$.

Available K (*mg/kg*) :

The available potassium (K_2O mg/kg) of post-harvest soil presented in Table 3 clearly indicates that the effect of different fertilizer dose and inoculation of selected *Azospirillium* and PSB at half dose of N, P and full dose of K was insignificant and they varies from 50.27 to 54.73 mg/kg in treatment control and full dose of NPK fertilizer, respectively. Similar work related to the present topic was also done by Hasanuzzaman and Karim (2007); Singh and Mukherjee (2005); Singh and Singh (2006); Singh *et al.* (2007); Verma and Dave (2005) and Vijayakumar *et al.* (2004).

Conclusion :

Integrate management different dose of NPK with or without bacterial strain (*Azospirillium* and PSB) to salt affected soil not only increase the yield of rice also improve the soil physico-chemical properties like pH, EC, OC, available N, available P, available K in the post-harvest soil. Conclusively our findings give us the confidence to suggest that the use of *Azospirillium* and PSB may be a boon for the farmers which are destined to grow cereal in salt affected field.

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