Indian Journal of Agronomy **58** (4): 517–520 (December 2013)

Research Paper

Sustainable nutrient management in *jhum* rice (*Oryza sativa*) under bush-fallow agriculture

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Received : March 2013; Revised accepted : November 2013

ABSTRACT

A field experiment was conducted during rainy (*kharif*), seasons of 2008 and 2009 at a *jhum* field in a north-eastern state of Manipur with a local rice (*Oryza sativa* L.) cultivar locally known as 'Chang-ngat'. Application of a low dose of fertilizers (25 kg N, 20 kg P_2O_5, 12.5 kg K_2O/ha) in conjunction with rice husk ash (RHA) @15 t/ha) resulted in optimum productivity and higher net returns,

***Key words*:** Compost, Fertilizer, FYM, *Jhum* rice, Nutrient, Management, Rice husk ash

The resource poor tribal farmers of the North-east India have been deprived of the modern technologies of cultivation including externally managed inputs to augment the low rice production. The low, negligible or no profit associated bush-fallow agriculture or *jhum/*shifting cultivating is still the only option owing to their socio-economic condition and physiographic location. Rapid degradation of the soils through erosion of topsoil, loss of forest cover and desertification, forest fires, loss of flora and fauna and beneficial microorganisms, destruction of biodiversity/ ecosystem are the ill-effects of *jhum* rice cultivation more severe in the north-eastern India (Raman *et al.*, 1998). Cropping on *jhum* fallows in north-eastern India is predominantly done for one year in a *jhum* cycle. If second year cropping is done, expanse of the forest land required for slashing and burning could be reduced significantly. The soil fertility decreases rapidly in the second year and is very poor in the third year. The cultivation during the third year and beyond is usually uneconomical (Tawnewnga *et al.*, 1996). Owing to economic condition, farmers are reluctant to adopt modern technologies including nutrient management for higher productivity. This pose a big challenge of technological intervention.

Nutrient deficiencies are commonly observed in bush-fallow agriculture in rice more so, after one year of cultivation on the same field. Nitrogen and phosphorus deficiencies are the most important nutrient disorders in upland conditions, while potash has been substituted with ash from burning after slash-and-burn operation during the first year *jhum* cultivation. Rice husk ash (RHA), which is wasted mostly during rice dehusking and milling has been utilized beneficially in agriculture owing to its fair content of potash and other micro-elements. The husk is not easily decomposed and without burning, it has no significant role in soil fertility. It contains 80.26% silica, 0.38% phosphorus, 1.28% potassium, 0.21% magnesium and 0.56% Ca (Hashim *et al.,* 1996). Compost made from water hyacinth contains 2.02% N, 1.10% P_2O_5, 2.5% K_2O and 3.9% lime with a C:N ratio of 13 (Bates *et al.,* 1976). Being low in nutrient content, the amount of these elements in organic nutrient sources may be insufficient for better plant growth. Therefore, application of chemical fertilizers can be a good practice to fulfil the upland rice nutrient requirements provided, the system is economical. Keeping this in view, the experiment was conducted to find out the best nutrient source combination, economics and possibility of widening the *jhum* cycle for ecosystem stability.

MATERIALS AND METHODS

The investigation was conducted during the rainy season (*kharif*) of 2008 and 2009 after a year of utilization of the initial soil fertility during the first traditional *jhum* cultivation by the farmers in the previous year. The average temperature during the 2 years was 28–32 °C, while the annual precipitation was 1,150–1,240 mm. The experimental site was at 24°25' 843 N, 94°03' 210 E with a unique physiographic landscape situated at 800–1,000 m-amsl. The soil was silty clay with pH 5.5, 1.0% organic

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carbon, and available N, P_2O_5 and K_2O at 255, 24 and 60 kg/ha, respectively. The experiment comprised treatment combinations, involving 3 levels each of N (25, 50 and 75 kg/ha), P_2O_5 (20, 40 and 60 kg/ha) and K_2O (12.5, 25 and 37.5 kg/ha), compost (7.5, 10 and 15 t/ha), FYM (7.5, 10 and 15.0 t/ha) and rice husk ash (7.5, 10 and 15 t/ha) and a no fertilizer, no manure control (the traditional method, (Table 2). The treatments were laid out in a 15 m^2 plot (5m × 3m) in randomized block design (CRBD) with 3 replications in log contour plot fashion (to reduce soil erosion) against 25% slope of the field site. Seeds were sown in the first fortnight of April during both the years by hand dibbling 2–3 seeds/hill with a spacing of 30cm × 15cm. Compost was made by pit composting of crop residues, vegetable wastes and different weed foliages (water hyacinth dominated). Nitrogen was applied in three splits, one-fourth at sowing, half at tillering and the remaining one-fouth at booting stage. Full quantities of compost, rice husk ash, P and K were applied during land preparation, a week before sowing the seeds. Laboratory and statistical analyses were done as per standard procedures. Nutrient composition of plant nutrient sources is given in (Table 1). Data for all the biometric parameters were recorded at harvest from 5 random plants from each plot. Harvesting was done in the first week of November on 80% maturity in both the years. Seed and straw yields/ha were worked out based on yields record in each plot. At maturity, plant sample for nitrogen, phosphorus and potassium content in grain and straw were analysed by following standard methods. Uptake of these nutrients in grain and straw was worked out by multiplying grain and straw yield under different treatments with the respective content of each nutrient.

Table 1. Major nutrient composition of FYM, RHA and compost used in the present study

Nutrient sources	N (%)	P (%)	K (%)
FYM	0.55	0.22	0.58
RHA	0.15	0.35	1.25
Compost	2.00	1.20	2.20

FYM, Farmyard manure; RHA, rice husk ash

RESULTS AND DISCUSSION

Growth and yield characters

Application of fertilizer and manure significantly increased plant height and flag leaf length (Table 2). N:P:K @ 75:60:37.5 kg/ha + RHA 7.5 t/ha or 50:40:25 N:P:K kg + RHA 10 t/ha gave significantly taller plants than other fertilizer treatments. The results show that RHA can partly substitute for inorganic fertilizers. Combined application of fertilizers and manures significantly increased tillers/plant, filled grains/panicle, panicle length and test weight over control (Table 2). With 50:40:25 kg NPK/ha or 75:60:37.5 kg NPK/ha application of compost produced significantly lesser tillers/plant, than their combination with FYM or RHA. This was also true for filled grains/panicle at 50:40:25 kg N:P:K/ha. Filled grains/panicle were maximum with 50:40:25 kg N:P:K/ha + FYM 10 t/ha, which were significantly more than 25:20:12.5 kg N:P:K/ha with compost or HRA. Panicle length was maximum with 75:60:37.5 kg N:P:K/ha + RHA 7.5 t/ha, and was significantly more than lower levels of NPK. Different fertilizer and manure treatments did not differ significantly in respect of test weight. This behaviour of treatments may be attributed to differential availability of major and minor nutrients under different treatments. Naing Oo *et al.* (2010) also reported that combining FYM with inorganic fertilizers increased growth characters and yield attributes of rice. Our results support the findings of Dunsmore (1970), who reported that yield of *jhum*/upland rice increased significantly when higher dose of N is applied with phosphorus.

Grain and straw yield

All fertilizer and manure treatments significantly increased grain and straw yields of rice as compared to control; however, the differences between treatments were narrow (Table 4). All the treatments showed better performance on plant growth and yield attributes over no-input applied control. Our results confirm the findings of Dunsmore (1970). Application of NPK levels above the lowest rate (25:20:12.5 kg NPK/ha) with FYM or RHA did not significantly increase rice grain yield, but it did so in the case of compost. Lack of increase in rice grain yield due to higher fertility level could be due to use of local low potential, less fertilizer responsive rice variety. The compost in this study performed poorer than FYM or RHA. The RHA has oxides of Ca, Mg and Na and these could help in in improving soil pH. Nottidge *et al*. (2009) also reported that, RHA application could increase the pH value of the soil from the initial value of 5.16 to 6.20. The advantage of compost in increasing rice yield as reported by Gupta and O'Toole (1986) and Rajkhowa *et al.* (2002) was not observed in the present study in the presence of chemical fertilizer. In the present study, inorganic and organic sources were studied together as suggested by Yankaraddi *et al*. (2009).

NPK uptake

N, P and K uptake increased with an increase in the rate of N, P and K and the highest N, P and K uptake was recorded with 75:60:37.5 kg NPK/ha + RHA 7.5 t/ha (Table 3). The advantage of RHA over organic manures is certainly noticeable and causes for need to be studied in future experiments. At all the three levels of NPK fertilization NPK uptake was the lowest in the presence of compost. Results support the findings of Singh and Modgal (1978).

Table 2. Effect of nutrient sources on grwoth and yield attributes of *jhum* rice (pooled mean of 2 years)

Treatment	Plant height (cm)	Flag-leaf length (cm)	Tillers/ plant	Filled grains/ panicle	Panicle length (cm)	Test weight(g)
Control	121.1	23.6	6.9	72.8	15.2	24.4
25:20:12.5 kg NPK/ha + 15 t compost /ha	132.8	27.7	8.5	90.8	17.6	27.0
25:20:12.5 kg NPK/ha + FYM 15 t/ha	130.8	28.7	9.8	92.7	17.3	27.4
25:20:12.5 kg NPK/ha + RHA 15 t/ha	128.0	27.1	8.0	83.6	16.8	27.5
50:40:25 kg NPK/ha + 10 t compost/ha	130.8	28.9	7.9	88.3	16.3	28.0
50:40:25 kg NPK/ha + 10 t FYM/ha	130.4	27.9	9.1	101.3	16.3	27.0
50:40:25 kg NPK/ha + 10 t RHA/ha	143.1	30.2	9.4	94.4	17.6	28.7
75:60:37.5 kg NPK/ha + 7.5 t compost/ha	139.0	29.1	7.6	96.1	16.5	28.1
75:60:37.5 kg NPK/ha +7. 5 t FYM/ha	134.5	28.4	9.3	89.8	17.3	28.4
75:60:37.5 kg NPK/ha + 7.5 t RHA/ha	143.9	29.9	9.9	94.6	18.0	28.7
SEm±	2.1	0.9	0.4	3.2	0.6	0.3
CD (P=0.05)	6.2	2.6	1.0	9.4	1.9	0.9

Table 3. Effect of nutrient sources on total N, P and K uptake (grain+straw) of *jhum* rice (pooled mean of two years)

Treatment	N uptake(kg/ha)	P uptake(kg/ha)	K uptake(kg/ha)
Control	26.6	13.3	32.1
25:20:12.5 kg NPK/ha + compost 15 t/ha	36.5	15.8	50.8
25:20:12.5 kg NPK/ha + FYM 15 t/ha	42.9	17.2	53.9
25:20:12.5 kg NPK/ha + RHA 15 t/ha	40.9	17.0	54.0
50:40:25 kg NPK/ha + 10 t compost/ha	36.5	19.1	52.5
50:40:25 kg NPK/ha + 10 t FYM/ha	45.1	21.1	55.7
50:40:25 kg NPK/ha + 10 t RHA/ha	45.7	20.4	51.3
75:60:37.5 kg NPK/ha + 7.5 t compost/ha	48.3	19.4	51.1
75:60:37.5 kg NPK/ha +7. 5 t FYM/ha	47.3	21.0	54.3
75:60:37.5 kg NPK/ha + 7.5 t RHA/ha	49.6	21.1	59.5
SEm±	1.5	0.5	1.6
CD (P=0.05)	4.3	1.4	4.6

Table 4. Effect of nutrient sources on grain and straw yields, harvest index (HI) and economics of *jhum* rice cultivation (pooled data of 2 years)

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	HI (%)	Cost of cultivation (×10^3 ₹/ha)	Gross returns (×10^3 ₹/ha)	Net returns (×10^3 ₹/ha)	Benefit : cost ratio
Control	0.9	1.7	34.9	7.8	11.7	3.9	0.5
25:20:12.5 kg NPK/ha + compost 15 t/ha	1.3	2.4	35.4	13.3	27.4	14.1	1.1
25:20:12.5 kg NPK/ha + FYM 15 t/ha	1.5	2.6	35.8	17.1	30.1	13.0	0.8
25:20:12.5 kg NPK/ha + RHA 15 t/ha	1.5	2.7	34.9	11.8	30.2	18.3	1.5
50:40:25 kg NPK/ha + 10 t compost/ha	1.3	2.2	36.3	13.9	25.8	12.0	0.9
50:40:25 kg NPK/ha + 10 t FYM/ha	1.4	2.5	36.7	16.4	27.8	11.4	0.7
50:40:25 kg NPK/ha + 10 t RHA/ha	1.4	2.5	37.0	12.9	29.6	16.7	1.3
75:60:37.5 kg NPK/ha + 7.5 t compost/ha	1.5	2.5	36.1	15.1	30.6	15.5	1.0
75:60:37.5 kg NPK/ha +7. 5 t FYM/ha	1.5	2.6	37.9	16.9	31.5	14.6	0.9
75:60:37.5 kg NPK/ha + 7.5 t RHA/ha	1.5	2.7	38.2	14.3	30.8	16.5	1.1
SEm±	0.04	0.06	0.9	-	-	-	-
CD (P=0.05)	0.11	0.17	2.6	-	-	-	-

Cost of fertilizers (Urea, SSP & MOP), 8.25, 9.25 and 9.25/kg respectively; Cost of FYM, Compost and RHA**,** 500, 250 and 150/t respectively; sale rate of paddy, 19,000; sale rate of straw, 1,000/t

Economics

Economics of cultivation revealed the profitability of the different treatment combinations (Table 4). The integrated treatment of 25 kg N, 20 kg P_2O_5, 12.5 kg K_2O/ha + RHA @ 15 t/ha fetched maximum net returns (₹18,300) and the highest: benefit: cost ratio (1.50). The next economical treatment with net returns and benefit: cost ratio of ₹16,700 and 1.30 was 50 kg N, 40 kg P_2O_5, 25 kg K_2O/ha + RHA 10 t/ha. Low-cost rice husk ash with fair nutrient supplementation and lower application rates of synthetic fertilizer might have attributed to higher economics of cultivation and profitability. Control (traditional method) recorded the lowest net returns, showing minimum benefit: cost ratio as compared to rest of the treatment combination.

It was concluded that in *bush*-fallow system with the traditional low yield potential rice cultivars in the north-eastern states, application of a low dose of fertilizers (25 N, 20 P_2O_5, 12.5 K_2O kg/ha) in conjunction with RHA @15 t/ha) results in optimum productivity and better net returns.

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