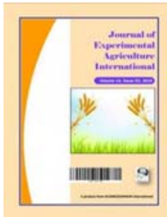

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Sustainable Nutrient Management in Aerobic Finger Millet (*Eleusine coracana* (L.) Gaertn) under Rainfed Agriculture

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The poor resource growers of southern Chhattisgarh have 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. 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*' for assessing the sustainability of finger millet productivity. The soil was sandy loam, low in organic carbon (0.43%), and available N (178 kg/ha), P (21.4 kg/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 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 along with Rice husk ash (RHA). Application of NPK above the level of 30:20:10 kg NPK/ha + FYM or RHA did not significantly

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increase finger millet grain yield. Higher net returns were produced when lower levels of NPK was applied along with RHA.

Keywords: Compost; FYM; finger millet; nutrient management; rice husk ash.

1. INTRODUCTION

The resource-poor tribal farmers of southern Chhattisgarh have 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 topsoil, 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 [1]. 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 [2]. 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 [3]. 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 appropriate 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 [4]. Compost made from water hyacinth contains 2.02% N, 1.10% P_2O_5, 2.5% K_2O and 3.9% Ca with a C: N ratio of 13 [5], 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 fertilisers and organic manures can be a good practice to fulfil 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.

2. MATERIALS AND METHODS

The investigation was conducted during the rainy (*Kharif*) seasons of 2011 and 2012 coordinating 19°05'30" N latitude and 81°57'45" E longitude and an altitude of 563 meters. 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 P_2 O_5 (20, 30 and 40 kg/ha) and K_2 O (10, 15 and 20 kg/ha), compost (10, 7 and 4 t/ha), FYM (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 the 25 m^2 plot (5 m×5 m) in Randomized Block 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× 8 cm. 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 modified Kjeldahl methods, phosphorus content by [6] and potassium content by flame photometer method, as described [7] and calcium by Atomic absorption spectrophotometry [8]. Statistical analysis was done using the method suggested [9]. 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. The 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

3. RESULTS AND DISCUSSION

3.1 Growth and Yield Characters

Application of fertilizer and manure significantly increased plant height and flag leaf length (Table 2). Being at par each other, 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 could partly substitute for inorganic fertilizers. The 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 a combination with FYM or RHA. 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 7 t/ha, and was significantly higher than lower levels of NPK. Different fertiliser and manure treatments did not differ significantly in respect of test weight. This behaviour of procedures may attribute to the differential availability of major and minor nutrients under different treatments. it was also reported that combining of FYM with inorganic fertilisers increased growth characters and yield attributes [10]. The results confirm the findings [11], who stated that yield of upland rice increased significantly when a higher dose of N was applied with phosphorus.

3.2 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 [11]. 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 using of low potential, less fertilizer responsive local finger millet variety. The compost in along with 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 and also reported that RHA application could increase the pH value of the soil from the initial value of 5.06 to 6.05 [12]. The advantage of compost in increasing finger millet yield was reported [13]. In the present study, inorganic and organic sources were studied together as earlier suggested by [14].

3.3 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 t/ha (Table 3). The advantage of RHA over organic manures is undoubtedly noticeable and causes for increasing the uptake need to be studied further in future. At all the three levels of NPK fertilisation, NPK uptake was the lowest in compost. These results are according to the findings of [15].

3.4 Economics

Economics of cultivation revealed the profitability of the different treatment combinations (Table 4). The integrated treatment of 30 kg N, 20 kg P_2O_5, 10 kg K_2 O/ha +RHA @ 10 t/ha fetched maximum net returns (Rs. 21640) and the highest: benefit: cost ratio (1.77). The next economic treatment with net returns and interest: cost ratio of Rs 19750/ha and 1.34 was with 40 kg N, 30 kg P_2O_5, 15 kg K_2O/ha + RHA 7 t/ha. Low-cost Rice husk ash with appropriate nutrient supplementation and lower application rates of synthetic fertiliser might have attributed to the 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.

Table 2. 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**

Table 3. Effect of nutrient sources on total N, P and K uptake (grain+straw) of rainfed finger millet (pooled data of 2011 and 2012)

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**

Table 4. Effect of nutrient sources on grain and straw yields, harvest index (HI) and economics of rainfed finger 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**	**-**	**-**	**-**	**-**

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

4. CONCLUSION

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 P_2O_5, 10 K_2O kg/ha in conjunction with RHA @ 10t/ha) can be recommended for obtaining good yields with better net returns.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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