Effect of Biofertilizer on Productivity of Upland Rice (*Oryza sativa* L.) in Nagaland, India

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Abstract

A field experiment was conducted in the experimental research farm of School of Agricultural Sciences and Rural development (SASRD), Nagaland University during April to September 2011 to study the effect of different sources of organic nutrients on productivity of upland rice (*Oryza sativa* L.). The soil of the experimental field was sandy loam in texture, acidic in nature (4.6 pH) with high organic carbon (1.31%), low available N (153.87 kg ha^{-1}), low available P (11.87 kg ha^{-1}) and medium available K (236.12 kg ha^{-1}). The treatments namely *Sesbania aculeata* @ 6.25 t ha^{-1}, Green leaf manure @ 10 t ha^{-1}, Paddy straw @ 10 t ha^{-1}, *Sesbania aculeata* @ 6.25 t ha^{-1} +*Azotobacter*@ 20 g kg^{-1} seed, Green leaf manure @ 10 t ha^{-1}+*Azotobacter*@ 20 g kg^{-1} seed, Paddy straw @ 10 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed and control were used in Randomised Block Design with 3 replication. The result of the experiment revealed that *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter*@ 20 g kg^{-1} seed significantly recorded maximum no of grains panicle^{-1} (173.14), no of panicles m^{-2} (163.43) and grain yield (30.88 q ha^{-1}), giving highest gross return (₹ 33116.8) and net return (₹ 20366.8).

1. Introduction

Rice is the most important cereal crop in the world and is the staple food for over half the world's population including India. It has supported a greater number of people for a longer period of time than any other crop since it was domesticated between 8,000 to 10,000 years ago (Greenland, 1997). It provides 60 % of the calorie intake for more than two billion people every day. About 40% of world population uses rice as a major source of calories. Rice production in India has increased in the past three decades continuously beginning with the green revolution, but has stagnated since 1999 (USDA, 2004). It occupies an area of 42.86 mha with a production of 95.48 mt and productivity of 2239 kg ha^{-1} (Agricultural Statistic at a Glance, 2011). It is estimated that the rice demand in 2025 will be 140 mt in India. Rice is the principal food grain crop of the North Eastern hilly ecosystem, occupying 3.369 m ha which accounts for more than 80% of the total cultivated area of the region and 7.8 % of the total rice area in India while its share in national rice production is only 5.9 %. The average productivity (1761 kg ha^{-1}) is poor even below the national average (2102 kg ha^{-1}) due to inadequate and even lack of resource based management practices (Directorate of Rice Research, 2011). Although, high input agriculture has certainly resulted in spectacular gains in productivity but it posses a threat to the environment resulting in adverse impact in the long run. Thus there is a need to preserve the natural balance with sustainable farming concept. Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment and emphasizes on maintaining the cycle of input-output with eco-friendly methods. The demand for organic food is steadily increasing both in developed and developing countries with an annual growth rate of 20-25 % (Ramesh et al., 2005). However the resource poor farmers are not able to use the recommended quantities in balanced proportion. This problem can be solved to a considerable extend by using available resources like crop residues, biofertilizer and organic manure. In today's context only few researches have been undertaken to find out the alternative sources of sustaining the productivity. The emerging scenario necessitates the need of adoption of the practice which maintains the soil health, keeps the production system more sustainable and provides quality food for meeting the nutritional requirement. Introduction of biofertilizers, crop residues, Green manures and their combination can serve as a means for sustainable organic based farming aimed at meeting the needs of the present generation without endangering the

resource for future generation.

2. Materials and Methods

A field experiment was conducted at the experimental research farm of School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, situated at 25°45′43″ N latitude and 93°53′04″ E longitude at an elevation of 310 m above mean sea level. The experiment was laid out in Randomized Block Design with three replications and 7 treatments. The treatments included T_1- *Sesbania aculeata* @ 6.25 t ha^{-1}, T_2- Green leaf manure @ 10 t ha^{-1}, T_3- Paddy straw @ 10 t ha^{-1}, T_4- *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed, T_5- Green leaf manure @ 10 t ha^{-1}+*Azotobacter*@ 20 g kg^{-1} seed, T_6- Paddy Straw @ 10 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed and T_7- Control. *Sesbania aculeata* was grown for 60 days and incorporated one month before sowing of rice. Green leaf manure and Paddy straw was incorporated one month and 6 weeks before growing of the rice crop respectively and properly irrigated everyday. Different sources of organic nutrients were applied according to the pre-planned doses made in each plot. So that well decomposition of organic manures would take place for the crop and thoroughly incorporated into the soil. Biofertilizer (*Azotobacter*) was applied as seed treatment method just before sowing the seed.

3. Results and Discussion

3.1. Growth attributes

It was observed that different organic sources of nutrients had significant influence on most of the plant growth attributes (Table 1). At 30 DAS, the plant height was not significantly influenced by different treatments. However, at 60 DAS, 90 DAS and at harvest, the application of *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} (T_4) seed recorded tallest plant (129.72 cm, 146.92 cm and 155.46 cm). This may be due to more availability of nutrients from *Sesbania aculeata* and biofertilizer activities. This finding was in accordance with Imayavaramban et al. (2004) observation who found out that application of FYM @ 12.5 t ha^{-1}, Green manure at 6.25 t ha^{-1}, and 100% of the recommended N, P_2O_5 and K_2O resulted in the highest values of growth parameters (plant height at harvest, number of tillers hill^{-1}, leaf area index and dry matter production at harvest), yield and yield parameters (number of panicles hill^{-1} and number of grains panicle^{-1}). Like plant height, number of tillers plant^{-1} at 30 DAS produced no significant influence between the treatments applied with organic sources of nutrients. The maximum tillers plant^{-1} (3.11, 3.62 and 4.39) was produced by the application of *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed (T_4) at 60 and 90 DAS and at harvest respectively. The increased in the number of tillers plant^{-1} might be due to favourable uptake of nutrients under the above treatments when compared to other treatments. These results are in line with the finding of Shanmugam and Veeraputhran (2000) who observed that application of either green manure (*Sesbania aculeata*) or FYM at 12.5 t ha^{-1} combined with *Azospirillum* (2 kg ha^{-1}) significantly increased the growth attributes of rice. Green manure with *Azospirillum* recorded significantly shorter period for 50% flowering, highest number of productive tillers m^{-2}, filled grain panicle^{-1}, panicle length and grain yield (5282 kg ha^{-1} and 5218 kg ha^{-1}).

The influence of organic sources of nutrients on the plant dry weight at 30 DAS was non-significant. Dry matter accumulation m^{-2} significantly increased with different sources of organic nutrient. The highest dry matter (84.21 g, 176.35 g and 444.2 g) accumulation was obtained with the application of *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed (T_4) at 60 DAS, 90 DAS and at harvest. This may be due to better growth characteristics due to more availability of nutrients from *Sesbania aculeata*+*Azotobacter*. This finding was in accordance with Hema and Swarajya (2008) who observed that organic manure and biofertilizer alone and in combination with inorganic N results in highest dry matter production and significantly increased the growth attributes of rice. Also supported by the observation of Naik and Yakadri (2004) who revealed that in situ green manuring and 150% N fertilizer gave the highest dry matter at harvest, effective tillers m^{-2}, filled grains panicle^{-1}, grain yield, straw yield, organic C content and benefit: cost ratio.

3.2. Yield attributes

It was observed that application of different organic sources of nutrients and their combinations had significant influence on the yield components (Table 2). The number of panicles m^{-2} was significantly influenced by the different sources of nutrients. It was observed that the maximum number of panicles m^{-2} (163.43) was obtained from the application of *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed (T_4). The highest number of grains panicle^{-1} (173.14) was also observed with the application of *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed (T_4). This might be due to more availability of nutrients from the given treatment. These results of panicle m^{-2} and number of grains panicle^{-1} are in accordance with the observation of Vaiyapuri and Sriramachandrasekaran (2002) who reported that incorporation of 12.5 t ha^{-1} of *Sesbania aculeata* recorded the highest plant height (87.3 cm), number of tillers hill^{-1} (15.4), LAI (7.9), number of panicles m^{-2} (296.7), number of filled grains panicle^{-1} (108.8), 1000-grain weight (21.0 g), grain yield (6.1 t ha^{-1}) and straw yield (7.9 t ha^{-1}) closely followed by *Sesbania speciosa and P. julifera.* It was observed that addition of organic nutrients, had no significant difference between the treatments on the length of panicle and fertility %.

Table 1: Effect of organic nutrients on growth attributes

Treatments	30	60	90	At harvest	30	60	90	At harvest	30	60	90	At harvest
T_1	45.99	114.31	127.68	129.18	1.15	2.72	3.17	3.80	9.73	79.69	150.76	344.90
T_2	45.91	103.41	120.70	130.17	1.13	2.12	2.88	3.5	9.20	72.22	139.09	320.85
T_3	45.07	100.03	123.74	125.91	1.04	2.06	2.72	3.45	9.02	71.25	138.35	259.09
T_4	47.72	129.72	146.92	155.46	1.33	3.11	3.62	4.39	11.44	84.21	176.35	444.2
T_5	46.91	115.58	135.56	139.68	1.31	3.04	3.41	4.27	10.15	81.90	162.95	381.97
T_6	45.54	111.01	134.36	138.25	1.07	2.87	3.21	4.07	10.14	81.07	151.14	375.88
T_7	41.08	86.92	109.63	113.16	0.92	1.8	2.50	3.12	7.97	61	129.82	242.6
SEm±	2.96	8.99	9.74	10.48	0.23	0.31	0.24	0.29	0.92	5.07	11.93	49.02
CD (p=0.05)	NS	19.58	21.23	22.83	NS	0.68	0.52	0.63	NS	11.06	26.00	106.81

T_1: *Sesbania aculeata* @ 6.25 t ha^{-1}; T_2-Green leaf manure @ 10 t ha^{-1}; T_3: Paddy Straw @ 10 t ha^{-1}; T_4: *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_5: Green leaf manure @ 10 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_6: Paddy Straw @ 10 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_7: Control

Table 2: Effect of organic nutrients on yield attributes

Treatments	Length of panicle (cm)	No of panicles m^{-2}	No of grains panicle^{-1}	Fertility %	1000 grain weight	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1	23.27	141.56	162.03	86.93	22.63	25.83	51.04	33.83
T_2	22.71	127.82	145.29	86.52	22.62	24.91	49.54	33.40
T_3	22.28	124.11	144.30	85.65	22.45	22.12	48.76	31.18
T_4	25.07	163.43	173.14	91.4	23.20	30.88	55.92	35.52
T_5	23.48	154.03	172.42	89.47	22.78	28.45	53.16	34.86
T_6	23.34	146.32	169.80	87.73	22.72	25.99	52.30	33.2
T_7	19.38	117.52	124.12	85.1	22.03	20.41	45.34	31.07
SEm±	1.52	11.00	12.58	2.70	0.63	2.45	2.40	2.50
CD (p=0.05)	NS	23.97	27.41	NS	NS	5.34	5.22	NS

T_1: *Sesbania aculeata* @ 6.25 t ha^{-1}; T_2-Green leaf manure @ 10 t ha^{-1}; T_3: Paddy Straw @ 10 t ha^{-1}; T_4: *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_5: Green leaf manure @ 10 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_6: Paddy Straw @ 10 t ha^{-1} +*Azotobacter* @ 20 g kg^{-1} seed; T_7: Control

The highest grain yield (30.88 q ha^{-1}) was observed under application of *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed (T_4). Higher grain yield recorded could be attributed to the higher yield components viz. number of panicles m^{-2} and number of grains panicle^{-1}. This result is in accordance with Singh et al. (2002) who observed that the incorporation of green manure, *Azotobacter* and FYM in combination with N fertilizer significantly increased grain and straw yield of rice. Result indicated that it was possible to sustain 18.92 q ha^{-1} of upland rice yield with the integrated use of green manure, FYM, *Azotobacter* and 30 kg N ha^{-1}. Higher grain yield could also be attributed to higher dry matter production and better uptake of nutrients. This is in accordance with the finding of Hemalatha et al. (1999) who studied the influence of organic, biofertilizers and inorganic forms of nitrogen on rice quality and found that grain yield were highest with *Sesbania aculeata* and 50% N+*Azospirillum*. Rualthankhuma and Sarkar, 2011 also investigated that biofertilizer in combination with organic manure had significantly increase the yield of rice. Roy and Srivastava (2009) also reported that integrated use of nitrogen fertilizer at 50% or 75% of recommended dose with inoculation of either *Azospirillum brasilense* or *Azotobacter chroococcum* is beneficial than 100% recommended dose of nitrogen fertilizer. Also supported by Pankaj et al. (2006) who observed that integrated nutrient management treatment having bio-organic sources like FYM, Green manure, crop residue and *Azolla/*

Azotobacter enhance nutrient availability which led to better nutrient uptake, ultimately leading to increase in yield. Addition of bio-organic sources of nutrients also maintained good soil health. The result indicated that the application of FYM+Green Manure+crop residue+*Azolla*+recommended fertilizer treatments are recommended for higher yields of rice. From the data recorded, the influence on the addition of different organic sources on the harvest index and test weight were found to be statistically non-significant.

3.3. Chemical characteristics of the soil

The result pertaining on the influence of organic nutrients alone or in combination with *Azotobacter* on the soil pH, soil organic carbon, and NPK had no significant difference (Table 3). However, it was found that application of *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed produced maximum (188.16 kg ha^{-1}) soil available N. The highest (17 kg ha^{-1} and 265.06 kg ha^{-1}) available P and available K were recorded in *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed (T_4) treated plot. The improved nutrient status of soil over initial values might be attributed to the mineralization of *Sesbania aculeata* and the contribution of fixed N by the biofertilizer. This study is in line with the report of Talathi et al. (2009) who observed that combined application of green manuring or FYM with chemical fertilizers significantly influenced the yield attributes and yield compared with sub optimal recommended dose of fertilizers and control. Application of organic manures or green leaf manures in conjunction with chemical fertilizers significantly influence the N, P and K uptake in grain and straw of rice compared to control. Pankaj et al. (2006) also observed that integrated nutrient management treatment having bio-organic sources like FYM, green manure, crop residue and *Azolla* or *Azotobacter* enhance nutrient availability which led to better nutrient uptake, ultimately leading to increase in yield. Addition of bio-organic sources of nutrients also maintained good soil health. The result indicated that the application of FYM+green manure+crop residue+*Azolla*+recommended fertilizer treatments are recommended for higher yields of rice. Chaphale et al. (2000) also observed that application of NPK at 100:50:50 kg ha^{-1} and green manure at 5 t ha^{-1} gave the highest grain and straw yields. Green manuring significantly increased soil water holding capacity, % porosity, organic C, total and available N, available P, and K content and decreased soil bulk density. DekaMedhi et al. (1996) also concluded that addition of N, regardless of N sources, increased grain yield significantly. Also *Sesbania rostrata*, *Sesbania aculeata*, FYM and Prilled Urea increased the availability and uptake of P, K, Fe and Mn by the rice plants.

Table 3: Effect of organic nutrients on the soil available NPK content, organic carbon, soil pH

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	OC (%)	Soil pH
T_1	169.17	12.85	252	1.34	4.81
T_2	148.32	12.08	226.95	1.26	4.77
T_3	143.78	11.77	226.91	1.17	4.76
T_4	188.16	17.00	265.06	1.65	5.05
T_5	181.84	16.56	263.07	1.47	5.00
T_6	173.53	16.09	258.48	1.31	4.94
T_7	142.17	11.35	219.06	1.08	4.72
SEm±	17.21	2.36	16.17	0.23	0.16
CD (p=0.05)	NS	NS	NS	NS	NS

T_1: *Sesbania aculeata* @ 6.25 t ha^{-1}; T_2-Green leaf manure @ 10 t ha^{-1}; T_3: Paddy Straw @ 10 t ha^{-1}; T_4: *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_5: Green leaf manure @ 10 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_6: Paddy Straw @ 10 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_7: Control

3.4. Economics

It was found that application of *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed gave the highest Gross return (₹ 33116.8) and Net return (₹ 20366.8) (Table 4). This findings is in accordance with Bajpai et al. (2002) who reported that green manuring with prickly sesban or dhaincha (*Sesbania aculeata*) to supplement 50% of the recommended nitrogen rate and the rest through inorganic fertilizer and 100% recommended rate of fertilizer to wheat crop gave the maximum yield of rice as well as wheat crops. The same treatment also gave the highest net returns and produced significantly higher biomass in terms

Table 4: Gross return, net return and benefit-cost ratio

Treatments	Cost of Cultivation (₹)	Gross return (₹)	Net return (₹)	B:C ratio
T_1	12700	27871.6	15171.6	2.19
T_2	11300	26891.6	15591.6	2.48
T_3	15300	24070.4	8770.4	1.57
T_4	12750	33116.8	20366.8	2.60
T_5	11350	30576.4	19226.4	2.69
T_6	15350	28082	12732	1.83
T_7	11300	22223.6	10923.6	1.97

T_1: *Sesbania aculeata* @ 6.25 t ha^{-1}; T_2-Green leaf manure @ 10 t ha^{-1}; T_3: Paddy Straw @ 10 t ha^{-1}; T_4: *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_5: Green leaf manure @ 10 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_6: Paddy Straw @ 10 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_7: Control

of rice equivalent yield. Also supported by the observation of Singh (2006) who revealed that green manure Dhaincha applied with 100% of recommended dose of NPK fertilizers gave the maximum yield of rice as well as wheat crop. This treatment also gave the highest net return and produced significantly higher biomass in terms of rice-equivalent yield. However the highest benefit cost ratio (2.69) was observed in Green leaf manure @ 10 t ha^{-1} (T_2) followed by *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed (T_4) i.e. 2.60.

4. Conclusion

From the investigation it can be concluded that among the different organic sources of nutrients, *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed proved best in significantly producing highest no of grains $panicle^{-1}$ (173.14), no of panicles m^{-2} (163.43)and yield (30.88 q ha^{-1}) of rice. The highest Gross return (₹ 33116.8) and Net return (₹ 20366.8) was also observed in *Sesbania aculeata* @ 6.25 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed treated plot, under agro-climatic condition of Nagaland. Further investigation is advisable before recommendation for farming.

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