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Effect of Microbial Inoculation on Yield and Yield Components in Low Land Rice

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ABSTRACT

A field trial was conducted at Agricultural Research Station , Amaravathi during *Kharif*, 2001-02 to study the effect of combined inoculation of *Azospirillum* and phosphate solubilising bacteria (*Pseudomonas sp*.) on low land rice. Different yield contributing characters like number of effective tillers m^{-2}, number of grains per panicle, percent chaff etc, varied significantly due to different levels of nitrogen and inoculation. The effective tillers m^{-2} significnatly decreased due to the application of both nitrogen and inoculation. The number of grains per panicle significantly increased due to both microbial inoculation and nitrogen application. The highest grain yield of 45.87 q ha^{-1} was obtained when combined inoculation of *Azospirillum* and phosphate solubilising bacteria was given along with 100 per cent recommended dose of nitrogen (RDN). However it was statistically on par with the grain yield (42.27 q ha^{-1}) obtained with 75% RDN and combined inoculation of *Azospririllum* and Psolubilising bacteria (*Pseudomonas* sp.)

Key words : *Azospirillum*, Nitrogenous fertilizers,phosphate solubilising bacteria (PSB),

Microbial inoculation of low land rice was found to give increased yields besides saving of nitrogenous fertilizers. *Azospirillum,* an associative nitrogen fixer was known to improve nitrogen nutrition in many cereal crops. *Azospirillum* is a preferential organism for low oxygen environments and performs well under low land rice cultivation, where anaerobic conditions exist in soil. Phosphate solubilising bacteria solubilises the fixed forms of native phosphates in the soil and improves the phosphate nutrition of crops when applied alone or in combination with nitrogen supplying inoculants like *Rhizobium, Azotobacter*. The P-solubilisers not only increase P uptake but also increase the yields. Hence a field experiment was conducted to know the effect of combined inoculation of *Azospirillum* and PSB *(Pseudomonas sp*.) on low land rice grown in medium black soils of Amaravathi mandal under NSP command area.

MATERIAL AND METHODS

A field experiment was conducted at Agricultural Research Station, Amaravathi during *Kharif* 2001-02 to study the effect of inoculation of *Azospirillum* and PSB on yield and yield components of rice. The soils were medium black, neutral in reaction (7.81), non saline (0.445 dSm^{-1}) low in available N (189.5 kg ha^{-1}), medium in available P_2O_5 (42.35 kg ha^{-1}), high in available K_2O (687.1 kg ha^{-1}) and low in organic carbon content (0.41%). The total recommended dose of phosphorus was applied as basal dose, while N and K were applied in split doses. Nitrogen was applied as per the treatments. The experiment was conducted with sixteen treatments consisting of four levels of inoculation (I_0-No inoculation, I_1 - inoculation with Azospirillum, I_2 - Inoculation with PSB and I_3 - Combined inocluation of Azospirillum+PSB) and four levels of nitrogen (N_0 - 0% RDN, N_1 - 50% RDN, N_2 - 75% RDN, N_3 - 100% RDN). Microbial inoculants were given one week after transplanting as soil application in the form of lignite based culture @ 1 kg *Azospirillum* and 1 kg PSB mixed in 50kg FYM ha^{-1}. Nitrogen was given in three splits at the time of transplanting, maximum tillering and panicle initiation stages as per the treatments in the form of urea. Potassium was applied at the time of transplanting and panicle initiation stages. The different treatments wer listed below.

$T_1 = N_0 I_0$ (0% RDN alone) - Control
$T_2 = N_0 I_1$ (Inoculation with *Azospirillum*)
$T_3 = N_0 I_2$ (Inoculation with PSB)
$T_4 = N_0 I_3$ (Inoculation with *Azospirillum* + PSB)
$T_5 = N_1 I_0$ (50% N alone)
$T_6 = N_1 I_1$ (50% N + Inoculation with *Azospirillum*)
$T_7 = N_1 I_2$ (50% N + Inoculation with PSB)
$T_8 = N_1 I_3$ (50% N + Inoculation with *Azospirillum* + PSB)

T_9 = N_2I_0(75% N alone)

T_{10} = N_2 I_1(75% N + Inoculation with *Azospirillum*)

T_{11} = N_2 I_2 (75% N + Inoculation with PSB)

T_{12} = N_2 I_3 (75% N + Inoculation with *Azospirillum* + PSB)

T_{13}= N_3 I_0(100% N alone)

T_{14} = N_3 I_1(100% N + Inoculation with *Azospirillum*)

T_{15} = N_3 I_2(100% N + Inoculation with PSB)

T_{16} = N_3 I_3(100% N + Inoculation with *Azospirillum* + PSB)

RESULTS AND DISCUSSION

Combined inoculation of *Azospirillum* and phosphate solubilising bacteria in wet land rice increased the grain yields significantly. Microbial inoculation could increase plant growth, nutrient uptake and grain filling in rice plants, which were reflected as significant positive effect on yield components like tillers m^{-2}, grains $panicle^{-1}$, per cent filled grains, etc.

Grain Yield

Grain yield varied from 26.88 to 45.87 qha^{-1} with a mean of 28.58 qha^{-1} at N_0, 35.95 qha^{-1} at N_1, 40.37 qha^{-1} at N_2 and 42.92 q ha^{-1} at N_3, which were significantly superior to N_0 and also significantly different among themselves except between 75% and 100% N levels. In case of inoculation means, inoculation with *Azospirillum* alone recorded 36.61 qha^{-1}, PSB alone recorded 37.15 qha^{-1} while combined inoculation recorded 38.84 qha^{-1}. All inoculations increased grain yield over no inoculation but only combined inoculation of *Azospirillum* + PSB increased the yield significantly. In case of interactions all N levels could increase grain yield significantly over N_0 at I_0, I_1 and I_3 where as at I_2, N_2, and N_3 alone increased yield significantly over N_0. (Table 1).

Highest grain yield of 45.87 qha^{-1} was recorded in the treatment of N_3I_3 where combined inoculation of *Azospirillum* and PSB was given at 100% RDN. The mean yield at N_3 (42.92 qha^{-1}) was statistically on par with the mean yield obtained at N_2 (40.37 qha^{-1}). Similarly the yield obtained at N_2I_3 (42.27 qha^{-1}) was statistically on par with N_3I_3 (45.87 qha^{-1}). These results indicated that combined inoculation given at 75% RDN recorded grain yields on par with yields obtained with 100% N alone and also with combined inoculation at 100% RDN. Thus 75% recommended dose of N with combined inoculation of *Azospirillum* and PSB can yield on a par with 100% recommended dose of N resulting in a saving of 25% fertilizer nitrogen.

Effective tillers m^{-2}

Means of nitrogen levels increased number of $tillersm^{-2}$ siginificantly over zero nitrogen at all inoculation levels and the means recorded were 252.6, 292.7,291.2 and 311.3 at N*0*,N*1*,N*2* & N_3 respectively. All the N levels were significantly superior over N_0 but not signifcantly different among themselves. The inoculation means significantly increased the same only in I_3 and I_1 over I_0. In case of interactions, I_3 (*Azospirillum* + PSB) and I_1 (*Azospirillum*) increased effective tillers m^{-2} significantlyat N_1 only whereas other inoculations at other N levels were non significant. Among different N levels, N_3 was significant at I_0, I_1 and I_3 while N_1, N_2 and N_3 were significant at I_2 only (Table 2).

Grains per panicle

Number of grains per panicle ranged from 101.83 to 177.87. Means of N levels as well as means of inoculation levels significanlty increased number of grains per panicle over N_0 and I_0 respectively. In case of interactions, N_2 and N_3 at I_0, I_2 and I_3 and N_1, N_2 and N_3 at I_1 level of inoculation were significant. The means recorded at N_0,N_1,N_2 and N_3 were 125.2, 138.9, 165.5 and 165.7 respectively. They were significantly superior over N_0 and also significantly different among themselves except at N_3 over N_2. The inoculation means were 134.8, 146.71, 155.16 and 159.78 at I_0, I_1,I_2 and I_3 respectively and were significantly superior over I_0 at I_1 and I_3 only. They were significantly different among themselves except between I_1 and I_2 (Table 3)

Per cent Chaff

Per cent chaff in panicles ranged from 3.00 to 7.88 in different treatments. Non supplementation of nitrogen with any inoculation resulted in more per cent chaff, while higher levels of N along with inoculation reduced it significantly. There was significant reduction in per cent chaff in all levels of inoculation over I_1 (both means and interactions) (Table 4)

The above results indicated that nitrogen application has shown prominent effect on yield and different yield components of rice. Levels of nitrogen were in gernal significantly different among themselves. The different microbial inoculation levels were able to show their beneficial effect on yield and yield components in different reatments but statistical significance was obtained in some treatments only. However the results clearly indicated that the microbial inoculation given at a low level of nitrogen application could yield on a par with the corresponding higher level of nitrogen without

Table 1 Effect of *Azospirillum* and Phosphate solubilising bacterial inoculation on grain yield of paddy

N level	Grain yield(qha^{-1})				
	I_0	I_1	I_2	I_3	Mean
N_0	26.88	27.41	29.79	30.24	28.58
N_1	34.19	35.57	34.75	39.28	35.95
N_2	37.94	41.89	41.39	42.27	40.37
N_3	41.34	41.57	42.69	45.87	42.92
Mean	35.21	36.61	37.15	38.84	36.95

CD at 5% Nitrogen: 3.21, Inoculation: 3.21
Interactions:6.41

Table 2 Effect of *Azospirillum* and Phosphate solubilising bacterial on number of effective tillers per m^2 in paddy

N level	Number of effective tillers per m^2				
	I_0	I_1	I_2	I_3	Mean
N_0	248.0	259.4	224.7	278.0	252.6
N_1	253.3	305.7	300.4	310.2	292.7
N_2	267.8	304.8	283.1	309.3	291.2
N_3	306.8	307.4	306.6	327.3	311.3
Mean	268.9	294.3	278.7	306.2	289.9

CD at 5% Nitrogen: 23.67, Inoculation:23.67
Interactions:47.34

Table 3 Effect of *Azospirillum* and Phosphate solubilising bacterial inoculation on Number of grains per panicle in paddy.

N level	Number of grains per panicle				
	I_0	I_1	I_2	I_3	Mean
N_0	101.83	123.63	129.67	135.87	125.2
N_1	106.73	146.00	150.17	152.77	138.9
N_2	152.3	171.03	168.20	170.87	165.5
N_3	166.67	166.97	172.60	177.87	165.7
Mean	134.38	146.71	155.16	159.78	148.2

CD at 5% Nitrogen: 10.74, Inoculation:10.74
Interactions:21.47

Table 4 Effect of *Azospirillum* and Phosphate solubilising bacterial inoculation on percent chaff in paddy

N level	Percent chaff				
	I_0	I_1	I_2	I_3	Mean
N_0	7.88	5.32	5.48	5.00	6.04
N_1	5.27	3.43	3.76	3.01	3.86
N_2	4.35	3.68	3.86	3.32	3.40
N_3	3.35	3.03	3.13	3.00	3.01
Mean	5.22	3.72	3.71	3.69	4.08

CD at 5% Nitrogen: 0.813, Inoculation:0.813
Interactions:1.626

inoculation . Accordingly the yield obtained at 75% N along with dual inoculation of *Azospirillum* +PSB was higher than the yield obtained at 100% N alone and on par with yield obtained at 100% N + *Azospirillum*+PSB indicating a saving of 25% fertilizer nitrogen for paddy by dual inoculation of *Azospirillum* and PSB. Dipping rice seedlings in 20% *Azospirillum* solution increased the paddy seed yield by about 0.2 t ha^{-1} in crops given no nitrogen. Inoculation with Azospirillum increased yields more significantly in crops given 40 or 60 kg N ha^{-1} compared with the yields obtained with no nitrogen. (Mahapatra and Sharma, 1988). Multiple inoculation of paddy with *Azospirillum* to seeds, seedlings and also soil resulted in higher grain yields followed by inoculation of seeds and roots compared to without inoculation and or soil inoculation (Gopalaswamy *et al.,* 1989). They also reported the effect of *Azospirillum* when applied as a combination of root, seed and soil treatment and effect of *Azolla microphylla* when inoculated @ 1 t ha^{-1} ten days after transplanting and incorporating at twenty days later without nitrogen fertilizer. Application of *Azolla* and *Azospirillum* alone augmented the grain yield by 21 and 19 per cent respectively. Their combined application increased the response giving the highest yields at 75kg N ha^{-1} Kanungo et al., 1998 found that inoculation effects were prominently seen when applied with low to medium levels of nitrogen. While studying the nitrogenase activity of *Azospirillum* sp. isolated from rice, they found that nitrogenase activity was significantly stimulated following the application of low level of nitrogen @ 1 g L^{-1}. Higher level of N (5g L^{-1}) can significantly inhibit the nitrogenase activity.

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