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Effect of Biofertilizer on the Productivity of Terraced Upland Rice (*Oryza Sativa* L.)

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Abstract

An experiment was conducted in the experimental farm at School of Agricultural Sciences and Rural Development, Medziphema, Nagaland to observe the effect of different organic sources of nutrients on growth, yield and yield contributing characters of rice. The experiment was laid out in RBD replicated thrice with seven treatments i.e. Forest litter @ 20 t ha^{-1}, Farmyard manure (FYM) @ 12 t ha^{-1}, Poultry manure @ 4 t ha^{-1}, FYM @ 12 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed, Forest Litter @ 20 t ha^{1}+*Azotobacter* @ 20 g kg^{-1} seed, Poultry manure @ 4 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed and control. The plant dry weight was recorded to be highest in FYM @ 12 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed followed by Poultry manure @ 4 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed. FYM @ 12 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed treated plot also produced highest yield contributing characters like number of panicles m^{-2}, grain yield, straw yield, grains panicle^{-1}, fertility percentage and test weight. Further there was an increase available NPK status of the soil in plots treated with organic manures.

1. Introduction

Rice (*Oryza sativa* L.) is the most widely cultivated crop and the longest cultivated cereal in the world. It constitutes 23% of the global cereal acreage (680 mha) and contributes 29% to the global cereal production (2064 mt). Rice plays a vital role in our food as well as nutritional security for millions of livelihood. Thus the slogan "Rice is life" by IRRI during 2004 seems to be most appropriate (Chandrasekaran et al., 2007). Rice ranks second to wheat in terms of area harvested but in terms of importance as a food crop, rice provides more calories ha^{-1} than any cereal crop (De Dutta, 1981). Besides its importance as food, rice provides employment to the largest sector of the rural population in most of the Asia. With the burgeoning increase of population, demand for food is on high. It has been estimated that rice demand in 2025 will be 765 mt in the world. As per the recent data, rice production in the world in 2011 accounts to 722.5 mt. Upland rice is also known as aerobic rice mainly grown in Asia, Africa, and Latin America. In respect to production, China rank first with 202.66 mt of paddy (28% of global rice production), followed by India with 157.9 mt (22% of global production). At the world level, average rough paddy yield is more than 4428 kg ha^{-1} whereas in India it is India 3590 kg ha^{-1} (FAO Stat, 2013).

The North-eastern part accounts for 10.48% of country's total area with 6.46% of the total rice production (Bujarbaruah, 2004). The North-eastern states though occupies 0.466 mha with 0.734 mt production. The average productivity of milled rice (1761.86 kg ha^{-1}) is even below the national average productivity (2239 kg ha^{-1}) during 2011-12 (Agricultural Statistics at a glance, 2012). The state of Nagaland have an area of 1,56,400 ha under rice cultivation with a total production of about 2,50,000 mt (Anonymous, 2006). Upland condition has an area of 88,150 ha with a total production of 1,34,100 mt and terraces and irrigated lowland condition covers an area of 68,250 ha with a production of 1,29,000 mt (Anonymous, 2007). At present, around 800 cultivars of rice have been collected in few pockets of the state (Anonymous, 2007). Out of these cultivars, *Liekhomo* has desirable qualitative traits (aroma, cooking, quality, taste, nutritional value) but are low yielder. The cultivar is suited to lowland condition and are best adopted and give highest return at Medziphema and nearby areas having altitude of 1100 ft to 1400 ft above mean sea level. On an above, Dimapur is the highest rice growing district covering 27.64% area and 26.53% production in Nagaland (164.70'000 ha area and 263.52'000 t, respectively). However, average yield (1575 kg ha^{-1}) of this district is lesser than the average productivity (1600 kg ha^{-1}) of the state due to poor agronomic management practices (Directorate of Rice Development, 2009).

The important yield limiting factors are the water and mineral stress, diseases, insect pest, and weeds. To improve and/or stabilize yield, this yield limiting factors should be managed sustainably. Research data related to yield limiting factors indicate much work is needed to improve upland rice yield under different agro-ecosystems. Therefore, a technological breakthrough in agro-techniques especially in nutrient management should be taken in increasing productivity under upland rice condition.

2. Materials and Methods

The experiment was conducted at the research farm at SASRD, Medziphema, Nagaland, India during April to September 2010. The experimental site was located at 25°45'43''N and 93°53'04"E longitude at an elevation of 310 m above mean sea level. The experimental farm lies in humid to subtropical zone with an average rainfall from 2000-2500 mm. The mean temperature ranges from 21°C to 32°C during summer and rarely goes below 8°C in winter due to high atmospheric humidity. The fertility status of the soil were ascertained by taking soil sample from a depth of 0-20 cm from different location of experimental plot before initiation of the experiment and analyzed in the laboratory. The initial soil texture was sandy loam, soil pH was 4.6, and organic carbon 1.42%, available NPK was 150.53, 11.97 and 221.31 kg ha^{-1} respectively. A rice variety, *Liekhomo* (local) was used for the experiment at 20×15 cm^2 spacing with seven treatments replicated thrice in RBD. The treatments are Forest litter @ 20 t ha^{-1} (T_1), Farmyard manure (FYM) @ 12 t ha^{-1} (T_2), Poultry manure @ 4 t ha^{-1} (T_3), FYM @ 12 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed (T_4), Forest Litter @ 20 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed (T_5), Poultry manure @ 4 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed (T_6) and control (T_7).

Organic manures were applied one month before sowing according to the pre-planned doses, so that well decomposition would take place. Biofertilizer (*Azotobacter*) was applied as seed treatment method just before sowing the seed. To maintain the uniform plant population, thinning and gap filling were done time to time after sowing. Bio-pesticides Neemshield's and *Tricho* card were used for controlling insects.

Soil pH was determined by the Method no. 21 U.S.D.A. handbook no. 60 (Richards, 1954) and organic carbon was determined by Walkey and Black method as outlined by Jackson (1967). For available N, the procedure involves distillation of soil with alkaline potassium permanganate solution and determining the ammonia liberated. This serves as an index of the available (mineralizable) N status of the soil and was proposed as soil test for N by Subbiah and Asija (1956). Available phosphorus (P) was extracted with 0.03 N, NH_4F in 0.025 N HCl solutions. The procedure is primarily meant for soils, which are moderating to strongly acidic acid pH around 5.5 or less (Brays & Kurtz, 1945). Available potassium (K) was extracted from 5 g of soil by shaking with 25 ml of neutral ammonium acetate (pH 7) solution for half an hour and the extract was filtered immediately through a dry filter paper (Whatman no.1) and then potassium concentration in the extract was determined by Flame photometer (Hanway & Heidal, 1952). The data related to each character were analyzed statistically by applying the techniques of analysis of variance and the significant of different source of variations was tested by F test.

3. Results and Discussion

3.1. Growth and yield attributes

It was observed that different organic sources of nutrients had significant influence on growth and yield parameters (Table 1). The highest dry matter (448.2 g) accumulation was obtained by the application of FYM @ 12 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed. This may be due to better growth characteristics due to more availability of nutrients from FYM+*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. It was observed that the maximum number of panicles m^{-2} (165) was recorded with the application of FYM @ 12 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed, which was at par with all except forest litter @ 20 t ha^{-1}, poultry manure @ 4 t ha^{-1} and control. The highest number of grains $panicle^{-1}$ (176) was also observed with the same at par with all treatments except control. These results of panicle m^{-2} and number of grains $panicle^{-1}$ are in accordance with the observation of Solunke et al. (2006). He found from a field experiment that FYM 5 t ha^{-1}+100% of recommended dose of fertilizer (RDF@75:37.5:37.5 kg NPK ha^{-1}), FYM @ 5 t ha^{-1}+75% of RDF+biofertilizer (*Azotobacter*+PSB)+foliar spray of $FeSO_4$ at 0.5%) and FYM @ 5 t ha^{-1}+75% RDF+biofetilizer+foliar spray of $ZnSO_4$ at 0.5% were at par with each other. It was observed that with the addition of organic sources, there was no significant different between the treatments on the fertility percentage and test weight.

The highest grain yield (36.03 q ha^{-1}) was observed under application of FYM @ 12 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed seed which produced about 40%, 50% and 70% higher than poultry manure @ 4 t ha^{-1} , forest litter @ 20 t ha^{-1} and control, respectively. Higher grain yield recorded could be attributed to

Table 1: Effect of organic manures on growth, yield parameters and yield

Treatments	Dry weight (g)	No. of panicles m^{-2}	No. of grains $panicle^{-1}$	Fertility percentage (%)	Test weight (gm)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index
T_1	262.3	118.33	158.8	85.00	22.23	24.08	47.20	33.73
T_2	348.2	151.63	164.4	87.37	22.33	28.42	56.91	33.44
T_3	324.9	122.00	162.2	86.53	22.33	25.68	50.22	34.02
T_4	448.2	165.20	176.2	88.20	23.42	36.03	65.03	35.64
T_5	378.9	152.39	172.5	87.60	22.46	31.59	55.07	33.59
T_6	386.2	155.30	174.2	87.80	22.86	32.04	58.28	35.44
T_7	237.2	118.23	126.7	84.30	22.23	21.23	41.40	33.77
SEm±	51.14	15.39	13.76	1.19	0.54	3.66	4.75	4.02
CD (p=0.05)	111.43	33.53	29.98	NS	NS	7.97	10.36	NS

T_1: Forest litter @ 20 t ha^{-1}; T_2: Farmyard manure (FYM) @ 12 t ha^{-1}; T_3: Poultry manure @ 4 t ha^{-1}; T_4: FYM @ 12 t ha^{-1-} +*Azotobacter* @ 20 g kg^{-1} seed; T_5: Forest Litter @ 20 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed; T_6: Poultry manure @ 4 t ha^{-1-} +*Azotobacter* @ 20 g kg^{-1} seed and T_7: control

the higher yield components viz. number of panicles m^{-1} and number of grains $panicle^{-1}$. Rualthankhuma and Sarkar (2011) also recorded that *Azospirillum*+FYM @ 9 t ha^{-1} was the most effective in influencing yield contributing characters and yield for direct seeded upland rice. This result is in accordance with Acharya and Mondal (2010), also supported by the observation of Majumder et al. (2007) who reported that yield, N, P and K uptake by paddy and various forms of N in the soil increased significantly with applied N, FYM and nitrogen fixing bacteria. A combined dose of 60 kg N ha^{-1}, 5 t FYM ha^{-1} and seed inoculation with *Azotobacter* was the most suitable treatment for upland paddy production (3.9 t ha^{-1}).

Similar trends were also noticed where application of FYM @ 12 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed produced the maximum straw yield (65.03 q ha^{-1}) which was also significantly higher than poultry manure @ 4 t ha^{-1}, forest litter @ 20 t ha^{-1} and control. Higher straw yield could also be attributed to higher dry matter production and better uptake of nutrients. This is in accordance with the finding of Singh and Bijayath (2006) in which application of *Azospirillum* and FYM showed superiority in terms of grain yield (5.6 t ha^{-1}) and straw yield (6.7 t ha^{-1}), number of spikelet's $panicle^{-1}$ (135), 1000 grain weight (29.5 g). Influence of the different organic sources on the harvest index is found to be statistically non-significant.

3.2. Chemical characteristics of the soil

The result pertaining on the influence of organic manures alone or in combination with *Azotobacter* on the soil pH and soil organic carbon had no significant difference (Table 2). However, it was found that application of organic manure had significant influence on the soil NPK. Among the manurial treatments, maximum (204.88 kg ha^{-1}) soil available N was recorded with FYM @ 12 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} which was significantly higher than forest litter @ 20 t ha^{-1} only. For available soil phosphorous also, similar trend was observed. The same superior treatment was statistically at par with the all treatments except forest litter @ 20 t ha^{-1} and control. The same also recorded highest (280.22 kg ha^{-1}) available K which was significantly higher than forest litter @ 20 t ha^{-1}, poultry manure @ 4 t ha^{-1} and control. The improved nutrient status of soil over initial values might be attributed to the mineralization

Table 2: Effect of organic manures on the soil organic carbon, soil pH, available NPK content

Treatments	Organic carbon	Soil pH	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1	2.70	4.73	150.53	13.68	233.41
T_2	2.80	4.98	183.98	15.39	262.98
T_3	2.80	4.88	158.89	14.53	236.54
T_4	3.63	5.13	204.88	19.66	280.22
T_5	3.07	5.03	175.61	17.10	269.69
T_6	3.33	5.11	188.16	18.81	279.55
T_7	2.37	4.66	137.98	11.95	226.69
SEm±	0.73	0.43	15.54	2.19	17.74
CD (p=0.05)	NS	NS	33.86	4.76	38.65

of FYM and the contribution of fixed N by the biofertilizer. Pankaj et al. (2006) was 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. The result indicated that the application of FYM+green manure+crop residue+*Azolla*+RDF are recommended for higher yields of rice. Bhardwaj and Omanwar (1994) also observed that continuous cropping without fertilization depleted not only soil organic matter (SOM) but also available nutrient sources. Integrated use of chemical fertilizers and FYM enhanced the SOM and available NPK status in the soil. Integrated use of FYM along with optimal NPK (100% NPK) for 14 years maximized the total microbial population including *Azotobacter* and Bacteria on acid red loam of Ranchi.

4. Conclusion

FYM @ 12 t ha^{-1}+*Azotobacter* @ 20 g kg^{-1} seed proved best nutrient management practice for terrace rice cultivation not only producing highest yield and yield attributes but also in improving available nutrients under agro-climatic condition of Nagaland.

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