Studies on Growth, Yield and Economics of rice (Oryza sativa. L.) var. Pusa Basmati-1 as Influenced by Biofertilizers

Chakravarthy Thejesh*, Chereddy Maheshwara and Joy Dawson

Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj – 211007, Uttar Pradesh, India

*Corresponding author

A B S T R A C T

A field experiment was conducted during kharif season of 2019, at crop research farm of Department of Agronomy at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj which is non-traditional area of basmati cultivation in North Eastern plains of Eastern Uttar Pradesh with the objective to study the effect of biofertilizers on growth, yield and economics of rice (Oryza sativa L.) Var. Pusa Basmati-1 under Randomized block design comprising of 11 treatments of which farmer’s practice (T₁) (N:P:K at 100:40:20 kg ha⁻¹) and rest of treatments (T₂–T₁₁) with sole and in combination of biofertilizers (Azotobacter, PSB, Azospirillum, Azolla) along with inorganic fertilizers (RDF N:P:K at 120:60:60 kg ha⁻¹) which are replicated thrice. The experimental results revealed that application of T₉ (RDF + PSB at 2 kg ha⁻¹ + Azospirillum at 2 kg ha⁻¹) has recorded highest No. of grains panicle⁻¹ (151.93) and No. of panicles hill⁻¹ (21.80). Highest Benefit: Cost ratio was recorded by application of T₂ (RDF + Azotobacter at 2 kg ha⁻¹) and the application of T₇ (RDF + Azotobacter at 2 kg ha⁻¹ + Azospirillum at 2 kg ha⁻¹) has recorded significantly maximum grain yield (6.88t ha⁻¹), gross return (Rs.1,92,550 ha⁻¹) and net return (Rs.1,34,470 ha⁻¹).

Key words: Basmati rice, Biofertilizers, Azolla, FYM, Growth, Yield, Economics

Introduction

Rice (Oryza sativa L.) is the most prominent crop of India as it is the staple food for most of the people of the country. Among the countries which are growing rice, India has the largest area under rice (about 45 million ha) accounting for 29.4 per cent of the global rice area. Of the total area, about 46 per cent is irrigated, 28 per cent is rain fed lowland, 12 per cent is rain fed upland and 14 per cent is flood prone (Budhar et al., 2006). Worldwide, India stands first in rice producing area and second in production after China. In the year 2017, China and India contributed the share of 27.63% and 21.89% of global rice production respectively (FAO 2017).

Basmati rice is unique among other long grain rice varieties and is often referred as “King of rice” and is valued for its distinctive long grain, fine aroma and delicious taste.
It is one of the most important agricultural produce that the country exports every year to gross foreign exchange. During the year 2018-2019 (April-March), India exported 11.9 million MT of rice, out of which basmati rice exports accounts for 4.4 million MT with 9.72 per cent increase in exports when compared to previous year export of 3.9 million MT (APEDA 2019).

Global agriculture is facing a serious consequence of climatic change, increased population pressure and detrimental environmental impacts. Increased population needs more food to live on the earth. New mechanism must be found to ensure food security through sustainable crop production systems that supply adequate nutrition, without harming the agro ecosystem (Panwar and Vijayaluxmi, 2005).

Biofertilizers are eco-friendly fertilizers, which are living cells of different types of micro-organisms (Bacteria, Fungi, and Algae) which have an ability to mobilize nutritionally important elements from non-usable form. It also improves soil quality and provides yield increments which greatly benefit farmers at very low input cost has engrossed the attention (Kumudha, 2005; Kumudha and Gomathinayagam, 2007).

These microorganisms require organic matter for their growth and activity in soil and provide valuable nutrients to the plant (Saini et al., 2004). Farmyard manure (FYM) acts as a soil conditioner improves physical, chemical and biological properties of the soil and provides congenial conditions for the growth of microbial populations. Therefore, resulting in better yield and grain quality by prolific root growth and greater nutrient accumulation (Adhikari et al., 2005). Nitrogen is most important nutrient with varying organic and inorganic nitrogen sources have significant influence and crucial role on grain quality. Crop productivity and the grain quality can be improved by integrated nutrient management including biofertilizers, organic and chemical sources. Quality parameters of scented rice can be improved by application of biofertilizers alone or in combinations with organic manures (Dixit & Gupta, 2000; Quyen & Sharma, 2003). Azotobacter in crop production has manifested its significance in plant nutrition and its contribution to soil fertility through production of growth substances and their effects on the plant has markedly enhanced crop production in agriculture.

Being free living N2- fixer diazotroph, substances like auxins, cytokinins, and GA can be synthesized by Azotobacter genus and these growth materials are the key substances which regulate the enhancement of growth. It improves nutrient uptake and ultimately boost up biological nitrogen fixation by stimulating rhizospheric microbes, protects the plants from phyto-pathogens, Phosphate solubilising bacteria (PSB) has the ability to solubilise and mineralize the residual or fixed phosphorous, enhances phosphorus availability in the soil, produces growth substances like indole acetic acid, and gibberellins hence, increases the phosphate use efficiency (Chhonkar and Tilak, 1997; Gull et al., 2004).

Azospirillum is recognized as a dominant soil microbe, mainly present in cereal plants which inhabit both root cells as well as surrounding of roots forming symbiotic relation and increasing N- fixing potential ranging of 20-40 kg ha⁻¹ in the rhizosphere. Up to 25-30% quantity of nitrogen fertilizer can be saved by the use of the Azospirillum inoculation. Azolla is a free-floating fresh water fern, by the symbiotic association with Anabaena azollae that resides inside the dorsal lobes of Azolla leaves which fixes atmospheric N and potentially supplying a substantial amount of N to the rice crop.
Azolla can fix 22–40 kg N ha\(^{-1}\) within 30 days (Peoples et al., 1995). Without additional requirements of land and water it can be grown concurrently with irrigated rice (Singh and Singh 1990; Mian and Kashem 1995).

**Materials and Methods**

A field experiment was conducted during kharif season of 2019, at Crop research farm of Department of Agronomy at Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj which is located at 25°24’42” N latitude, 81°50’56” E longitude and 98 m altitude above the mean sea level (MSL). To assess the effect of biofertilizers on growth and yield of rice (Oryza sativa L.).

The experiment was laid out in Randomized Block Design comprising of 11 treatments which are replicated thrice. Each treatment net plot size is 3m x3m. First treatment (T\(_1\)) is categorized as farmer practice 100 kg N ha\(^{-1}\) through urea and DAP, 40 kg ha\(^{-1}\) P\(_2\)O\(_5\) through DAP and 20 kg ha\(^{-1}\) K\(_2\)O through Muriate of Potash.

Rest of the treatments applied with recommended dose of fertilizers (RDF) 120 kg ha\(^{-1}\) through urea and DAP, 60 kg ha\(^{-1}\) through DAP and 60 kg ha\(^{-1}\) through Muriate of Potash in addition with biofertilizers like *Azotobacter*, Phosphate-solubilizing bacteria (PSB), *Azospirillum*, Azolla when applied as sole and in combinations as follows, (T\(_2\)) RDF + *Azotobacter* at 2 kg ha\(^{-1}\), (T\(_3\)) RDF + PSB at 2 kg ha\(^{-1}\), (T\(_4\)) RDF + *Azospirillum* at 2 kg ha\(^{-1}\), (T\(_5\)) RDF + Azolla at 2 tonnes ha\(^{-1}\), (T\(_6\)) RDF + *Azotobacter* at 2 kg ha\(^{-1}\) + PSB at 2 kg ha\(^{-1}\), (T\(_7\)) RDF + *Azotobacter* at 2 kg ha\(^{-1}\) + *Azospirillum* at 2 kg ha\(^{-1}\), (T\(_8\)) RDF + *Azotobacter* at 2 kg ha\(^{-1}\) + Azolla at 2 tonnes ha\(^{-1}\), (T\(_9\)) RDF + PSB at 2 kg ha\(^{-1}\) + *Azospirillum* at 2 kg ha\(^{-1}\), (T\(_10\)) RDF + PSB at 2 kg ha\(^{-1}\) + Azolla at 2 tonnes ha\(^{-1}\), (T\(_11\)) RDF + *Azospirillum* at 2 kg ha\(^{-1}\) + Azolla at 2 tonnes ha\(^{-1}\).

Soil application of *Azotobacter*, Phosphate-solubilizing bacteria(PSB), *Azospirillum* was done by inoculating the microbial culture as per aforesaid dosages in 8 tonnes ha\(^{-1}\) of Farm yard manure (FYM) for each treatment and incubated for mass multiplication for a fortnight (a period of two weeks). Azolla is grown in separate cultivation pits and is introduced to main field on the 4\(^{th}\) day after transplanting.

The seedlings of rice var. Pusa Basmati-1 are transplanted after application of basal doses of fertilizers with biofertilizers between spacing 22.5 cm row to row. Except azolla rest of the biofertilizers are applied during land preparation, nitrogen fertilizer was applied at three split doses half of the nitrogen fertilizer was applied as basal dose and rest parts are divided equally and applied 30 and 48 days after transplanting. The rice crop was harvested treatment wise at harvesting maturity stage.

After harvesting, grains were separated from each net plot and were dried under sun for three days. Later winnowed, cleaned and weight of the grain per net plot value, the grain yield per ha was computed and expressed in tonnes per hectare. After complete drying under sun for 10 days straw yield from each net plot was recorded and expressed in tonnes per hectare.

The data was computed and analysed by following statistical method of Gomez and Gomez (1984). The benefit: cost ratio was worked out after price value of grain with straw and total cost included in crop cultivation. After thorough field preparation initial soil samples were taken to analyse for available major nutrients. Nitrogen (N), phosphorous (P), potassium (K), sulphur (S), organic carbon (OC), pH and soluble salts.

The type of soil in experimental field is sandy clay. The pH of the experimental field was...
The N status of the experimental field was low (215 kg ha\(^{-1}\)), medium in available P (12 kg ha\(^{-1}\)) while available K status was in higher range (232 kg ha\(^{-1}\)). Growth parameters viz. plant height (cm), No. of tillers plant\(^{-1}\), dry matter accumulation g plant\(^{-1}\), No. of panicles plant\(^{-1}\), No. of grains panicle\(^{-1}\) and Test weight (g) were recorded manually on five randomly selected representative plants from each plot of each replication separately as well as yield and yield attributing character viz. grain yield t ha\(^{-1}\), straw yield t ha\(^{-1}\), No. of panicles plant\(^{-1}\), No. of grains panicle\(^{-1}\) and Test weight (g) were recorded as per the standard method.

The oxidizable organic carbon was determined by Walkley and Black (1934), pH by pH meter and EC\(_e\) by electrical conductivity bridge with glass electrode in a 1:2.5 soil water suspension (Jackson 1973). Soil texture by the Bouyoucos Hydrometer Method (Gee and Baudov, 1986). Available nitrogen was determined by Subbiah and Asija (1956). Available phosphorus was determined by Olsen et al., (1954) and available potash was determined by Flame photometric method, Jackson (1973).

**Results and Discussion**

**Effect on growth parameters**

It is evident from Table 1 that plant height measured increased with advancement in crop growth. The treatment T\(_{11}\) (RDF + Azospirillum at 2 kg ha\(^{-1}\) + Azolla at 2 tonnes ha\(^{-1}\)) recorded maximum height of 16.29, 69.25, 115.67 cm in all 3 stages i.e., tillering stage (20DAT), P.I (Panicle Initiation) stage (60DAT), harvesting stage (100 DAT) respectively. At harvesting stage maximum plant height was measured in T\(_{11}\) and treatments T\(_{6}\), T\(_{7}\) and T\(_{8}\) were found statistically at par to T\(_{11}\). The highest plant height in treatment T\(_{11}\) may be ascribed due to the continuous supply of nutrients through out all growth stages with beneficial association between biofertilizers (azolla and Azospirillum) along with chemical fertilizers. Leaching losses of nutrients must have been minimized by use of biofertilizers, which have ability to mobilize nutritionally important elements from non-usable form to usable forms. According to Tien et al., (1979), in addition to its high N fixation, Azospirillum is known to synthesize growth substances such as IAA and other auxines and vitamins B which might have also helped in growing the plant height. T\(_{7}\) (RDF + Azotobacter at 2 kg ha\(^{-1}\) + Azospirillum at 2 kg ha\(^{-1}\)) plants at tillering stage and P.I stage, produced more number of tillers of 13.73 and 27.87 respectively.

At harvesting stage maximum number of tillers (19.53) are produced by T\(_{11}\) (RDF + Azospirillum at 2 kg ha\(^{-1}\) + Azolla at 2 tonnes ha\(^{-1}\)) plants and T\(_{6}\), T\(_{7}\) are statistically at par to maximum. Higher nutrient supply converts carbohydrates into protein which in turn elaborated into protoplasm which increased the number of tillers. Nitrogen also increases the proportion of protoplasm to cell wall material and leads to several consequences; one of them being an increase in size of cell which expressed morphologically increase growth attributes Arnon, I. (1953). The results were in accordance to Fakir et al., (2007) and Razie et al., (2008) and Prasad and Singh (1984).

They reported that the combined effect of inoculation of biofertilizers in rice with application of N increased number of tillers, growth, nutrient uptake and yield of rice. Irrespective of varietal differences higher the nitrogen available; greater was the number of tillers (Amin et al., 2006). The treatment T\(_{2}\) (RDF + Azotobacter at 2 kg ha\(^{-1}\)) recorded maximum dry matter accumulation of 102.82 (g) at the harvesting stage and except T\(_{3}\), T\(_{9}\), T\(_{10}\) rest all other treatments are found statistically at par to maximum dry matter.
accumulation. The application of biofertilizers had increased the formation and development of numerous root branching, root hairs, and primary and secondary lateral roots which enhanced the nutrient uptake capacity of roots. Due to the release of growth hormones by the bacteria and also by nitrogen fixation have probably shown effect on the root system as well as more root colonization and root proliferation. The increased uptake of nitrogen from the soil might have correspondingly increased the biomass to some extent (Gopalswamy and Vidhyasekaran 1988) and (Hartmann et al., 1983).

**Yield and yield attributes**

Grain yield was significantly influenced with different combinations of biofertilizers with chemical fertilizers. The maximum yield (6.88 t ha\(^{-1}\)) was observed with T\(_7\) (RDF + Azotobacter at 2 kg ha\(^{-1}\) + Azospirillum at 2 kg ha\(^{-1}\)). The effect of biofertilizers had significant influence on grain yield at production increased 15.4 per cent over farmer practices (T\(_1\)) when compared with treatment T\(_{11}\) (RDF + Azospirillum at 2 kg ha\(^{-1}\) + Azolla at 2 tonnes ha\(^{-1}\)) with lowest yield of biofertilizers and chemical fertilizers combination. Treatments T\(_2\), T\(_3\), T\(_4\), T\(_5\) and T\(_6\) were found statistically at par to maximum (T\(_7\)). Kumari et al., (2000) reported that increase N level brought about significant increase in grain yield. Inoculation of biofertilizers increases the grain yield of rice (Gopalswamy and Vidhyasekaran, 1988) and Jayaraman (1990). The increase in yield due to biofertilizers inoculates may not be solely due to N fixation or phosphate solubilisation, but because of several other factors such as release of growth promoting substances, control of plant pathogen, proliferation of beneficial organism in the Azotobacter and PSB. These findings are in accordance with Kundu and Gaur (1984). Datta et al., (1982) and Mudenoor (2002) observed that the response to mixed culture inoculation is more than that for single culture, showing the synergistic effect of two types of organism. The significant response was mainly due to the supply of two major nutrients N and P.

The application of biofertilizers had also significantly influenced the straw production of the rice crop. T\(_2\) (RDF + Azotobacter at 2 kg ha\(^{-1}\)) gained maximum straw yield and treatments T\(_3\), T\(_6\), T\(_7\), T\(_{10}\), T\(_{11}\) were found statistically at par to maximum. Straw yield also exhibited similar trend as that of grain yield of rice.

Due to application of nitrogen with biofertilizers and synthetic fertilizers remarkably increased the tillering rice resulted in significant improvement in straw yield Devasenamma et al., (1999). The increase in straw yield might be because more amount of nitrogen availability through bio fertilizers. Nitrogen is known to promote tillering, improve length and width of leaves, which inturn increase the dry matter and are responsible for increase in straw yield. Gopalswamy et al., (1989) also reported that the straw yield of rice increased by soil application of biofertilizers. T\(_9\) (RDF + PSB at 2 kg ha\(^{-1}\) + Azospirillum at 2 kg ha\(^{-1}\)) recorded maximum number of grains per panicle with T\(_2\), T\(_8\), and T\(_{11}\) are at par to T\(_9\). Solubilizers of inorganic phosphates in the soil (PSB) make them available to the crop and resulted in better number of grains per panicle. It also produces a phytohormone. IAA which increased its capacity of nutrient extraction from the soil Datta et al., (1982). Number of panicle per hill shown the same trend as number of grain per panicle, T\(_9\) (RDF + PSB at 2 kg ha\(^{-1}\) + Azospirillum at 2 kg ha\(^{-1}\)) with maximum (21.8) and T\(_4\) (RDF + Azospirillum at 2 kg ha\(^{-1}\) + Azolla at 2 tonnes ha\(^{-1}\)) with minimum (15.07).
Table 1: Effect of Biofertilizers on growth parameters of rice var. ‘Pusa Basmati-1’ at harvest

| S.No | T.no | Treatments                                      | Plant height (cm) | No. of tillers hill$^{-1}$ | Dry matter accumulation (g hill$^{-1}$) |
|------|------|-------------------------------------------------|-------------------|-----------------------------|----------------------------------------|
| 1    | T$_1$| Farmers practice                                | 103.53            | 13.53                       | 100.14                                 |
| 2    | T$_2$| RDF + Azotobacter at 2 kg ha$^{-1}$             | 105.33            | 16.00                       | 102.82                                 |
| 3    | T$_3$| RDF + PSB at 2 kg ha$^{-1}$                    | 105.73            | 16.33                       | 85.58                                  |
| 4    | T$_4$| RDF + Azospirillum at 2 kg ha$^{-1}$           | 104.80            | 15.60                       | 99.12                                  |
| 5    | T$_5$| RDF + Azolla at 2 tonnes ha$^{-1}$             | 107.40            | 16.20                       | 93.90                                  |
| 6    | T$_6$| RDF + Azotobacter at 2 kg ha$^{-1}$ + PSB at 2 kg ha$^{-1}$ | 109.20            | 16.93                       | 97.70                                  |
| 7    | T$_7$| RDF + Azotobacter at 2 kg ha$^{-1}$ + Azospirillum at 2 kg ha$^{-1}$ | 112.53            | 18.33                       | 95.20                                  |
| 8    | T$_8$| RDF + Azotobacter at 2 kg ha$^{-1}$ + Azolla at 2 tonnes ha$^{-1}$ | 109.93            | 15.20                       | 95.43                                  |
| 9    | T$_9$| RDF + PSB at 2 kg ha$^{-1}$ + Azospirillum at 2 kg ha$^{-1}$ | 99                | 15.80                       | 91.21                                  |
| 10   | T$_{10}$| RDF + PSB at 2 kg ha$^{-1}$ + Azolla at 2 tonnes ha$^{-1}$ | 103.47            | 14.80                       | 88.35                                  |
| 11   | T$_{11}$| RDF + Azospirillum at 2 kg ha$^{-1}$ + Azolla at 2 tonnes ha$^{-1}$ | 115.67            | 19.53                       | 101.40                                 |

SEm (±) 2.36 1.02 3.56

CD (P 0.05) 6.97 3.00 10.50

Farmer practice - 100 kg N through urea and DAP, 40 kg P2O5 through DAP and 20 kg K2O through MOP, RDF- 120 kg N through urea and DAP, 60 kg P2O5 through DAP and 60 kg through MOP, DAP- Di-ammonium phosphate, MOP- Muriate of Potash, RDF- Recommended dose of fertilizers, *Significant at P < 0.05;
Table 2 Effect of Biofertilizers on yield and yield attributing characters of rice var. ‘Pusa Basmati-1’

| S. No | T. No | Treatment                                      | No. of grains panicle\(^{-1}\) | No. of panicles hill\(^{-1}\) | Grain Yield (t ha\(^{-1}\)) | Straw Yield (t ha\(^{-1}\)) |
|-------|-------|-----------------------------------------------|-------------------------------|-------------------------------|----------------------------|-----------------------------|
| 1     | T\(_1\) | Farmers practice                              | 136.60                        | 16.13                         | 4.52                        | 9.23                        |
| 2     | T\(_2\) | RDF + Azotobacter at 2 kg ha\(^{-1}\)         | 143.07                        | 16.93                         | 6.71                        | 12.37                       |
| 3     | T\(_3\) | RDF + PSB at 2 kg ha\(^{-1}\)                 | 134.73                        | 18.20                         | 5.73                        | 11.67                       |
| 4     | T\(_4\) | RDF + Azospirillum at 2 kg ha\(^{-1}\)        | 138.80                        | 15.67                         | 5.92                        | 10.17                       |
| 5     | T\(_5\) | RDF + Azolla at 2 tonnes ha\(^{-1}\)          | 136.53                        | 19.47                         | 5.93                        | 10.47                       |
| 6     | T\(_6\) | RDF + Azotobacter at 2 kg ha\(^{-1}\) + PSB at 2 kg ha\(^{-1}\) | 126.67                        | 17.47                         | 6.36                        | 12.07                       |
| 7     | T\(_7\) | RDF + Azotobacter at 2 kg ha\(^{-1}\) + Azospirillum at 2 kg ha\(^{-1}\) | 139.27                        | 21.73                         | 6.88                        | 11.72                       |
| 8     | T\(_8\) | RDF + Azotobacter at 2 kg ha\(^{-1}\) + Azolla at 2 tonnes ha\(^{-1}\) | 141.60                        | 17.00                         | 5.56                        | 10.67                       |
| 9     | T\(_9\) | RDF + PSB at 2 kg ha\(^{-1}\) + Azospirillum at 2 kg ha\(^{-1}\) | 151.93                        | 21.80                         | 5.41                        | 10.40                       |
| 10    | T\(_{10}\) | RDF + PSB at 2 kg ha\(^{-1}\) + Azolla at 2 tonnes ha\(^{-1}\) | 139.93                        | 16.60                         | 5.39                        | 11.17                       |
| 11    | T\(_{11}\) | RDF + Azospirillum at 2 kg ha\(^{-1}\) + Azolla at 2 tonnes ha\(^{-1}\) | 143.27                        | 15.07                         | 5.52                        | 11.97                       |

SEm (±) 3.93 1.46 0.40 0.57
CD (P 0.05) *11.60 *4.30 *1.19 *1.68

Farmer practice - 100 kg N through urea and DAP, 40 kg P\(_2\)O\(_5\) through DAP and 20 kg K\(_2\)O through MOP, RDF - 120 kg N through urea and DAP, 60 kg P\(_2\)O\(_5\) through DAP and 60 kg through MOP, DAP- Di-ammonium phosphate, MOP- Muriate of Potash, RDF- Recommended dose of fertilizers,

*Significant at P < 0.05; NS- Non Significant at P > 0.05
**Table 3** Effect of Biofertilizers on economic of rice var. ‘Pusa Basmati-1’

| S.No | T.No | Treatment                                                                 | Cost of cultivation (# x 10^3 ha^-1) | Gross return (x 10^3 ha^-1) | Net return (x 10^3 ha^-1) | Benefit:Cost ratio |
|------|------|---------------------------------------------------------------------------|--------------------------------------|-----------------------------|---------------------------|--------------------|
| 1    | T1   | Farmers practice                                                          | 54.46                                | 126.47                      | 71.99                     | 2.32               |
| 2    | T2   | RDF + *Azotobacter* at 2 kg ha^-1                                         | 56.11                                | 187.88                      | 131.77                    | 3.34               |
| 3    | T3   | RDF + PSB at 2 kg ha^-1                                                   | 56.11                                | 160.44                      | 104.33                    | 2.85               |
| 4    | T4   | RDF + *Azospirillum* at 2 kg ha^-1                                         | 56.44                                | 165.67                      | 109.23                    | 2.93               |
| 5    | T5   | RDF + Azolla at 2 tonnes ha^-1                                             | 56.71                                | 165.95                      | 109.24                    | 2.92               |
| 6    | T6   | RDF + *Azotobacter* at 2 kg ha^-1 + PSB at 2 kg ha^-1                      | 57.76                                | 178.08                      | 120.32                    | 3.08               |
| 7    | T7   | RDF + *Azotobacter* at 2 kg ha^-1 + *Azospirillum* at 2 kg ha^-1           | 58.09                                | 192.55                      | 134.47                    | 3.31               |
| 8    | T8   | RDF + *Azotobacter* at 2 kg ha^-1 + Azolla at 2 tonnes ha^-1               | 58.36                                | 155.81                      | 97.45                     | 2.67               |
| 9    | T9   | RDF + PSB at 2 kg ha^-1 + *Azospirillum* at 2 kg ha^-1                     | 58.09                                | 151.48                      | 93.39                     | 2.60               |
| 10   | T10  | RDF + PSB at 2 kg ha^-1 + Azolla at 2 tonnes ha^-1                          | 58.36                                | 150.92                      | 92.56                     | 2.58               |
| 11   | T11  | RDF + *Azospirillum* at 2 kg ha^-1 + Azolla at 2 tonnes ha^-1              | 58.69                                | 154.47                      | 95.89                     | 2.63               |

SEm (±) 11.34 11.34 0.20

CD (P 0.05) *33.45 *33.46 *0.58

Farmer practice - 100 kg N through urea and DAP, 40 kg P_2O_5 through DAP and 20 kg K_2O through MOP, RDF- 120 kg N through urea and DAP, 60 kg P_2O_5 through DAP and 60 kg through MOP, DAP- Di-ammonium phosphate, MOP- Muriate of Potash, RDF- Recommended dose of fertilizers. *Significant at P < 0.05; NS- Non Significant at P > 0.05. #Data not subjected to statistical analysis
The treatments T₃ and T₅ were found to be at par with maximum. According to Khorshidi et al., (2011) the highest number of panicles produced with the combination between nitrogen and bacteria *Azospirillum lipoferum*. This finding is with the agreement of Devasenamma et al., (1999) and Nayak et al., (1986).

The statistical analysis on test weight was found to be non-significant. However, highest test weight (31.50g) was recorded with treatment T₅ (RDF+ Azolla at 2 tonnes ha⁻¹). The data showed non-significant difference in harvest index. However, T₇ (RDF+ Azotobacter at 2 kg ha⁻¹ + Azospirillum at 2 kg ha⁻¹) recorded highest value of (36.98%) and lowest value (31.47%) was recorded with T₁₁ (RDF + Azospirillum at 2 kg ha⁻¹ + Azolla at 2 tonnes ha⁻¹). A superior value of harvest index indicates more efficient translocation of metabolites from source to sink.

**Economics**

Among the different combination of nutrient source highest gross return (Rs.1, 92, 550 ha⁻¹) and maximum net return (Rs.1, 34,470 ha⁻¹) recorded by (T₇) RDF + Azotobacter at 2 kg ha⁻¹ + Azospirillum at 2 kg ha⁻¹. Higher benefit cost ratio of 3.34 was recorded from nutrient applied (T₂) RDF + Azotobacter at 2 kg ha⁻¹. The yield advantage through application of Azotobacter with more proportional increase in cost of cultivation which has been statistically superior over other treatments but treatment with biofertilizers proved to be far better than the farmer practices and the conjoint use of RDF with biofertilizers is capable of sustaining higher rice productivity, improving nutrients status and profitability on long term basis. Thus recommended for farmers.

In spite, the treatment (T₇) RDF + Azotobacter at 2 kg ha⁻¹ + Azospirillum at 2 kg ha⁻¹ proved to gain significantly higher yield than sole fertilizer application. They also reduces the damage caused due to continuous usage of chemical fertilizers, improves the soil fertility, enhances the soil micro fauna, and reduces the input costs of farmers. It is our duty to create awareness on soil depletion, health hazards and encourage farmers to use biofertilizers, to save our natural resources and environment.

**Experiment results revealed that basmati rice responded well to balanced use of chemical fertilizers along with the biofertilizers when applied solely and in combinations. Therefore, the treatment (T₇) RDF + Azotobacter at 2 kg ha⁻¹ + Azospirillum at 2 kg ha⁻¹ proved to gain significantly higher grain yield, as the economics are the paramount importance in the farmers point of view the treatment (T₂) RDF + Azotobacter at 2 kg ha⁻¹ has gained more B: C ratio and concluded that it beneficial for farmers.**

**Acknowledgements**

I express my gratitude to my advisor Prof. (Dr.) Joy Dawson for constant support, guidance and for his valuable suggestions for improving the quality of this work. I am indebted to Prof. (Dr.) Thomas Abraham who has been a constant source of inspiration and all the faculty members of Department of Agronomy, SHUATS, Prayagraj, Uttar
Pradesh (U.P), India for providing necessary facilities, for their cooperation, encouragement and support.

References

Anonymous, APEDA2019. Analytical trade profile of Basmati rice. APEDA Agriexchange.In: https://agriexchange.apeda.gov.in/indexp/reportlist.aspx.

Adhikari, N. P., Mishra, B. N., & Mishra, P. K. 2005. Effect of integrated nitrogen management on quality of aromatic rice. *Annals of Agricultural Research*, 26, 231-234.

Amin MR, Hamid A, Choudhury SM and Asaduzzaman M. 2006. Nitrogen fertilizer: Effect on tillering, dry matter production and yield of traditional varieties of rice. *International Journal of Sustainable Crop Production*. 1(1): 17-20.

Arnon, I. 1953. The physiology and biochemistry of phosphorus in green plants. *Agronomy Monogram*. 4: 10.

Budhar MN, Rajendran R and Chandrasekaran B 2006. Integrated nutrient management for rice grown under SRI and aerobic situations. In Winter School on *New Dimensions in Integrated Nutrient Management of Major Field Corps for Sustainable Crop Production* (eds Raghjavaiah et al.) Indian Council of Agriculture Research New Delhi and Directorate of Oilseeds Research, Hyderabad pp. 177-186.

Chhonkar, P.K. and Tilak, K.V.B.R. 1997. Bio-fertilizers for sustainable agriculture: Research gaps and future needs. In: *Plant Nutrient Needs Supply, Efficiency and Policy Issues*: 2000–2025 (Eds. J.S. Kanwar and J.C. Katyal). NationalAcademy of Agricultural Sciences, New Delhi. pp. 52–66.

Datta M, Banik S and Guptha P K. 1982. Studies on efficiency of phytoharmone producing phosphate solubilizing *Bacillus firmis* in augmenting paddy yield in acid soils of Nagaland. *Plant and Soil* 69: 365-73.

Devasenamma V, Reddy M R and Rajan M S. 1999. Effect of varying levels of nitrogen on growth and nitrogen uptake of rice hybrids. *Andhra Agric J* 46: 124-25.

Dixit, K.G. and Gupta, B.R. 2000. Effect of farmyard manure, chemical and biofertilizer on yield and quality of rice (*Oryza sativa L.*) and soil properties. *Journal of the Indian Society of Soil Science* 48 (4): 773-780.

FAO. 2017. FAO STAT Production Statistics, Food and Agriculture Organization, Rome, Italy, December 12, 2017, pp 25-43.

Fakir M A, Hasan S M and Sattar M A. 2007. Growth and yield of rice as influenced by *Azotobacter* and *Azospirillum* inoculation in presence and absence of urea-N. *J Bangladesh Soc Agric Sci Technol* 4: 247-50.

Gee, G.W. and Baudev, J.W. 1986. Particle size analysis. In methods of soil analysis. Part 1, Physical and mineralogical method (A. Kluse Ed) pp. 404-408. Agronomy monogramNo. 9, *American Society of Agronomy*, Madisom, w1.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical procedures for agricultural research* (2nd Ed.), John Wiley and Sons: NEW YORK, U.S.A.

Gopalswamy, G. and Vidhyasekaran, P. 1988. Efficiency of *Azospirillum brasilense* in increasing rice yield. *Internat. Rice Res. Newsletter*, 12(1) : 34.

Gopalswamy, G., Vidhyasekaran, P. and Chelliah, S. 1989. Effect of *Azospirillum lipoferum* inoculation and inorganicnitrogen on wetland rice.
Oryza, 26 : 378-380.
Gull, M., Hafeez, F.Y., Saleem, M. and Malik, K.A. 2004. Phosphorus uptake and growth promotion of rice by co-inoculation of mineral phosphate solubilising bacteria and mixed rhizobial culture. *Aust. J. Experim. Agric.*, 44: 623-628.
Hartmann A, Mahavir S and Kligmaller W. 1983. Isolation and characterization of *Azospirillum* mutants excreting high amounts of indole acetic acid. *Canadian J Microbiol* 29: 916-22.
Jackson, M.L. 1973. Soil chemical analysis. Prentice Hall of India Private Limited, New Delhi, p. 498.
Jayaraman, S. 1990. Studies on comparative performance of different biofertilizers with sub-optimal level of nitrogen on rice. *Andhra Agril. J.*, 37(4) : 366-369.
Khorshidi Y R, Mohammad R A and Mahmoud R. 2011. Response of yield and yield components of Rice (*Oryza sativa L.*) to *Pseudomonas florescenc*e and *Azospirillum lipoferum* under different nitrogen levels. *American-Eurasian J Agric Environ Sci* 10 (3): 387-95.
Kumari, M.B.G.S., Subbaiah, G., Veeraraghavaiah, R. and Rao,C.V.H. 2000. Effect of plant density and nitrogen level on growth and yield of rice. *Andhra Agric. J.*, 47 : 188-190.
Kumudha P (2005) Studies on the effect of biofertilizers on the germination of *Acacia nilotica* Linn. seeds. *Adv Pl Sci* 18(11): 679-84.
Kumudha P and Gomathinayagam M. 2007. Studies on the effect of biofertilizers on germination of *Albizialebbek* (L.)Benth. seeds. *Adv Pl Sci.* 20(11): 417-21.
Kunda B S and Gaur A C. 1984. Rice responses to inoculation with nitrogen fixing and P solubilizing microorganisms: *Plant and Soil* 79: 227-34.
Mian MH, Kashem MA 1995. Comparative efficiency of some selected methods of applying *Azolla* for cultivation of irrigated rice. *Bangladesh J Crop Sci* 6: 29–36.
Moore AW 1969. Azolla: biology and agronomic significance. *Bot Rev* 35:17–30.
Mudenoor M G. 2002. Effect of micronutrient supplemented *Azospirillum biofertilizers* on maize (*Zea mays* L.). M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka (India).
Nayak, D.N., Ladha, J.K. and Watanabe, I. 1986. The fate of marker *Azospirillum lipoferum* inoculated into rice and its effect on growth, yield and N2 fixation of plants studied by acetylene reduction N2 feeding and 15N dilution technique. *Biology & Fertility Soils*, 2 : 7-14.
Olsen, S.R., Cole, C.V., Watanable, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *U.S. Department of Agriculture Circular 930, U.S. Govt. Printing Office, Washington DC*.
Panwar, J.D.S. and Vijayluxmi, 2005. In: Biological nitrogen fixation in pulses and cereals. Development in physiology, biochemistry and molecular biology of plants (Editor: Bandana Bose and A. Hemantaranjan) Published by New India Publishing Agency, New Delhi, pp. 125-158.
Peoples MB, Herridge DF, Ladha JK 1995. Biological nitrogen fixation: an efficient source of nitrogen for sustainable agricultural production. *Plant Soil* 174:3–28.
Prasad J and Singh R S 1984. Effect of *Azolla*, seedling bacterization with *Azotobacter* and *Azospirillum* with and without nitrogen on paddy (*Oryza sativa*). *Indian J Agric Res* 18: 63-67.
Quyen, N.V. and Sharma, S.N. 2003. Relative
effect of organic and conventional farming on growth grain quality of scented rice and soil fertility. Archives of Agronomy and Soil Sciences 49: 623-629.

Razie F and Anas I 2008. Effect of Azotobacter and Azospirillum on growth and yield of rice grown on tidal swamp rice fields in south Kalimantan. J Tanah dan Lingkungan 10: 41-5.

Sartaj Ahmad and Wani. 2013. Potential Use of Azotobacter chroococcum in Crop Production: An Overview. Current Agriculture Research Journal 1(1):35-38.

Singh AL, Singh PK, 1990. Intercropping of Azollabiofertilizerwith rice at different crop geometry. Trop Agric 67:350–354.

Saini, V., R. Berwal, J. Sharma and A. Singh, 2004. Biofertilizers: current status and perspectives in agriculture. Poll. Res.,23(4): 665-676.

Subbiah B and Asija G L 1956. A rapid procedure for estimation of available nitrogen in soils. Curr Sci 25(8): 1-6.

Tien T M, Gaskins M H and Hubbel D H. 1979. Plant growth substances produced by Azospirillumbrasilese and their effect on growth of pearl millet (Pennisetum americanum L.). Appl Env Microbiol 37: 1016-24.

Walkley A and Black I A, 1934. An examination of degtjareff method for determining soil organic matter and a proposed modification of chromic acid titration method. Soil Sci 37: 29-37.

---

**How to cite this article:**

Chakravarthy Thejesh, Chereddy Maheshwara and Joy Dawson. 2020. Studies on Growth, Yield and Economics of rice (Oryza sativa. L) var. Pusa Basmati-1 as Influenced by Biofertilizers. *Int.J.Curr.Microbiol.App.Sci.* 9(06): 86-97.

doi: [https://doi.org/10.20546/ijcmas.2020.906.011](https://doi.org/10.20546/ijcmas.2020.906.011)