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Biofertilizers on Nutrient Acquisition, Grain Yield and Grain Quality of Rice

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Abstract

A pot culture experiment was conducted to assess the efficacy of different biofertilizers on the productivity of rice, cv Lalat. Of the biofertilizers tested, Azolla along with 50% N recommended dose (RD) and recommended P and K excelled in all respects and the grain yield obtained was at par with chemical fertilizers (RD) applied. Inoculation of *Azospirilium* also produced substantial grain yield as compared to that of control which received only farm yard manure (FYM). Most of the physiological and biochemical putative traits excelled in Azolla-treated plants compared to that of other treatments. The yield attributes like number and weight of panicles, number of spikelets, number of filled grains produced were increased in *Azolla*-treated plants as compared to the plants received RD of chemical fertilizers. Total chlorophyll, nitrate reductase activity at different stages of growth, nutrient contents and their uptake by plants were found to improve under *Azolla* and *Azospirilium-inoculated* plants. However, phosphorus content and its uptake were maximum in phosphate solublizing bacteria treatment. Grain protein was increased by 5 to 7% and 29% in *Azolla* + 50/N + full PK (T_6) as compared to that of RD of chemical nutrients and control (only FYM) plants respectively.

Key words : Biofertilizers, Nutrient acquition, Grain yield, Quality, Rice.

Nitrogen among the essential fertilizer elements, is important in rice farming, followed by phosphorus. Efficient use of fertilizers increases crop production . Ironically, only 30—40% of applied N fertilizers is utilized by the rice crops, while the rest is lost through various ways like leaching, surface runoff, volatilization, denitrification, fixation in soil. In phosphatic fertilizer, the major problem is the chemical fixation. Energy crisis and subsequent price hike in fertilizers due to withdrawal of fertilizer subsidy coupled with low purchasing power of the farming community have again revived interest in organic recycling (1). Further, continuous and reckless use of inorganic fertilizers coupled with injudicious application has made the soil sick rendering it deficient in secondary and micro nutrients. The use of bacterial biofertilizers (*Azotobacte*r and *Azospirillum*) to supplement the N requirements has been studied by several investigators (2,3). Further,the introduction of P solublizing Pseudomonas in the rhizophere of crops and soils helped in increasing the P availability from insoluble sources of phosphate and its use efficiency (4,5). with these viewpoints the present investigation was undertaken to assess the physiological and biochemical basis along with the productivity of the most popular variety of rice like Lalat grown throughout Orissa, in response to nitrogen fixing and phosphate solublizing microorganisms. The study also aims to find out the extent of nutrient supplementation by the biofertilizers in rice.

Methods

The present investigation was carried out in a pot culture in the Department of Plant Physiology, Orissa University of Agriculture and Technology, Bhubaneswar during rainy season (*kharif*) using rice cultivar Lalat that matures between 120 and 130 days. Seedlings (four in number) after treatment with thiram (0.2%) were transplanted in each earthen pots having capacity of 20 kg soil. Azolla was applied at 150 g/pot whereas Azospirillum and PSB phosphate solublizing bacteria (PSB) were given at the rate of 15 g. All the pots received uniform quantity of farm yard manure (soil : FYM =6 : 1). There were altogether eight treatments with five replications.

Table 1. Relative growth rate (RGR), net assimilation rate (NAR) and leaf area ratio (LAR) at 65–80 DAS and yield and its attributes of rice cv Lalat in response to biofertilizers.

Treatments	RGR (g/g/wk)	NAR (gd/m^2/wk)	LAR (dm^2/g)	No. of panicles per plant	Filled grain panicle (%)	Grain yield (g/plant)
T_1 Control	0.35	0.42	0.83	6.2	66.6	16.1
T_2 NPK (80 : 40 : 40 kg ha)	0.60	0.58	0.02	9.8	78.5	28.1
T_3 *Azolla*	0.51	0.50	0.92	9.0	72.1	27.1
T_4 *Azospirillm*	0.50	0.51	0.98	8.4	66.5	27.1
T_5 PSB	0.43	0.51	0.84	6.6	64.5	18.1
T_6 Azolla + 50% N + full PK	0.61	0.63	0.94	10.8	79.6	28.0
T_7 Azospirillum +50% N + full PK	0.48	0.53	0.90	9.6	70.5	22.5
T_8 PSB + 50% P + full NK	0.44	0.50	0.88	7.6	66.2	23.1
CD (0.05)	0.06	0.05	0.12	0.46	8.9	3.5

The physiological parameters like relative growth rate (RGR), net assimilation rale (NAK) and leaf area ratio (LAR) recorded in the present investigation were computed at the peak growth stage (6). Total chlorophyll and nitrate reductase activity in leaves were measured following the protocols of Arnon (7) and Hatam and Hume (8), respectively. For, nitrate reductase (NR), the second expanded leaf from the top was cut into thin pieces and about 500 mg of leaves was taken. In a test tube 3 ml of phosphate buffer 0.5 M was taken to which 3 ml KNO (0.4 M) was added. The test tube was put in boiling water and cooled. Then 500 mg of plant samples were added to it. Infiltration was done by a vacuum pump. Then test tube was incubated in dark at 33C for half an hour and then was kept in hot water for 5 min to remove the enzyme. Then 1 ml of aliquot was transferred to another test tube, 1 ml sulfanilamide (1%) and 1 ml NEDD (0.02%) were added. Twenty minutes were allowed for color development. Then 3 ml of distilled water was added and OD was measured at 540 nm in a spectrocolorimeter. The amount of nitrite was calculated from a standard curve using $NaNO_2$. The enzyme activity was expressed in n mole of NO_2 released per gram fresh weight of leaf tissue per hour. Grain protein, nitrogen and phosphorus contents at harvest were estimated following the procedure of AOAC (9). Potassium in plant sample was determined according to the method outlined by Chapman and Pratt (10). Statistical analysis was done according to Panse and Sukhatme (11).

Results and Discussion

RGR, NAR and LAR recorded at 65-80 days after sowing revealed a typical contrasting characteristic among the treatments (Table 1). RGR and NAR were significantly higher in T_6 (*Azolla* +50% N + 100% PK) than all the treatments hut was at par to T_2 (recommended doses). On the other hand, LAR was maximum in T_2 (RD) followed by T_6 and T_3 (*Azolla*) . In all the cases T_1 (control) showed lowest value as compared to the rest of the treatments. The present findings are in agreement with those of other workers (12, 13) working with biofertilizers in rice.

The highest response of reproductive growth parameters like number of panicles and number of filled grains was found under treatment T_6 (*Azolla* + 50% N + 100% PK) and T_2 with performance to grain yield and yield attributes the position of T_2 and T_g was almost at par to each other and significantly higher than other treatments (Table 2).

Application of either *Azolla* or *Azospirillum* yielded substantially and was more effective compared to phosphate solublizing bacteria (PSB). The augmentation in grain yield in rice either in T_2 or T_6 might be attributed to greater number of panicles and filled grains per panicle. The higher response under higher fertilizer level coupled with biological sources (Azolla) of nutrients was obviously due to higher nutrient uptake under liberal supply of nutrient which favours the rate of metabolic processes leading to higher productivity. In the present context, Azolla seems to be more efficient and effective than Azospirillum in supplementing nitrogen needs of rice. Similar results were obtained by Jayaraman (14) and Solaiman et al. (15) studying the performance of different biofertilizers with sub-optimal levels of nitro-

Table 2. Total chlorphyll and nitrate nediute (NR) activity at 50 DAS and nutrient uptake at harvest of rice cv Lalat in response to biofertilizers.

Treatments	Total chlrophyll mg/g fr wt	NR activity (micro mol NO_3 reduced/g fr wt/h)	Nutrient uptake (g/plant) N	P	K	Seed protein content (%)
T_1 Control	1.92	0.72	0.25	0.05	0.27	8.3
T_2 NPK (80 : 40 : 40 kg/ha)	2.36	0.90	0.69	0.12	0.56	10.5
T_3 *Azolla*	2.03	0.86	0.55	0.11	0.54	10.0
T_4 *Azospirillum*	1.98	0.84	0.52	0.10	0.53	9.9
T_5 PSB	1.94	0.78	0.32	0.10	0.38	7.8
T_6 *Azolla* + 50% N + full PK	2.30	0.96	0.81	0.14	0.57	11.2
T_7 *Azospirillum* + 50% N + full PK	2.03	0.86	0.64	0.12	0.54	10.2
T_8 PSB + 50% P + full NK	0.94	0.82	0.50	0.13	0.50	9.2
CD (0.05)	0.21	0.09	0.02	0.01	0.04	1.1

gen in rice. Significant variation existed among the treatments in respect of chlorophyll content (Table 2) trait. T_2 produced maximum chlorophyll but was in the same line as that of T_2, Substantial amount of chlorophyll content was also recorded in treatment T_3 (receiving only *Azolla*). On the contrary, the highest NR activity was obtained in T_6 followed by T_2. T_3 and T_7 resulted in almost the same NR activities. The higher nutrient uptake under liberal supply of nutrient, N in particular might be responsible in endorsing the NR activity in T_6. The increase in total chlorophyll and NT activity in T_2 and T_6 was in the order of 16—20 and 25—33% respectively as compared to that of control (only FYM) . Application of biofertilizers in the present investigation either improved or maintained the biochemical traits in rice, particularly in Azolla-treated plants (16) compared to that of control plants.

There was significant variation in nutrient uptake by the plants amongst the treatments. Control plants receiving only FYM registered lowest uptake of all these nutrients. The plants receiving chemical fertilizers (RD) T_2 were not even at par with T_6 (Azolla + 50% N + 100% PK) in respect of nitrogen uptake while uptake of P and K between these two treatments remained similar. The present findings show that application of biofertilizers alone (T_3, T_4 and T_5) was superior compared that in control (T_1) which received only FYM. Most of these traits improved further when biofertilizers were applied in combination with chemical fertilizers (T_6, T_7 and T_8). On the whole , it is pertinent to mention here that nutrient uptake, N in particular, is not that affected irrespective of the applied N sources through organics as is evident from the present study and moreover, in *Azolla* combination there is improvement in nitrogen uptake by the plants. Our study is in agreement with the findings of Latha et al. (17) and Sikandar et al. (18) in respect of the above traits.

seed protein content computed from per cent seed-N was higher in T_6 than T_2 and lowest protein content was in control. It was suggested that biofertilizers like Azolla combined with NPK produced an additive effect by improving the seed protein content and the quality of grain in rice.

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