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Effect of Bio-Fertilizers and Organic Manures on Growth and Yield of Organic Rice (*Oryza sativa* L.)

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ABSTRACT: A field experiment was conducted during *kharif* 2020 at Central Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.). The effect of biofertilizers and organic manures on growth and yield of organic rice, the soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (PH 7.1), low in organic carbon (0.28%), available N (225 kg/ha), available p (19.50 kg/ha), The treatment consists of *Azotobacter* (25 g/kg), *Azospirillum* (25 g/kg), *Azotobacter* + *Azospirillum* (12.5 + 12.5 g/kg) as seed inoculants and Farm Yard Manure (12 t/ha), Poultry Manure (4 t/ha) and Vermicompost (4 t/ha), whose effect was observed in Rice. The experiment was laid out in Randomized Block Design (RBD) there are 10 treatments which are replicated thrice. The result showed that the growth parameters *viz.* plant height (75.83 cm) at 100 DAT, number of tillers per hill (12.07) at 100 DAT and dry weight (25.03 g) at 100 DAT was recorded superior with the application of *Azotobacter* (12.5 g/kg) + *Azospirillum* (12.5 g/kg) + FYM (12 t/ha). The yield parameters and yield *viz.* effective tillers/m^2 (427.33), number of grains per panicle (188.73), test weight (24.67 g), grain yield (4.77 t/ha) and straw yield (11.07 t/ha) was recorded superior with the application of *Azotobacter* (12.5 g/kg) + *Azospirillum* (12.5 g/kg) + FYM (12 t/ha), the maximum gross return (119250.00 INR/ha), net return (77518.00 INR/ha) and B:C ratio (1.85) were recorded superior with application of *Azotobacter* (12.5 g/kg) + *Azospirillum* (12.5 g/kg) + FYM (12 t/ha). According to research results, *Azotobacter* (12.5 g/kg) + *Azospirillum* (12.5 g/kg) + FYM (12 t/ha) had the most positive effect on the measured characteristics. Also the using of *Azotobacter, Azospirillum* and FYM was increased the yield and yield components of organic rice.

Keywords: Rice, *Azotobacter*, *Azospirillum,* FYM, Poultry Manure, Vermicompost, Growth and Yield.

INTRODUCTION

India is one of the world's major rice (*Oryza sativa* L.) growers, accounting for 20% of global rice output. Rice is a widely grown food crop that provides sustenance for more than half of the world's population. Demand for rice is anticipated to climb from 439 million tonnes in 2010 to 496 million tonnes in 2020, and then to 553 million tonnes in 2035. (FAO, 2013). India's rice productivity is 2.98 t/ha, compared to a global average of 4.25 t/ha (IRRI, 2011). Paddy procurement will total 15,26,534 MT by 2020, including 4,82,656 MT in Haryana, 10,08,028 MT in Punjab, 6,945 MT in Chandigarh, 1545 MT in Uttar Pradesh, 1809 MT in Kerala, and 25,551 MT in Tamilnadu.

With the use of various manures and crop wastes to enhance crop production as well as soil fertility status, the concept of organic farming has gained traction. Organic manures, green manures, and crop wastes, in addition to inorganic fertilisers, improve the effectiveness of applied nutrients by improving the physical, chemical, and biological characteristics of the soil (Prasad *et al.,* 1992).

The principal additives of incorporated nutrient deliver machine are fertilizer, FYM, vermicompost, inexperienced manure, crop residue/recyclable wastes and bio-fertilizers. These additives own outstanding range in phrases of chemical and bodily properties, nutrient launch efficiencies, positional availability, crops specificity and farmers acceptability. Therefore, the aggregate of various additives to make sure most advantageous nutrient deliver to a manufacturing machine may also rely on land use, ecological, social and financial condition. Indian agriculture have been historically depending on natural manure reassets and the inclusion of FYM regulates nutrient uptake, crop yields and bodily fame of soil and as a consequence has a synergistic effect (Yadav and Kumar, 2002).

Balanced nutrition due to release of macro and micro nutrients due to application of vermicompost, poultry manure and Farm Yard Manure under favourable environment might have helped in higher uptake of nutrients. This accelerated the growth of new tissues and development of new shoots that have ultimately increased the plant height, dry matter accumulation, chlorophyll content and total tillers per meter row length (Togas *et al.,* 2017).

The compost prepared through the application of earthworm is known as vermicompost and the technology of using close by species of earthworms for manner of existence or composting has been known as vermi tech. Vermicompost is normally of a finely divided peat like fabric proudly owning exceptional structure, porosity, aeration, drainage and moisture water retaining capacity. Vermicompost improves the physical, chemical and natural houses of soil. There is a outstanding evidence that vermicompost promotes growth of vegetation and it is been determined to have a useful effect on all yield parameters of flowers like, wheat, paddy, and sugarcane.

Azotobacter is a nitrogen-fixing bacterium that may fix up to 20 kg of nitrogen per hectare in nonlegumes. It converts elemental nitrogen to ammoniacal form (NH^{4+}), which the crop may use. In addition, *Azotobacter*'s capacity to produce auxins, vitamins, growth factors, and antifungal medicines gives it a competitive edge. The roots absorbed the nitrogen fixed by *Azotobacter* in the soil near the root zone (rhizosphere), which may have boosted the crop's growth characteristics (Rathore and Gautham, 2003; Kumar *et al*., 2012).

Azospirillum benefits plants through processes that boost plant development, increase mineral uptake, increase dry matter, improve water absorption, and increase yield. In recent years, carrier-based *Azospirillum* inoculants for non-leguminous crops have grown in popularity in India. *Azospirillum* is a rhizosphere bacteria that colonises the roots of agricultural plants and fixes a significant quantity of atmospheric nitrogen using root exudates. They have an impact on the growth and production of a variety of commercially significant crops (Okon and Vanderleyden, 1997).

MATERIALS AND METHODS

A field experiment was conducted during kharif season 2020 at Crop Research Farm, department of agronomy, Naini Agriculture Institute, Sam Higginbottom university of Agriculture, Technology and sciences (SHUATS), Prayagraj, (U.P.) which is located at 25°39′ 42″ N latitude, 81°67′56″ E longitude and 98 m altitude above the mean sea level (MSL) on sandy loam soil, having moderately basic pH (7.1), organic carbon (0.28%), available nitrogen (225 kg/ha), phosphorus (19.50 kg/ha) and potassium (92.00 kg/ha). The climate of the region is semi -arid subtropical.

A. Experimental design and treatment and treatment combinations

This experiment was laid in Randomized Block Design. Treatment consists of T_1- *Azotobacter* + Farm Yard Manure 12t/ha, T_2- *Azotobacter* + Poultry manure 4t/ha, T_3- *Azotobacter* + Vermicompost 4t/ha, T_4- *Azospirillum* + Farm Yard Manure 12t/ha, T_5- *Azospirillum* + Poultry manure 4t/ha, T_6- *Azospirillum* + Vermicompost 4t/ha, T_7- *Azotobacter* + *Azospirillum* + Farm Yard Manure 12t/ha, T_8- *Azotobacter* + *Azospirillum* + Poultry manure 4t/ha, T_9- *Azotobacter* + *Azospirillum* + Vermicompost 4t/ha, T_{10}- Control (Recommended FYM 10t/ha). These ten treatments replicated thrice during kharif season during 2020.

Chemical analysis of soil: To establish the initial soil characteristics, a composite soil sample was obtained before the experiment was laid out. The soil sample was taken from a depth of 0-15 cm, dried in the shade, pulverised using a wooden pestel and motor, passed through a 2 mm filter, and utilised for analysis. Available organic carbon and black technique by (Jackson 1973), available nitrogen by alkaline permanganate method by Subbaih and Asija (1956), available phosphorus by Olsen’s colorimeter method as outlined by Oslen *et al.*, (1954), and available potassium by flame photometer method by Jackson (1973; Toth and Prince, (1949).

Statistical analysis: Experimental data collected was subjected to statistical analysis of variance (ANOVA) as outline by Gamez and Gomez (2010). Critical Difference (CD) values were calculated the ‘F’ test was found significant at 5% level.

RESULT AND DISCUSSION

A. Performance of biofertilizers and organic manures on growth attributes of organic rice

Plant height (cm): At 100 days after transplanting, the application of *Azotobacter* + *Azospirillum* + 12 t/ha of FYM produced the highest plant height (75.83 cm), which was significantly superior to all other treatments except *Azotobacter* + *Azospirillum* + 4 t/ha of Poultry manure (74.24 cm) and *Azotobacter* + *Azospirillum* + 4 t/ha of Vermicompost (74.24 cm) (73.73 cm). According to Daveri *et al.*, (2012), applying Farm Yard Manure considerably enhances overall plant height in both the 2006-07 and 2007-08 research years. The use of accessible organic sources, notably Farm Yard Manure and Poultry Manure, as well as the full required dose of mineral fertilisers, is critical for crop growth improvement.

Number of tillers/hills: At 100 days after transplanting, the application of *Azotobacter* + *Azospirillum* + 12 t/ha of Farm Yard Manure provided the highest number of tillers per hill (12.07), which was substantially superior to all other treatments except *Azotobacter* + *Azospirillum* + 4 t/ha of Poultry Manure (11.53). According to Tigangam and George, (2017), the highest tillering seen in the treatment when FYM and inorganic fertilisers were applied together was due to increased nitrogen availability, which aided plant growth, and elevated phosphorus solubility, which aided root development and tillering.

Dry weight (g)/hill: At 100 DAT, the application of *Azotobacter* + *Azospirillum* + 12 t/ha of FYM produced the greatest dry weight (25.03g), which was substantially superior to all other treatments except *Azotobacter* + *Azospirillum* + 4 t/ha of Poultry manure (23.85g).

According to (Singh *et al.*, 2013), bio-organic sources had a significant impact on yield attributes, with the combined use of FYM @ 5 t/ha + BGA registering the highest number of effective tillers/m^2, filled grains/panicle, and 1000-grain weight, which was significantly better than either FYM @ 5 t/ha or BGA both.

According to Tigangam and George, (2017), various treatment combinations had a substantial impact on plant height, which enhanced as crop growth progressed up to 90 DAT. T_{11} (FYM @ 10 t/ha + 100 percent RDF) had the maximum plant height and was statistically comparable to T_{10} (FYM @ 10 t/ha + 75% RDF) in all plant growth, development, and reproductive phases where both organic and inorganic nutrients were treated in combination. The number of tillers/hill progressively grows until it reaches 45 DAT, after which it gradually decreases until it reaches 60 DAT. At 45 DAT, the highest number of tillers/hill was seen with treatment T_{11} (FYM @ 10 t/ha + 100% RDF), which is statistically comparable to T_{10} (FYM @ 10 t/ha + 75% RDF). The maximum plant dry weight/hill was observed in treatment T_{11} (FYM @ 10 t/ha + 100% RDF), which used both organic and inorganic fertilisers and was statistically comparable to T_{10} (FYM @ 10 t/ha + 75% RDF) throughout the growing season, but not to T_8 at 30 and 75 DAT.

Table 1: Effect of biofertilizers and organic manures on growth attributes of organic rice.

Treatments	Plant height (cm) 100 DAT	Number of tillers/hills 100 DAT	Dry weight (g)/hill 100 DAT
Azotobacter + 12t/ha of FYM	70.70	10.20	21.07
Azotobacter + 4t/ha of Poultry manure	70.11	10.07	21.15
Azotobacter + 4t/ha of Vermicompost	69.79	10.00	20.96
Azospirillum + 12t/ha of FYM	73.46	10.47	22.62
Azospirillum + 4t/ha of Poultry manure	72.76	10.33	22.29
Azospirillum + 4t/ha of Vermicompost	71.51	10.20	21.88
Azotobacter + *Azospirillum* + 12t/ha of FYM	75.83	12.07	25.03
Azotobacter + *Azospirillum* + 4t/ha of Poultry manure	74.24	11.53	23.85
Azotobacter + *Azospirillum* + 4t/ha of Vermicompost	73.73	10.80	23.29
Control (Recommended FYM 10t/ha)	69.29	9.73	20.44
SEm (±)	0.78	0.36	0.52
CD (p = 0.05)	2.31	1.08	1.55

B. Performance of biofertilizers and organic manures on yield attributes, yield and economics of organic rice.

Number of panicles/m^2

The application of *Azotobacter* + *Azospirillum* + 12t/ha of FYM led to the highest number of panicle/m^2 (427.33), which was significantly superior to all other treatments except *Azotobacter* + *Azospirillum* + 4t/ha of poultry manure (409.00), *Azotobacter* + *Azospirillum* + 4t/ha of vermicompost (403.00), *Azospirillum* + 12t/ha of FYM (387.00).

Length of panicle (cm): At harvest, the application of *Azotobacter* + *Azospirillum* + 4t/ha of vermicompost resulted in the longest panicle length (24.50cm), whereas the application of *Azotobacter* + 4t/ha of poultry manure resulted in the shortest panicle length (23.80cm). There isn't much of a difference between the therapies.

No. of grains/panicle: The application of *Azotobacter* + *Azospirillum* + 12t/ha of FYM resulted in the highest number of grains/panicle (188.73), which was significantly superior to all other treatments except *Azotobacter* + *Azospirillum* + 4t/ha of poultry manure (187.73) and *Azotobacter* + *Azospirillum* + 4t/ha of vermicompost (187.40).

Grain yield (t/ha): With the exception of *Azotobacter* + *Azospirillum* + 4t/ha of poultry manure (4.67t/ha), *Azotobacter* + *Azospirillum* + 4t/ha of vermicompost (4.40t/ha), and *Azospirillum* + 12t/ha of FYM (4.20t/ha), the greatest grain yield (4.77t/ha) was observed with *Azotobacter* + *Azospirillum* + 12t/ha of FYM.

Straw yield (t/ha): The application of *Azotobacter* + *Azospirillum* + 12t/ha of FYM produced the highest straw yield (11.07t/ha), which was significantly superior to all other treatments except *Azotobacter* + *Azospirillum* + 4t/ha of poultry manure (10.97t/ha), *Azotobacter* + *Azospirillum* + 4t/ha of vermicompost (10.37t/ha), and *Azospirillum* + 12t/ha of FYM (10.13t/ha).

Test weight (g): With the exception of *Azotobacter* + *Azospirillum* + 4t/ha of chicken manure, the greatest test weight (24.67g) was observed with *Azotobacter* + *Azospirillum* + 12t/ha of FYM, which was substantially superior to all other treatments (23.67g).

Harvest index (%): The application of *Azotobacter* + *Azospirillum* + 12t/ha of FYM resulted in the greatest Harvest index percent (30.13), whereas the application of Control (Recommended FYM-10 t/ha) resulted in the lowest Harvest index percent (26.61). There isn't much of a difference between the therapies.

Economics of organic rice: Maximum Gross returns (119250.00 INR/ha), Net returns (77518.00 INR/ha), and B:C ratio (1.85) were recorded with the application of *Azotobacter* + *Azospirillum* + 12t/ha of FYM, while the minimum was recorded with the application of Control (Recommended FYM 10t/ha).

According to Singh *et al.*, (2013), the combined application of FYM @ 5 t/ha with BGA resulted in a vastly higher grain yield (41.68 q/ha) than either FYM (5t/ha) or BGA alone. A similar reaction was seen in straw yield as well.

According to Tigangam and George (2017), treatment T_{11} has the greatest grain yield, although treatments T_{10}, T_9, and T_8 have yields that are comparable to T_{11}. T_{11} had a 59.47 % higher grain yield/ha than T_{12}. Additionally, combining 10 tonnes FYM with 100 RDF (T_{11}) boosts grain yield by 29.57 % to 100 RDF (T_5) alone. Furthermore, treatment T_{11}, which is comparable to T_{10}, T_8, T_9, and T_7, had the highest straw yield. T_{12} (No manure and fertiliser) had the lowest straw yield (kg/ha) but was comparable to T_1, T_2, and T_3.

The observe carried out by Andriamananjara *et al.*, (2021) discovered that FYM may want to increase the performance of P mineral use in rainfed lowlands and increase rice yields after non-stop application for 3 years. These consequences are constant with that of Mahajan *et al.,* (2008); Naing *et al.,* (2010) who reported increased straw and grain yields in rice with the combined application of FYM and inorganic fertilizers.

According to Apriyani *et al.,* (2021), the use of cow manure and inorganic fertilisers (NPK), either alone or in combination, had no significant influence on Inpari 43 rice yields ($P<0.05$), but was substantially different from the control. The maximum yield was obtained with a 20 t/ha cow manure treatment (9.6 t/ha), whereas the lowest yield was obtained with the control (4 t/ha). On rainfed lowland, long-term (4-year) application of cow dung at doses of 10 t/ha and 20 t/ha can enhance Inpari 43 yields by 135% and 140%, respectively, as compared to control.

Table 2: Effect of biofertilizers and organic manures on yield attributes and yield of organic rice.

Treatments	No. of panicle/m^2	Length of panicle (cm)	No. of grains/panicles	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
Azotobacter + 12t/ha of FYM	365.00	24.13	185.63	22.67	3.63	9.43	27.85
Azotobacter + 4t/ha of Poultry manure	361.67	23.80	185.60	22.33	3.60	9.37	27.72
Azotobacter + 4t/ha of Vermicompost	358.00	24.23	185.17	22.33	3.57	9.23	27.86
Azospirillum + 12t/ha of FYM	393.33	24.17	186.90	23.33	4.20	10.13	29.40
Azospirillum +4t/ha of Poultry manure	387.00	23.87	186.63	22.67	3.90	9.83	28.34
Azospirillum + 4t/ha of Vermicompost	378.67	24.20	185.77	22.67	3.67	9.67	27.49
Azotobacter + *Azospirillum*+12t/ha of FYM	427.33	24.43	188.73	24.67	4.77	11.07	30.13
Azotobacter + *Azospirillum*+4t/ha of Poultry manure	409.00	24.43	187.73	23.67	4.67	10.97	29.84
Azotobacter + *Azospirillum*+4t/ha of Vermicompost	403.00	24.50	187.40	23.33	4.40	10.37	29.89
Control (Recommended FYM 10t/ha)	348.00	24.20	184.93	22.33	3.30	9.10	26.61
SEm (±)	15.72	0.22	0.57	1.35	0.19	0.35	1.35
CD (p=0.05)	46.72	NS	1.69	NS	0.57	1.05	NS

Table 3: Effect of biofertilizers and organic manures on economics of organic rice.

Treatments	Total cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C
Azotobacter +12t/ha of FYM	41552	90750	49198	1.18
Azotobacter + 4t/ha of Poultry manure	45552	90000	44448	0.97
Azotobacter + 4t/ha of Vermicompost	45552	89250	43698	0.95
Azospirillum + 12t/ha of FYM	41512	105000	63488	1.52
Azospirillum + 4t/ha of Poultry manure	45512	97500	51988	1.14
Azospirillum + 4t/ha of Vermicompost	45512	91750	50018	1.09
Azotobacter + *Azospirillum*+12t/ha of FYM	41732	119250	77518	1.85
Azotobacter + *Azospirillum*+4t/ha of Poultry manure	45732	116750	71018	1.55
Azotobacter + *Azospirillum*+4t/ha of Vermicompost	45732	110000	64268	1.40
Control (Recommended FYM 10t/ha)	39332	82500	43168	1.09

CONCLUSION

The treatment with *Azotobacter* + *Azospirillum* +12 t/ha of FYM was shown to be more productive (4.77t/ha) and economically (77518 INR/ha) feasible after one season of testing. The conclusion drawn based on the one season data only which require further conformation for recommendation.

FUTURE SCOPE

Application of farmyard manure in the soil commonly will increase CO_2 emissions (Fangueiro *et al.,* 2008). Farmyard manure software to the soil can commonly be carried out with methods: surface and subsurface applications. In subsurface application, farmyard manure is commonly unfold at the soil after which combined with tillage equipment consisting of a plow and rotary tiller. Liquid manure also can be injected into the soil. Some researchers have suggested that injection of liquid manure can reduce the nutrient shipping via way of means of run-off (Daverede *et al.,* 2004) and decrease NH_3 emissions as compared to surface application (Misselbrook *et al.,* 1996). The motive of this observe is to decide the impact of wheel visitors, farmyard manure software technique, and manure quantity on soil CO_2 emissions, O_2 content, soil temperature, and moisture content. Our particular hypotheses have been as follows: 1) an increase in wheel visitors will bring about a lower in CO_2 emissions from the soil to the ecosystem, and a comparable impact might be visible in the soil oxygen capacity; 2) the CO_2 emission from the soil to the ecosystem might be proportional to the quantity of fertilizer; 3) most CO_2 emission might be determined in subsurface manure application.

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Conflict of Interest. Nil.

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