

Sustainable nutrient management in aerobic finger millet (*Eleusine coracana* (L.) Gaertn) under rainfed agriculture

ABSTRACT

The field experiment was conducted during the rainy (*Kharif*) seasons of 2011 and 2012 at Bastar district of Chhattisgarh with local finger millet (*Eleusine coracana* L. Gaertn) locally known as 'Mandiya'. The soil was sandy loam, low in organic carbon (0.43%), and available N (178 kg/ha), P (21.4kg/ha), medium in K (179 kg/ha) available with almost neutral (pH 6.8) in reaction. Application of fertilizer and manure significantly increased plant height and flag leaf length; N:P:K @ 40:30:15 kg/ha + 7 t/ha [What?](#) or 50:40:20 N:P:K kg/ha + Rice husk ash 4t/ha gave significantly taller plants, flag leaf length, tillers/hill, filled grains/finger and finger length than other fertilizer treatments alongwith Rice husk ash (RHA). Application of NPK above the level of 30:20:10 kg NPK/ha + FYM ([please write clear name](#)) or RHA did not significantly increase finger millet grain yield. Higher net returns were produced when lower levels of NPK was applied alongwith RHA.

Key words: Compost, FYM, finger millet, Nutrient Management, Rice husk ash

The resource poor tribal farmers of southern Chhattisgarh have been deprived of modern technologies of cultivation including externally managed inputs to augment the finger millet production. The low, negligible or no profit associated rainfed (aerobic) agriculture is still the only option owing to their socio-economic condition and physiographic location. Rapid degradation of the soils, through erosion of top soil, loss of forest cover desertification, forest fires, loss of flora and fauna, beneficial microorganisms, destruction of biodiversity/ecosystem are the ill-effects of finger millet cultivation or more severe in such parts of India (Raman *et al.*, 1998). Cropping on fallows is predominantly done for one year in a cycle; if second year cropping is done, cost of inputs on land would be increased significantly and also 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. These pose a big challenge for technological intervention.

Nutrient deficiencies are very commonly observed in aerobic/rainfed agriculture in finger millet. Especially, 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 existing soil *i.e.* remaining was maintained in dose during the first year of 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 without burning, that is why it was burned for rice ash. 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% P₂O₅, 2.5% K₂O and 3.9% Ca with a C: N ratio of 13 (Bates *et al.*, 1976). Being low in nutrient content, the amount of these elements in organic sources may be insufficient for better plant growth. Therefore, conjunctive application of chemical fertilizers and organic manures can be a good practice to fulfill the nutrient requirements of upland finger millet provided (the system is economical). Keeping this in view, the experiment was conducted to assess the best nutrient source combination, economics and possibility of ecosystem stability.

MATERIALS AND METHODS

The investigation was conducted during the rainy (*Kharif*) seasons of 2011 and 2012. The soil was sandy loam, low in organic carbon (0.43%) and N (178 kg/ha), medium in available P (21.4kg/ha), K (179 kg/ha) with almost neutral (pH 6.8) condition. The experiment comprised of different treatment combinations, involving 3 levels each of N (30, 40 and 50 kg/ha) with P₂O₅ (20, 30 and 40 kg/ha) and K₂O (10, 15 and 20 kg/ha), compost (10, 7 and 4 t/ha), FYM [please write clear name](#) (10, 7 and 4 t/ha) and Rice husk ash (10, 7 and 4 t/ha) and absolute control (the traditional method). The treatments were laid out in 25m² plot (5m×5m) in Randomized Block Design [Please check the test desing. Because there are 3 different NPK doses and 3 different applications and controls. It should be in split parcel or factorial design.](#) (RBD) with three replications. Seeds were sown in the last fortnight of June during both the years by seed cum fertilizer drill at a spacing of 30cm× 8cm. Compost was made by pit composting of crop residues, vegetable wastes and different weed foliage (water hyacinth dominated). Nitrogen was applied in two equal splits, half at sowing, half at 30 days after sowing. Entire quantities of compost, Rice husk ash, required phosphorus and potash 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 10 random plants from each plot. Harvesting was done in the first week of November on synchronized maturity in both the years. Seed and straw yields were recorded in each plot and expressed in kg/ha at maturity, plant sample for nitrogen, phosphorus and potassium content in grain and straw were analyzed 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.

RESULTS AND DISCUSSION [literature search is less, literature is out of date or not new.](#)

Growth and yield characters

Application of fertilizer and manure significantly increased plant height and flag leaf length (Table 2). Being at par each others, N:P:K @ 40:30:15 kg/ha+ RHA 7 t/ha and 50:40:20 N:P:K kg + 4 t/ha RHA or compost gave significantly taller plants than other treatments. The results showed that RHA can partly substitute for inorganic fertilizers. Combined application of fertilizers and manures significantly increased tillers/plant, filled grains/finger and finger length over control as in Table 2. 40:30:15 kg or 50:40:20 kg NPK/ha +application of compost produced significantly lesser tillers/plant, than combination with FYM or RHA [This statement does not seem clear in table 2. Please check and explain again.](#) This was also true for filled grains/finger at 40:30:15 kg N:P:K/ha. Filled grains/finger were maximum with 40:30:15 kg N:P:K/ha + FYM 7 t/ha, which were significantly higher than 30:20:10 kg N:P:K/ha with compost or HRA. Finger length was maximum with 50:40:20 kg N:P:K/ha + RHA [74](#) t/ha, and was significantly higher than lower levels of NPK. Different fertilizer and manure treatments did not differ significantly in respect of test weight. This behavior 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 of FYM with inorganic fertilizers increased growth characters and yield attributes. The results confirm the findings of Singh (2006), who reported that yield of upland rice increased significantly when higher dose of N was applied with phosphorus.

Grain and straw yield

All fertilizer and manure treatments significantly increased grain and straw yields of finger millet 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 than control. The results confirm the findings of Singh (2006). Application of NPK levels above the lowest rate (30:20:10 kg NPK/ha) with FYM or RHA did not significantly increase finger millet grain yield except in the case of compost. Lack of increase in finger millet grain yield at higher fertilizer level could be due to use of low potential, less fertilizer responsive local finger millet variety. The compost in alongwith NPK at lower doses performed poorer than FYM or RHA. The RHA has oxides of Ca, Mg and Na and these could help 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 5.06 to 6.05. The advantage of compost in increasing finger millet yield was reported by Pradhan (2010). [Check it. It is not compatible with references](#). In the present study, inorganic and organic sources were studied together as earlier 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 (kg/ha) was recorded with 50:40:20 kg NPK/ha + RHA 7.4 t/ha (Table 3). The advantage of RHA over organic manures is certainly noticeable and causes for increase the uptake need to be studied further in future. At all the three levels of NPK fertilization, NPK uptake was the lowest in compost [except for N uptake to 50:40:20 kg NPK/ha](#). These results are accordance to the findings of Singh and Modgal (1978).

Economics

Economics of cultivation revealed the profitability of the different treatment combinations (Table 4). The integrated treatment of 30 kg N, 20 kg P₂O₅, 10 kg K₂O/ha +RHA @ 10 t/ha fetched maximum net returns (Rs. 21640) and the highest: benefit: cost ratio (1.77). The next economical treatment with net returns and benefit: cost ratio of Rs 19750/ha and 1.34 [Check it, there is an error](#) was with 40 kg N, 30 kg P₂O₅, 15 kg K₂O/ha + RHA 7 t/ha [Check it, there is an error](#). 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 (Rs), with minimum benefit: cost ratio (0.59) as compared to rest of the treatments.

It was concluded that under aerobic rainfed system, for traditional finger millet varieties with low yield potential in southern Chhattisgarh, application of low dose of fertilizers (30 N, 20 P₂O₅, 10 K₂O kg/ha in conjunction with RHA @ 10t/ha) can to be recommended for obtaining good yields with better net returns.

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Table1. Major nutrient composition of FYM, RHA and compost

Nutrient source	N (%)	P (%)	K (%)
FYM	0.56	0.22	0.58
RHA	0.15	0.36	1.24
Compost	2.01	1.22	2.21

Table2.Effect of nutrient sources on growth and yield attributes of rainfed finger millet (pooled data of 2011 and 2012)

Treatment	Plant height (cm)	Flag leaf length (cm)	Tillers/hill	Filled grains/ finger	finger length (cm)	Test weight (g)
Control	129.6	24.3	1.7	232.9	6.8	6.1
30:20:10 kg NPK/ha + 10 t compost/ha	142.1	28.5	2.1	290.5	7.9	6.7
30:20:10 kg NPK/ha + 10 t FYM/ha	139.9	29.5	2.4	296.6	7.7	6.8
30:20:10 kg NPK/ha + 10 t RHA/ha	136.9	27.9	2.0	267.5	7.5	6.8
40:30:15 kg NPK/ha + 7 t compost/ha	139.9	29.7	1.9	282.5	7.3	7.0
40:30:15 kg NPK/ha + 7 t FYM/ha	139.5	28.7	2.2	324.1	7.3	6.7
40:30:15 kg NPK/ha + 7 t RHA/ha	153.1	31.1	2.3	302.0	7.9	7.2
50:40:20 kg NPK/ha + 4 t compost/ha	148.7	29.9	1.9	307.5	7.4	7.0
50:40:20 kg NPK/ha + 4 t FYM/ha	143.9	29.2	2.3	287.3	7.7	7.1
50:40:20 kg NPK/ha + 4 t RHA/ha	153.9	30.8	2.4	302.7	8.1	7.2
SEM±	2.2	0.9	0.1	10.2	0.2	0.1
CD (P=0.05)	6.6	2.6	0.2	30.1	0.8	NS

174 **Table3. Effect of nutrient sources on total N, P and K uptake (grain+straw) of rainfed finger millet (pooled data of**
 175 **2011 and 2012)**

176	Treatment	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
	Control	26.7	13.5	32.7
	30:20:10 kg NPK/ha + 10 t compost/ha	37.2	16.1	51.8
	30:20:10 kg NPK/ha + 10 t FYM/ha	43.7	17.5	54.9
	30:20:10 kg NPK/ha + 10 t RHA/ha	41.7	17.3	55.0
	40:30:15 kg NPK/ha + 7 t compost/ha	37.2	19.4	53.5
	40:30:15 kg NPK/ha + 7 t FYM/ha	46.0	21.5	56.8
	40:30:15 kg NPK/ha + 7 t RHA/ha	46.6	20.8	52.3
	50:40:20 kg NPK/ha + 4 t compost/ha	49.2	19.7	52.1
	50:40:20 kg NPK/ha + 4 t FYM/ha	48.2	21.4	55.3
	50:40:20 kg NPK/ha + 4 t RHA/ha	50.5	21.5	60.6
	SEM±	1.5	0.5	1.6
	CD (P=0.05)	4.3	1.4	4.6

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179 **Table4. Effect of nutrient sources on grain and straw yields, harvest index (HI) and economics of rainfed finger**
 180 **millet (pooled data of 2011 and 2012)**

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	HI (%)	Cost of cultivation (X10 ³ Rs/ha)	Gross returns (X10 ³ Rs/ha)	Net returns (X10 ³ Rs/ha)	Benefit: cost ratio
Control	0.7	1.1	36.1	9.2	13.8	4.6	0.59
30:20:10 kg NPK/ha + 10 t compost/ha	1.6	3.0	36.6	15.7	32.4	16.6	1.30
30:20:10 kg NPK/ha + 10 t FYM/ha	1.8	3.2	37.0	20.2	35.5	15.3	0.95
30:20:10 kg NPK/ha + 10 t RHA/ha	1.8	3.3	36.1	13.9	35.7	21.6	1.77
40:30:15 kg NPK/ha + 7 t compost/ha	1.6	2.7	37.6	16.3	30.5	14.1	1.06
40:30:15 kg NPK/ha + 7 t FYM/ha	1.7	3.1	38.0	19.3	32.8	13.4	0.83
40:30:15 kg NPK/ha + 7 t RHA/ha	1.7	3.1	38.3	15.2	35.0	19.7	1.54
50:40:20 kg NPK/ha + 4 t compost/ha	1.8	3.1	37.3	17.8	36.1	18.3	1.18
50:40:20 kg NPK/ha + 4 t FYM/ha	1.8	3.2	39.2	19.9	37.2	17.2	1.06
50:40:20 kg NPK/ha + 4 t RHA/ha	1.8	3.3	39.	16.9	36.4	19.5	1.30
SEM±	0.05	0.08	0.93	-	-	-	-
CD (P=0.05)	0.14	0.21	2.69	-	-	-	-

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 182 *Cost of fertilizers (Urea, SSP & MOP) Rs. 8.25, 9.25 and 9.25 kg/ha respectively; Cost of FYM, Compost and HRA, Rs.
 183 500, 250, and 150/t respectively; sale rate of paddy, Rs 19000 and selling rate of straw, 1000/t