



Effects of bio-fertilizer on growth and yield of rice (*Oryza sativa*) aulgsr cultivar

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Abstract

Rice is the second most widely grown cereal crop and staple food for more than half the world's population. Fertilizers supply essential nutrients, mainly NPK. These fertilizers increase the yield of the crop but they cause several health hazards. To overcome that, bio-fertilizers have emerged as an important component for biological nitrogen fixation. They offer an economically attractive and ecologically sound route for providing nutrient to the plant. Bio-fertilizers are low-cost renewable sources of nutrient that supplement the chemical fertilizers. The present study was conducted to determine the effects of bio-fertilizer on the growth and yield performance of rice variety AULGSR cultivar. The field experiment revealed that the treatment T₅-75% NPK + *Azospirillum* + *Pseudomonas fluorescens* AU1 was found to be the best in promoting the growth and yield of rice followed by T₁-100% NPK. T₆-Control were found to perform less. The result obtained from the study indicated that the application of the bio-fertilizer combination is the best for rice production as it was superior over other fertilizer combinations in terms of yield and yield attributing characters with the highest benefit cost ratio.

Keywords: biofertilizers, *Azospirillum* and *pseudomonas fluorescens*, aulgsr cultivar, treatment, growth and yield

Introduction

Rice (*Oryza sativa* L.) is a staple food for about 50% of the world population especially those who reside in Asia, where 90% percent of the world rice is grown and consumed. Now a days a modern agricultural management is heavily dependent on the fertilizers for promotion of crop production, but the massive use of inorganic and chemical based fertilizers currently available may be a serious threat to human health and environment. Bio-fertilizer research is therefore focusing on shifting to the exploitation of microbes as a more ecofriendly approach for sustainable agriculture. Bio-fertilizers are the formulations of living microorganisms which are able to fix nitrogen in the available form of plants either by living freely in the soil or being associated symbiotically with plants (Subba Rao 1993). A healthy plant usually contains many beneficial microbes in their rhizosphere in soil. Bio-fertilizer containing beneficial microbes help to improve soil chemical and biological characteristics, phosphate solution and agricultural production (Yosefi *et al.*, 2011) [13]. In addition, microbial inoculants can be used as an economic input to increase crop productivity where fertilizer doses can be lowered and more nutrients can be harvested from the soil. Microbiological fertilizers are important for sustainable agricultural practices and it is environment friendly (Bloemberg *et al.*, 2000) [2]. *Pseudomonas fluorescens* encompasses a group of common, saprophytes that colonize soil, water and plant surface environments. Its common Gram negative, rod shaped bacterium. As its name implies, it secretes a soluble greenish fluorescent pigment called fluorescein, particularly under conditions of low iron availability. It's an obligate aerobe, except for some strains that utilize NO₃ as an electron acceptor in place of O₂. *Pseudomonas fluorescens* has simple nutritional requirements and grows well in mineral salts media supplemented with any of a large number of carbon sources.

They can be utilized in sustainable agricultural applications, such as biocontrol agents (Raaijmakers *et al.*, 2002) [8].

Pseudomonas fluorescens strain was found to exhibit plant growth promotional activity in rice under both *in-vitro* and *in-vivo* conditions. Yadhav *et al.*, (2013) observed increased germination rate and better growth of plant in treatment of *Pseudomonas* sp. Efficacy of *P. fluorescens* strain in promoting plant growth in rice under glass house and field conditions was studied. In recent years, biofertilizer products containing living cells of different types of micro-organisms have emerged as an important component in integrated nutrient supply and hold a great promise to improve yield and quality of crop through better nutrient supplies. (Wani S. P and Lee K.K., 1995) [12]. Beneficial microbes in bio-fertilizers help in regulating the dynamics of organic matter decomposition and increase the availability of plant nutrients such as nitrogen, phosphorus and sulfur (Venkatesvaralu B., 2008). Improving the exchange capacity of nutrients, increasing soil water retention, promoting soil aggregates and buffering the soil against acidity, alkalinity, salinity, pesticides and toxic heavy metal (Chen, J. H., 2006) [3].

The capacity of fixing atmospheric nitrogen (N) has made many microorganisms as a center of modern agronomic interest. *Azospirillum*, *Pseudomonas fluorescens*, blue green algae & azolla can reproduce very fast, reduce the inorganic fertilizers up to 25% with their atmospheric N fixation and perform a dynamic part in supporting yield rise (Patel, 1998) [7]. The present study was undertaken to determine the effects of different rates of biofertilizer on the growth and yield performance in rice cultivar AULGSR.

Material and Methods

Experiments were conducted in the backyard of Department of Agricultural Microbiology, Faculty of Agriculture, Annamalai University, Annamalai Nagar,

608002 during Samba season (August- December 2019-2020). The soil of the experimental field was alluvial soil and sandy loam in texture with pH 6.91 and has good water holding capacity and high fertility. The annual mean minimum and maximum temperature of the experimental plot is 25° C and 39°C, respectively and the mean highest and lowest relative humidity was 96 and 78 per cent respectively. The mean annual rainfall of this area is 1500 mm. The microbial cultures viz., *Azospirillum*, *Pseudomonas fluorescens* used in the present study were obtained from the Department of Agricultural Microbiology, Faculty of Agriculture, Annamalai University. The experiment consisted of six treatments viz., T₁– 100% NPK (Recommended dose), T₂–*Azospirillum*+*Pseudomonas fluorescens*, T₃ 25%NPK+*Azospirillum*+ *Pseudomonas fluorescens*, T₄ - 50% NPK+ *Azospirillum* + *Pseudomonas fluorescens* T₅ - 75% NPK + *Azospirillum* + *Pseudomonas fluorescens*, T₆ – Control. The experiment was conducted in Randomized block design with 3 replications. The size of the each plot 5m x 3m.

AU1GSR rice cultivar is the outcome of IRRI-AU MoU, The parentage of the variety is ZGY1 bred and developed through GSR funding from Bill Gates and Melinda foundation. AU1GSR seeds were sown with seed treatment of bio fertilizers.

The recommended dose of N: P₂O₅: K₂O for rice was 60:30:30 kg/ha and the chemical fertilizer in the form of urea, Single Super Phosphate (SSP) and Murate of Potash (MOP) were broadcasted and incorporated into 15cm depth of soil half dose of nitrogen and recommended dose of P₂O₅ and K₂O were applied as basal and remaining half nitrogen was top dressed at 30 days after transplanting (DAT). Different doses of biofertilizer were applied in the field. The biofertilizer in liquid form were applied for four times at 30, 45, 60 and 75 days after transplanting. The application of NPK (recommended dose) were at 15, 35, 55 and 75 days after transplanting. The irrigation was stopped at 15 days before harvesting of the crop. Ten plants were selected randomly from the each plot and plant height, leaf area index, dry matter production, number of panicles per hill, number of filled grains per panicle, test weight of grains, grain and straw yield were recorded.

Result and Discussion

a) Effect on growth parameters

The effect of biofertilizers on plant height, leaf area index, dry matter production of rice are given in Table 1, 2 and 3. The plant height increases gradually with increase in the age

of the crop. Rice seeds treated with different bacterial suspensions showed improvement in plant growth parameters over untreated seeds.

Among the strains of *P. fluorescens* strain. Significantly increased the vigor index of rice seedlings. Among all treatments, T₅ - 75% NPK + *Azospirillum*+ *Pseudomonas fluorescens* has recorded highest plant height in all the growth stages of rice. At 30 DAT, T₅ (101.10cm) was observed as maximum plant height followed by T₁ (100.30) and T₄ (99.80) treatments. The lowest plant height was recorded in T₆ (89.00). Similarly at 60 DAT and 90 DAT, the highest plant height (124.00 cm & 131.20 cm respectively.) were observed in T₅ was on par with T₁ and T₄ treatments (120.20 cm & 119.70 cm, 129.70 &128.40 respectively.) and the lowest plant height (96.60 & 102.10 respectively) recorded in control T₁. Biofertilizers sources supply plant nutrients as well as plant growth regulators and humic acid and they have additive effect on the growth of plant (Tomati *et al.*, 1988). Nitrogen plays the vital role in the growth of plant height.

However plant height is a genetic character but largely influenced by availability of nitrogen. The highest leaf area index was observed in T₅ (5.93) followed by T₁ (5.82) and T₄ (5.30) treatments and T₆ observed as lowest (3.05). The highest LAI were observed in T₅ was on par with T₁ and T₄ treatments. Leaf area index is directly related with the vegetative growth of the crop which is influenced by the availability of nutrients in soil & *Azospirillum* and *Pseudomonas fluorescens* accelerated the growth of the crops. Dry matter production gradually increased with the growth stages.

The maximum DMP at active tillering stage, flowering stage and harvesting stage was observed in T₅ (8852, 10700 and 13640 kg/ha respectively) followed by T₁ (8540, 9970 and 12720 kg/ha respectively,) and T₄ (8100, 9650 and 11450 kg/ha respectively.) The highest DMP were observed in T₅ was on par with T₁ and T₄ treatments and the lowest DMP recorded in control T₁ (5030, 5650 & 6290 kg/ha respectively.) According to Oladele and Awodun 2014. Symbiotic Microorganisms in biofertilizer helped in improving nutrition and growth increasing photosynthesis, producing bioactive substances such as hormones and enzymes which caused the increase in leaf number due to sufficient nutrition that has possibly increased nutrient adsorption capacity of the plant. Leaves are important organ in which play an active role in photosynthesis. The highest number of leaves was treatment 50% biofertilizer as compared to other treatment.

Table 1: Effect of biofertilizer on the plant height of Rice AU1GSR cultivar

S. No	Treatments	Plant height (cm)		
		30 DAS	60 DAS	At Harvest
1.	T ₁ – 100% NPK	100.30	120.20	129.70
2.	T ₂ - <i>Azospirillum</i> + <i>Pseudomonas fluorescens</i>	96.50	108.40	115.30
3.	T ₃ -25%NPK+ <i>Azospirillum</i> + <i>Pseudomonas fluorescens</i>	99.10	111.20	119.90
4.	T ₄ - 50% NPK+ <i>Azospirillum</i> + <i>Pseudomonas fluorescens</i>	99.80	119.70	128.40
5.	T ₅ - 75% NPK + <i>Azospirillum</i> + <i>Pseudomonas fluorescens</i>	101.10	124.00	131.20
6.	T ₆ – Control	89.00	96.60	102.10
	S Ed	2.21	2.45	2.15
	CD (P=0.05)	4.98	5.52	4.79

Table 2: Effect of bio fertilizer on the leaf are index (LAI) of Rice AU1GSR cultivar

S. No	Treatments	Leaf area index At harvest
1.	T ₁ – 100% NPK	5.82
2.	T ₂ -Azospirillum+ <i>Pseudomonas fluorescens</i>	4.30
3.	T ₃ -25%NPK+ Azospirillum+ <i>Pseudomonas fluorescens</i>	4.85
4.	T ₄ - 50% NPK+ Azospirillum+ <i>Pseudomonas fluorescens</i>	5.30
5.	T ₅ - 75% NPK + Azospirillum+ <i>Pseudomonas fluorescens</i>	5.93
6.	T ₆ – Control	3.05
	S Ed	0.09
	CD (P=0.05)	1.15

Table 3: Effect of biofertilizer on the Dry matter production (DMP) of Rice AU1GSR cultivar

S. No	Treatments	DMP (kg ha ⁻¹)		
		Active tillering	Flowering stage	Harvesting stage
1.	T ₁ – 100% NPK	8540	9970	12720
2.	T ₂ -Azospirillum+ <i>Pseudomonas fluorescens</i>	7360	8860	10850
3.	T ₃ -25%NPK+ Azospirillum+ <i>Pseudomonas fluorescens</i>	7824	9390	9870
4.	T ₄ - 50% NPK+ Azospirillum+ <i>Pseudomonas fluorescens</i>	8100	9650	11450
5.	T ₅ - 75% NPK + Azospirillum+ <i>Pseudomonas fluorescens</i>	8852	10700	13640
6.	T ₆ – Control	5030	5650	6290
	S Ed	11.2	164.8	180.8
	CD (P=0.05)	231.4	351.2	386.6

Effect on yield parameters

Yield attributes of rice such as number of tillers/ plant, number of panicles/hill, no of filled grains/panicle and 1000 grain weight (g), grain and straw yield (kg/ha) has showed in table 4 and table 5. Application of biofertilizer have shown significant improvement in yield parameters than control. The highest number of tillers/plant (33) number of panicles/hill (16.50), no of filled grains/panicle (127.25) and 1000 grain weight (g) (22.53) were observed in the case of T₅ followed by T₁ and T₄. The highest tillers/ plant, number of panicles/hill, no of filled grains/panicle and 1000 grain weight (g), were observed in T₅ was on par with T₁ and T₄ treatments and the lowest recorded in control T₆ (15, 8, 8, 116. 61 and 17.40 respectively.). Biofertilizer which enhances soil biological activity thus improving nutrient mobilization from organic and chemical sources for the use in panicle development (Sundara *et al.*, 2002). The integrated use of chemical and organic fertilizers improves plant growth and increases rice field and quality (Masarirambi *et al.*, 2012). Excessive application of organic manure should be avoided, particularly in soil, to reduce the risk of toxic effects from reduced metabolic intermediates. (Liang *et al.*, 2003). Grain yield and straw yield were significantly influenced by biofertilizer sources the grain yield was maximum in T₅ treatment (7620 kg/ha) which was on par with T₁ (6958 kg/ha) followed by the rest of treatments. The lowest grain yield was observed in case of control T₆ (2845 kg/ha). The grain yield comes from the product of number of tillers/plant, number of panicles/hill, number of filled grains/panicle & test weight (g). The

productivity of paddy was measured at 105 days after planting. (Dekhane *et al.*, 2014) stated that the increasing amount of bacteria in biofertilizer helped to fix the nitrogen and increased the nitrogen plant uptake. It can significantly Increased yield parameters such as the number of panicles per plant and weight of 1000 grains. The straw yield was maximum in T₅ treatment (8610 kg/ha) which was on par with T₁ (7945 kg/ha) followed by the rest of treatments. The lowest straw yield was observed in case of control T₆ (4530 kg/ha). Reduction of more than 25 per cent of recommended dose of nitrogen and phosphorous was supplemented by biofertilizers.

Many previous studies have focused on applying manure on a weight on a basis to rice (Hasanuzzaman *et al.*, 2010; Arif *et al.*, 2014; Zhang *et al.*, 2018). However, they have typically neglected the total nutrient composition and mineralization of the manure. Thus, the a portion of organic N is converted to NH₄ – N by soil microbes after application, NH₄ – N is nitrified to nitrate by other soil microbes. Plants can use only mineralized nutrients. Based on the experiment the treatment with biofertilizer application gave significant improvement thus facilitating in the uptake of nutrients in the plants. Enhancement of chlorophyll content and carbohydrate synthesis by helping the root growth and uptake of other nutrients to a greater extent. As a result, the enlargement in cell size and cell division increased the number of leaves, number of tillers, Number of panicles, fresh weight and grains dry weight in paddy.

Table 4: Effect of biofertilizer on the number of tillers/plant, number of panicles/hill, filled grains/panicle & 1000 grain weight of Rice AU1GSR cultivar

S. No	Treatments	No of tillers/plant At harvest	No of panicles/hill At harvest	Filled grains/panicle	1000 grain weight (g)
1.	T ₁ – 100% NPK	30	15.20	126.59	20.10
2.	T ₂ -Azospirillum+ <i>Pseudomonas fluorescens</i>	23	11.87	122.72	18.66
3.	T ₃ -25%NPK+ Azospirillum+ <i>Pseudomonas fluorescens</i>	28	13.0	123.80	19.60

4.	T ₄ - 50% NPK+ <i>Azospirillum</i> + <i>Pseudomonas fluorescens</i>	31	14.89	125.70	19.83
5.	T ₅ - 75% NPK + <i>Azospirillum</i> + <i>Pseudomonas fluorescens</i>	33	16.50	127.25	22.53
6.	T ₆ - Control	15	8.8	116.61	17.40
	S.Ed	0.74	0.36	0.32	0.17
	CD (P=0.05)	1.63	0.78	0.98	0.52

Table 5: Effect of biofertilizer on the grain yield and straw yield of rice var AU1GSR cultivar

S. No	Treatments	Yield parameters	
		Grain yield kg/ha	Straw yield kg/ha
1.	T ₁ - 100% NPK	6958	7945
2.	T ₂ - <i>Azospirillum</i> + <i>Pseudomonas fluorescens</i>	3984	5010
3.	T ₃ - 25% NPK+ <i>Azospirillum</i> + <i>Pseudomonas fluorescens</i>	5646	6656
4.	T ₄ - 50% NPK+ <i>Azospirillum</i> + <i>Pseudomonas fluorescens</i>	5836	6743
5.	T ₅ - 75% NPK + <i>Azospirillum</i> + <i>Pseudomonas fluorescens</i>	7620	8610
6.	T ₆ - Control	2845	4530
	S Ed	102.5	11.5
	CD (P=0.05)	215.3	240.6

Conclusion

The effect of different biofertilizers has a significant effect on the yield of rice. It is concluded that the application of biofertilizers was vital in enhancing the yield of rice. Overall studies shows that the Treatment T₅ - 75% NPK + *Azospirillum*+ *Pseudomonas fluorescens* was best and superior as compared to other Treatments. In this study, rice variety AU1GSR was used and different doses of biofertilizer were applied for several times the growth and yield was very high when compared to other varieties. The result obtained from the study indicated that use of biofertilizers is more efficient than chemical fertilizers, compared to growth and yield attributes of paddy. From the financial perspective, farmers can utilize the mix of biofertilizer and thus lessen the use of inorganic fertilizers.

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