Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP5: 148-151

Pawan Kumar Srivastwa
University Department of Botany, J. P. University, Chapra, Bihar, India

Kanhaiyaji Verma
University Department of Botany, J. P. University, Chapra, Bihar, India

Correspondence
Pawan Kumar Srivastwa
University Department of Botany, J. P. University, Chapra, Bihar, India

(Special Issue- 5)
International Conference on
"Food Security through Agriculture & Allied Sciences"
(May 27-29, 2019)

Nutrient mobilization by rhizobacteria in salt affected soil of Muzaffarpur District of Bihar

Pawan Kumar Srivastwa and Kanhaiyaji Verma

Abstract
Rice is one of the most important food crops of India in term of area, production and consumer preference. India is the second largest producer and consumer of rice in the world. The present study was conducted to investigate the effect of microbial culture on yield and yield attributes of rice and effect on physico-chemical property of post harvest salt affected soil of Muzaffarpur district of Bihar under pot experiment. The experimental design was Randomized Block Design (RBD) having twelve treatments in three replications. The results revealed that the rice responded well to microbial culture and significant improvement was observed in different yield and yield attributes of rice and physico-chemical properties of soil when rice were treated with *Azospirillum* and Phospho-Solubilizing Bacteria (PSB).

Keywords: Microbial culture, salt affected soil, *Azospirillum* and PSB

Introduction
In recent years, maintenance of soil fertility for paddy soil involved application of *Azospirillum and PSB* affected the production of high quality rice and soil fertility. This study was carried to effect of use of different microbial isolates with recommended fertilizer dose on Tillers, Effective tillers, Plant height, Panicle length, Grain yield, Straw yield, Test weight and physico-chemical properties of post-harvest soil of rice. During the present investigation, inoculation of eight efficient PGPR strains *(*$AzsMUZ_{6,}$ $AzsMUZ_{7,}$ $AzsMUZ_{8,}$ $AzsMUZ_{8B,}$ $AzsMUZ_{9,}$ $AzsMUZ_{13,}$ $AzsMUZ_{13B,}$ and $PsbMUZ_{8B}$) on rice variety (usardhan-3), showed significant results. Our results resemble to the findings of Rothballer *et al*., (2003) [3] where they have reported that the responses of inoculation in three varieties of wheat (Brazilian, Naxos and Atir) with *Azospirillum brasilense* Sp7 or Sp245 showed variable response in different wheat varieties. Effect of nutrients and bio-fertilizers on yield and yield components of rice in coastal alluvial soil of Karnataka was studied by Mathews *et al.,* (2006) [2]. On the other hand Effect of different doses of farm yard manure and poultry manure and their interaction with fertilizer nitrogen on yield and nutrient uptake in mesta-rice cropping system was studied by Sreelatha *et al.,* (2006) [4]. Chauhan *et al.,* (2010) [1] studied the effect of nutrient management on the performance of upland rice (*Oryza sativa* L.) on terraced land under continuous cultivation. According to them the grain yield in 1/2 N+P+K+*Azospirillum* was 26.6% higher compared to 1/2 N+P+K but was 11.2% less than that obtained in NPK.

Method and Material
The pot experiment with rice variety '*Usar dhan*–3' was conducted in *kharif* 2012 with 12 (7 *Azospirillum* and 01 phospho-solubilizing bacteria) treatment in salt-affected soil. The treatments consist of control, full dose of fertilizer, 3/4th dose of NP+K 1/2th dose of NP+K with eleven isolates of *Azospirillum* and one isolates of phospho-solubilizing bacteria (PSB) tested with 1/2 NP+K fertilizer dose. The soil samples were collected from (0–15 cm soil 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%, 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%, Available nitrogen, Available P2O5, and Available K2O were low. The experiment was laid out with randomized block design (RBD) having 3 replication.

Thirty five days old three seedlings per hill and three hills per pot were used for transplanting purpose. The recommended dose of fertilizer (120:60:40 kg NPK/ha) were applied to rice crop. Half dose nitrogen (60 kg ha–1) through urea (0.58 g pot–1) and full dose of P_2O_5 (tricalcium phosphate 0.54 g pot–1) and K_2O (muriate of potash 0.29 g 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.

Result and Discussion

The data regarding the effect of use of different microbial isolates with recommended fertilizer dose on Tillers, Effective tillers, Plant height, Panicle length, Grain yield, Straw yield and Test weight are given in table 1 and discussed under following heads.

Tillers

Number of tillers per pot as affected by fertilizer dose and different isolates of *Azospirillum* and Phosphate Solubilizing Bacteria was increased significantly and varies from 21.0 tillers per pot in absolute control to 30.6 tillers per pot in the treatment T_6 ($N_{½}$ $P_{½}$ K + $AzsMUZ_7$) which received half dose of N, P and full dose of K with bacterial isolates $AzsMUZ_7$. Further the increase in N and P fertilizer dose from 50% to 75% and 100% increased the total number of tillers per pot significantly over absolute control. Full dose of fertilizer cause 15.71% increase in number of tillers over the absolute control. Bacterial isolates tested at 50% N and P showed significant increase in number of tillers with 7 out of 7 isolates of *Azospirillum* ($AzsMUZ_6$, $AzsMUZ_7$, $AzsMUZ_8$, $AzsMUZ_{8B}$, $AzsMUZ_9$, $AzsMUZ_{13}$, and $AzsMUZ_{13B}$,) but 1 out of 1 isolates of Phosphate Solubilising Bacteria ($PsbMUZ_{8B}$) was in significant. The highest increase in number of tillers (45.71%) was recorded with $PsbMUZ_{8B}$ where as PSB isolates $PsbMUZ_{8B}$ caused (12.38%) increase in number of tillers over control (without isolate).

Effective tillers/pot

Number of effective tillers per pot as affected by fertilizer dose and different isolates of *Azospirillum* and Phosphate Solubilizing Bacteria (PSB) was increased significantly and varies from 11.6 effective tiller per pot in absolute control to 23.3 tiller per pot in the treatment T_9 ($N_{½}$ $P_{½}$ K + $AzsMUZ_7$) and T_{10} ($N_{½}$ $P_{½}$ K + T_{10} ($N_{½}$ $P_{½}$ K + $AzsMUZ_{13B}$)) and which received half dose of N P and full does of K with bacterial isolates $AzsMUZ_7$ and $AzsMUZ_{13B}$ Further the increase in N and P fertilizer dose from 50% to 75% and 100% increased the total number of effective tillers per pot significantly over absolute control. Full does of fertilizer caused 43.10% increase in number of effective tillers over the absolute control. Bacterial isolates tested at 50% N, P and full dose of K showed significant increase in number of effective tillers with 7 out of 7 isolates of *Azospirillum* ($AzsMUZ_6$, $AzsMUZ_7$, $AzsMUZ_8$, $AzsMUZ_{8B}$, $AzsMUZ_9$, $AzsMUZ_{13}$, $AzsMUZ_{13B}$,) and 1 out of 1 isolates of Phosphate Solubilising Bacteria $PsbMUZ_{8B}$. The highest increase in number of effective tillers (69.92%) was recorded with $AzsMUZ_{8B}$ and $AzsMUZ_{13B}$ where as PSB isolates PsbMUZ8B caused (32.33%) increase in number of effective tillers over without isolate.

Plant height

Plant height as affected by fertilizer dose and different isolates of *Azospirillum* and Phosphate Solubilizing Bacteria was increased significantly and varies from 61.3 cm plant height in absolute control to 72.0 cm in the treatment T_7 ($N_{½}$ $P_{½}$ K + $AzsMUZ_8$) which received half dose of N, P and full does of K with bacterial isolates $AzsMUZ_8$. Further the increase in N and P fertilizer dose from 50% to 75% and 100% increased the plant height significantly over absolute control. Full dose of fertilizer caused 9.13% increase in plant height over the absolute control. Bacterial isolates tested at 50% N, P and full dose of K increased significantly in plant height with all isolates of *Azospirillum* and PSB ($AzsMUZ_6$, $AzsMUZ_7$, $AzsMUZ_8$, $AzsMUZ_{8B}$, $AzsMUZ_9$, $AzsMUZ_{13}$, $AzsMUZ_{13B}$, and $PsbMUZ_{8B}$,). The highest increase in plant height (10.26%) was recorded with isolates $AzsMUZ_8$ where as PSB isolates $PsbMUZ_{8B}$ caused (5.45%) increase in plant height over without isolate.

Panicle length

Panicle length as affected by different fertilizer dose with isolates of *Azospirillum* and Phosphate Solubilizing Bacteria (PSB) was increased significantly and varies from 12.6 cm in absolute control to 17.6 cm in the treatment T_7 ($N_{½}$ $P_{½}$ K + $AzsMUZ_8$) which received half dose of N, P and full dose of K with bacterial inoculant $AzsMUZ_8$. Full dose of fertilizer caused 26.19% increase in panicle length over the absolute control. Bacterial isolates tested at 50% N, P and 100% of K increased significantly in panicle length with all isolates of *Azospirillum* ($AzsMUZ_6$, $AzsMUZ_7$, $AzsMUZ_8$, $AzsMUZ_{8B}$, $AzsMUZ_9$, $AzsMUZ_{13}$, $AzsMUZ_{13B}$) and 1 out of 1 isolates of Phosphate Solubilising Bacteria ($PsbMUZ_{8B}$). The highest increase in panicle length (32.33%) was recorded with inoculant $AzsMUZ_8$ whereas PSB inoculant $PsbMUZ_{8B}$ caused (17.29%) increase panicle length over without isolate.

Grain yield

Grain yield as affected by fertilizer dose and different isolates of *Azospirillum* and Phosphate Solubilizing Bacteria was increased significantly and varies from 8.6 g/pot in absolute control to 20.7 g/ pot in the treatment T_7 ($N_{½}$ $P_{½}$ K + $AzsMUZ_8$) which received half does of N, P and full dose of K with bacterial isolate $AzsMUZ_8$. Full dose of fertilizer caused 46.51% increase in grain yield over the absolute control. Bacterial isolates tested at 50% N, P and 100% of K increased significantly in grain yield with 7 out of 7 isolates of *Azospirillum* ($AzsMUZ_7$, $AzsMUZ_8$, $AzsMUZ_{8B}$, $AzsMUZ_9$, $AzsMUZ_{13}$, and AzsMUZ13B) and 1 out of 1 isolates of Phosphate Solubilising Bacteria ($PsbMUZ_{8B}$). The highest increase grain yield (72.5%) was recorded with inoculant $AzsMUZ_8$ whereas PSB inoculant $PsbMUZ_{8B}$ caused (13.33%) increase in grain yield over without isolate.

Straw yield

Straw yield per pot as affected by fertilizer dose and different isolates of *Azospirillum* and Phosphate Solubilizing Bacteria was increased significantly and varies from 20.3 g/pot in absolute control to 30.2 g/pot in the treatment T_8 ($N_{½}$ $P_{½}$ K + $AzsMUZ_{8B}$) and T_{11} ($N_{½}$ $P_{½}$ K +$AzsMUZ_{13B}$) which received half dose of N, P and full dose of K with bacterial inoculant

$AzsMUZ_{8B}$ and $AzsMUZ_{13B}$. Full dose of fertilizer caused 11.33% increase in straw yield over the absolute control. Bacterial isolates tested at 50% N, P and 100% of K increased significantly in straw yield with 7 out of 7 isolates of *Azospirillum* ($AzsMUZ_6$, $AzsMUZ_7$, $AzsMUZ_8$, $AzsMUZ_{8B}$, $AzsMUZ_9$, $AzsMUZ_{13}$, and $AzsMUZ_{13B}$) and isolates of Phosphate Solubilizing Bacteria ($PsbMUZ_{8B}$). The highest increase in straw yield (37.89%) was recorded with $AzsMUZ_{8B}$ and $AzsMUZ_{13B}$. whereas PSB isolates $PsbMUZ_{8B}$ caused (17.80%) increase in straw yield over without isolate.

Test weight

Test weight per pot as affected by fertilizer dose and different isolates of *Azospirillum* and Phosphate Solubilizing Bacteria was increased significantly and varies from 12.6 g in absolute control to 16 g in the treatment T_7 ($N_{½}$ $P_{½}$ K + MUZ_8) which received half dose of N, P and full dose of K with bacterial isolates $AzsEC_{11}$. Full dose of fertilizer caused 10.31% increase in test weight over the absolute control. Bacterial isolates tested at 50% N, P and 100% of K increased significantly in test weight with all isolates of *Azospirillum* and Phosphate Solubilizing Bacteria ($AzsMUZ_6$, $AzsMUZ_7$, $AzsMUZ_8$, $AzsMUZ_{8B}$, $AzsMUZ_9$, $AzsMUZ_{13}$, $AzsMUZ_{13B}$, $PsbMUZ_{8B}$,). The highest increase in test weight (26.98%) was recorded with inoculant $AzsMUZ_8$ whereas PSB isolates $PsbMUZ_{8B}$ caused (14.28%) increase in test weight over without isolate.

Table 2: Effect of *Azospirillum* and Phosphate Solubilizing Bacteria on yield and yield attributes of rice.

Treatment	Tillers/pot	Effective tillers/pot	Plant height (cm)	Panicle length (cm)	Grain yield (g/pot)	Straw yield (g/pot)	Test weight (g/pot)
T_1(N_0 P_0 K_0) (control)	21.0	11.6	61.3	12.6	8.6	20.3	12.6
T_2 (N P K) (full dose)	24.3	16.6	66.9	15.9	12.6	22.6	13.9
T_3 ($N_{¾}$ $P_{¾}$ K)	23.6	14.6	66.0	15.3	12.3	22.9	13.0
T_4 ($N_{½}$ $P_{½}$ K)	22.3	13.3	65.3	13.3	12.0	21.9	12.6
T_5($N_{½}$ $P_{½}$ K + $AzsMUZ_6$)	28.6	21.0	70.3	17.0	17.1	28.6	15.6
T_6 ($N_{½}$ $P_{½}$ K + $AzsMUZ_7$)	30.6	22.6	71.6	17.3	19.0	29.5	15.7
T_7 ($N_{½}$ $P_{½}$ K + $AzsMUZ_8$)	26.0	23.3	72.0	17.6	20.7	29.2	16.0
T_8 ($N_{½}$ $P_{½}$ K + $AzsMUZ_{8B}$)	30.3	23.3	71.6	17.3	18.8	30.2	15.9
T_9 ($N_{½}$ $P_{½}$ K + $AzsMUZ_9$)	24.6	17.6	69.0	16.6	13.6	25.8	15.4
T_{10}($N_{½}$ $P_{½}$ K + $AzsMUZ_{13}$)	25.6	18.0	69.3	17.0	15.0	27.2	15.6
T_{11} ($N_{½}$ $P_{½}$ K + $AzsMUZ_{13B}$)	29.6	22.6	71.0	17.3	17.8	30.2	15.9
T_{12} ($N_{½}$ $P_{½}$ K + $PsbMUZ_{8B}$)	23.6	17.6	69.6	15.6	13.6	25.8	14.4
CD at (0.05)	1.60	0.90	1.51	0.62	1.69	0.49	1.03
CD at (0.01)	2.06	1.17	1.95	0.80	2.18	0.64	1.33
CV	5.89	4.67	2.09	3.69	6.14	3.20	6.50

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 2. The effect of different *Azospirillum* 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 2 clearly indicates that the effect of different fertilizer dose alone and in combination with inoculation of selected *Azospirillum* 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 2. The available nitrogen varies from 54.55 to 64.51 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 *Azospirillum* or PSB significantly improved the available nitrogen content of the post-harvest soil. The highest available N was recorded in *Azospirillum* treatment T_7 with inoculant $AzsMUZ_8$. Increasing dose of fertilizer from control to 1/2 dose, 1/2 dose to $3/4^{th}$ and $3/4^{th}$ to full dose of fertilizer have significantly increased the available nitrogen in post harvest soil. The effects of selected *Azospirillum* 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 *Azospirillum* may fix atmospheric nitrogen in the rhizosphere and increased the available N significantly. The available nitrogen in post-harvest soil after the treatment with *Azospirillum* inoculant $AzsMUZ_6$ $AzsMUZ_7$, $AzsMUZ_8$, $AzsMUZ_{8B}$, $AzsMUZ_{13}$, $AzsMUZ_{13B}$ and were found to be almost equivalent to $3/4^{th}$ dose of fertilizer. It means if these inoculants of *Azospirillum* are used in farm field, it may save $1/4^{th}$ dose of Nitrogen of paddy cultivation in salt-affected soil.

Available P (mg/Kg)

Available phosphorous (P_2O_5 mg/Kg) of post-harvest soil presented in table 2, the available phosphorous varies from 6.30 to 7.33 mg/Kg due to different treatment in control and treatment T_{12} with inoculants $PsbMUZ_{8B}$ inoculants respectively. The effect of fertilizer dose alone and half dose of N, P and full dose of K with microbial inoculant of either *Azospirillum* or PSB significantly improved the available phosphorous of the post-harvest soil. Increasing dose of fertilizer from control to 1/2 dose, 1/2 to $3/4^{th}$ dose and $3/4^{th}$ to full dose of N and P has significantly increased the available phosphorous of the post-harvest soil. The effect of selected *Azospirillum* inoculants at half dose of N, P and full dose of K has increased positively, but the available phosphorous due to *Azospirillum* inoculant was insignificant. All *Azospirillum* 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 phosphorous in post-harvest soil except the treatment with PSB inoculants PsbMUZ8B.

Available K (mg/Kg)

The available potassium (K_2O mg/Kg) of post-harvest soil presented in table 2 clearly indicates that the effect of different fertilizer dose and inoculation of selected *Azospirillum* 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.

Table 2: Effect of different Bacterial isolates on physico-chemical properties of post-harvest soil of rice.

Treatment	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	64.51	7.20	54.73
T_3 ($N_{¾}$ $P_{¾}$ K)	8.72	1.24	62.77	6.97	52.90
T_4 ($N_{½}$ $P_{½}$ K)	8.71	1.24	58.53	6.74	51.96
T_5 ($N_{½}$ $P_{½}$ K + $AzsMUZ_6$)	8.72	1.23	61.74	6.97	52.81
T_6 ($N_{½}$ $P_{½}$ K + $AzsMUZ_7$)	8.71	1.23	62.59	6.97	52.90
T_7($N_{½}$ $P_{½}$ K + $AzsMUZ_8$)	8.71	1.23	63.53	7.03	53.71
T_8($N_{½}$ $P_{½}$ K + $AzsMUZ_{8B}$)	8.72	1.23	63.13	7.02	53.26
T_9($N_{½}$ $P_{½}$ K + $AzsMUZ_9$)	8.72	1.23	61.88	6.95	52.81
T_{10}($N_{½}$ $P_{½}$ K + $AzsMUZ_{13}$)	8.72	1.24	62.01	6.94	52.86
T_{11}($N_{½}$ $P_{½}$ K + $AzsMUZ_{13B}$)	8.71	1.23	62.77	6.99	52.95
T_{12}($N_{½}$ $P_{½}$ K + $PsbMUZ_{8B}$)	8.51	1.23	60.13	7.33	50.71
CD at (0.05)	NS	NS	0.55	0.33	NS
CD at (0.01)			0.71	0.43	
CV			0.85	4.63	

Conclusion

On the basis of results obtained under the present investigation it may be concluded that the application of full dose of fertilizers are necessary to harvest a good crop of rice. Isolates of *Azospirillum* and PSB respond differently with half dose of fertilizers. In view of different parameters studied the strain $AzsMUZ_7$, $AzsMUZ_8$, and $PsbMUZ_{8B}$ were found to be superior to other strain. Conclusively our findings give us the confidence to suggest that the use of *Azospirillum* and PSB may be a boon for the farmers which are destined to grow cereal in salt affected field. However, before making any recommendation, it will be worthwhile to further evaluate the performance of these strains in farmer's fields.

References

1. Chauhan BS, Imtilemla Dutta, Manoj. Effect of nutrient management practices on the performance of upland rice (*Oryza sativa* L.) on terraced land under continuous cultivation, Department of Soil Conservation, School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema Campus, Medziphema 797 106, Nagaland, India, Environment-and-Ecology. 2010; 28(1A):374-380.
2. Mathews DV, Patil PL, Dasog GS. Effect of nutrients and biofertilizers on nutrient uptake by rice and residual soil fertility status in coastal alluvial soil of Karnataka. Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Dharwad - 580005, India, 2006.
3. Rothballer M, Schmidt M, Hartmann A. *In situ* localization and PGPR-effect of *Azospirillum brasiliense* strains colonizing roots of different wheat varieties. Symbiosis. 2003; 34:261-279.
4. Sreelatha T, Raju AS, Raju AP. Effect of different doses of farm yard manure and poultry manure and their interaction with fertilizer nitrogen on yield and nutrient uptake in mesta-rice cropping system. Agricultural Research Station, Ragolu, Srikakulam District, India. Journal of Research ANGRAU. 2006; 34(1):41-47.