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Field Evaluation of Consortium of *Azospirillum,* PSB and AM Fungus on Yield Parameters of Direct Seeded Rice

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Abstract A field experiment was conducted to know the influence of efficient strains of *Azospirillum,* phosfate solubilizing bacteria (PSB) and AM fungus on yield parameters of direct seeded rice (DSR). Direct seeded rice variety gangavati sona was selected and seeds were treated with 3 efficient strains of *Azospirillum brasilense* (ADSR-9), PSB (*Bacillus megatarium* var *phosphaticum*) and AM fungi *Glomus* sp. (MDSR-3). The treatment T_{10} (*Azospirillum* X PSB X AMF + 75% N + 75% P + 100% K) recorded significantly higher 100 seed weight (2.50 g), number of seeds per panicle (193.31), grain yield (7,640 kg ha^{-1}) and stover yield (11.219 kg ha^{-1}) of the DSR compared to individual and dual biofertilizer inoculated treatments and controls.

Keywords AM fungi, *Azospirillum,* DSR, PSB and AM fungus, Yield parameter.

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Introduction

Rice (*Oryza sativa* L.) is the second most important cereal in the world after wheat, and the principal crop in Asia, serving as food for about 50% of the world's population. It occupies an area of 153.76 mha^{-1} with an annual production of 598.85 m t with a productivity of 3895 kg ha^{-1} in the world. Asia produces and consumes 90% of world's rice. Among the rice growing countries. India ranks first in area followed by China and Bangladesh with an area of 43.95 mha^{-1} and production of 106.54 m t with an average productivity of 2,424 kg ha^{-1} [1].

Rice is generally cultivated by transplanting or direct seeding methods. Transplanting method is extensively used, but is laborious , cumbersome, time-consuming and expensive than direct seeding method. Non availability of labor in time and increase in cost of land preparation and transplanting are the problems in the major rice growing areas. While, the scarcity of labor at peak demand period results in increased cost of operation and delay in transplanting. Higher productivity is achieved by making certain changes in the management of rice and the resources depending on soil nutrients, air, water, soil biota and solar energy [2—4].

The current scientific challenge is to find physiological and agronomic systems in crop establishment under direct seeded rice (DSR). The ecological intensification (EI) platform has been designed as a futuristic advanced research plot in which the efficiency of water use, land area and other agronomic

inputs are maximized. Ecological intensification develops highly productive rice-based cropping systems with sustainable ecological footprints,using water-saving irrigation and labor-saving technologies in the humid tropics of Asia [5].

Azospirillum represents the main group of microaerophilic associative nitrogen fixing bacteria [6]. The phosphorus solubilising microorganisms include different groups of microorganisms, which not only assimilate phosphorus from insoluble forms of phosfates, but also cause a large portion of soluble phosfates to be released in quantities in excess of their requirements. Seed or soil inoculation with PSMs is known to improve solubilization of fixed soil phosphorus and applied phosfates resulting in higher crop yields [7].

Arbuscular mycorrhizal (AM) symbiosis ia a mutualistic association between vast range of terrestrial plants and a class of fungi (Glomeromycota) which occurs in the root zone of plants. This association aid in plant mineral nutrition and plant health with a wide range of applications in sustainable agricultural systems. With the use of AM fungi, it is possible to increase plant water acquisition and/or drought tolerance [8]

The success of the microbe-plant interactions depends on the survival and persistence of the microorganisms in soil and the effective colonization in the rhizosphere. If two or more microorganisms are used, may lead to synergistic effect which may have direct reflection on plant yield. The present field evaluation was carried out by inoculating biofertilizer inoculants with 75% of recommended doses of fertilizers and compared with RDF alone and uninoculated control.

Materials and Methods

Collection and maintenance of pure culture of bioinoculants

Pure cultures of *Azospirillum (A. brasilense,* ADSR-9), PSB (*Bacillus megaterium* var *phosphaticum*) and AM fungus (*Glomus* sp., MDSR-3) were used individually, dual and in consortium.

Field experiment

The field experiment was carried out to study the effect of inoculation of efficient *Azospirillum*, PSB and Arbuscular mycorrhizal fungal strains on yield of direct seeded rice at ARS, Dhadesugur during 2015-16. The experiment was laid out in randomized block design (RBD) with 10 treatments and 3 replications.

Plant yield parameters

The crop was harvested after attaining the physiological maturity. Then plants in the net plot were havested treatment wise and kept separately for sun drying. Hand threshing and winnowing was done to separate the grains. The grains were sun-dried and the weight was recorded treatment wise at moisture content of 15% and finally expressed in kg ha-^{1}.

100-seed weight

From the seed yield of each net plot, 100 seeds were randomly counted and weight was recorded and expressed in grams.

Seeds per panicle

Total numbers of panicles per hill were counted at harvest from randomly selected from five hills and then mean of five hills was worked out.

Grain yield

The crop in the net plot was harvested, threshed, dried in sun. The grains were cleaned and weight was recorded and converted in to kg per hectare.

Straw yield

The straw from net plot after threshing was dried in sun, weighed and converted into kg per hectare.

Harvest index

Harvest index was calculated by the formula as outlined by Donald [9].

$$\text{Harvest index} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Grain yield (kg ha}^{-1}\text{) + Straw yield (kg ha}^{-1}\text{)}}$$

Table 1. Effect of *Azospirillum,* PSB and AM fungus on yield parameters of direct seeded rice. Values are mean of three replications ; Means values followed by the same letter are not significantly different based on Duncan's multiple range test ($p<0.05$), a > b > c.

Treatments	100-seed weight (g)	Number of seeds per panicle	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index
T_1 - Uninoculated control	1.35^{e}	108.33^{c}	4886^{e}	6842^{f}	0.416^{cde}
T_2 - Recommended dose of fertilizers (100% NPK)	1.60^{cde}	126.13^{c}	6439^{bcd}	9175^{c}	0.410^{de}
T_3 - 75% N+75% P+100% K	1.50^{de}	153.10^{b}	6316^{cd}	7526^{c}	0.456^{a}
T_4 - *Azospirillum* + 75% N +75% P +100% K	1.80^{cd}	155.03^{b}	6237^{d}	7982d	0.440^{ab}
T_5 - PSB + 75%N + 75% P + 100% K	1.83^{ed}	157.90^{b}	6675^{b}	9157^{c}	0.423^{bcd}
T_6 - AMF + 75% N + 75% P + 100% K	1.90^{c}	163.60^{b}	6588^{bc}	9649^{b}	0.403^{c}
T_7 - *Azospirillum* X PSB + 75% N + 75% P +100% K	1.91^{bc}	166.60^{b}	7360^{a}	10026^{b}	0.423^{bcd}
T_8 - *Azospirillum* X AMF + 75% N + 75% + 100% K	1.90^{cd}	164.70^{b}	7395^{a}	10982^{a}	0.413^{cde}
T_9 - PSB X AMF + 75% N + 75% P + 100% K	2.30^{ab}	176.70^{a}	7518^{a}	10026^{b}	0.430^{bc}
T_{10} - *Azospirillum* X PSB × AMF+75% N + 75% P + 100% K	2.50^{a}	193.31^{a}	76.40^{a}	11219^{a}	0.403^{e}
SEm ±	0.10	8.00	99.43	140.53	0.006
CD (0.05)	0.40	23.71	295.44	417.55	0.019

The experimental data obtained were subjected to statistical analysis adopting Fisher's method of analysis of variance as outlined by Gomez [10]. The means were compared by Duncan's multiple range test (DMRT). The level of significance used in F test was at 5%. Critical difference (CD) values are given for the data at 5% level of significance, wherever the F test was significant.

Results and Discussion

100-seed weight and seeds per panicle

Among the different yield attributes, significant increase in the 100-seed weight and seeds per panicle were noticed at harvest as influenced by inoculation of Azospirillum, PSB and AM fungi in DSR.

Combined inoculation of *Azospirillum,* PSB and AM fungi recorded significantly higher 100-seed weight and seeds per panicle. The seeds treated with T_{10} (*Azospirillum* X PSB X AMF + 75% N + 75% P + 100% K) recorded highest 100-seed weight (2.50g) and seeds per panicle (193.31) followed by T_9 (PSB X AMF + 75% N + 75% P + 100% K) which recorded 100 seed weight of 2.30g and seeds per panicle of 176.70 at harvest. The lowest 100-seed weight (1.35 g) and seeds per panicle (108.33) were recorded in uninoculated control (Table 1). The results are in agreement with the findings of Naidu et al. [11] wherein, they reported that Azospirillum increased the number of tillers, dry matter, number of panicles, number of filled grains and 1,000 grain weight in rice under field experiment.

Grain yield, straw yield and harvest index

The results of the present investigation indicated that the seed inoculation of efficient strains of *Azospirillum,* PSB and AM fungus along with 75%N, 75% P and 100% K showed increased grain yield (7640 kg ha^{-1}) and straw yield (11219 kg ha^{-1}) of DSR over dual inoculation, single inoculation and uninoculated control (Table 1).

The significantly highest harvest index was found in treatment T_3 (0.456) compared to other inoculated treatments and controls. This was followed by treatments T_9, T_7 and T_5 with harvest index of 0.430, 0.423 and 0.423 respectively which were non- significant to each other. The lowest harvest index of 0.403 was observed in T_{10} (Table 1). Similar results on effects of inoculation of *Azospirillum* on yield of several crop plants have been reviewed [12]. The supporting reviews for the above parameters are cited by Mitra et al. [13] which stated that the application of *Azospirillum* increases the dry matter yield, yield attributes and grain yield of wheat. Malik et al. [14]

reported that inoculation of *Azospirillum* increased the rice yield significantly by 1.6-10.5 g/haii (32-81% increase) in green house conditions. This may be due to increase in the photosynthetic ability of the plants with high chlorophyll content due to PGPR effect. Channabasavanna et al. [15] reported interaction between N and *Azospirillum* and showed that application of 75% N with *Azospirillum* to nursery and seedling dip recorded the rice yields similar to 100% N indicating saving of 25% N.

In the present study, the combined inoculation of Azospirillum, PSB and AM fungi were superior over dual and individual inoculation with 25% reduction in recommende N and P in increasing the yield attributes of DSR under field conditions.

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