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Research Paper

Yield and economics of Integrated nutrient management in rice (*Oryza sativa*)-zero tillage finger millet (*Eleusine coracana*) cropping system

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ABSTRACT

An experiment was conducted during the rainy (*kharif*) and winter (*rabi*) seasons of 2017–18 and 2018–19 on sandy loam soil of the Agricultural College, Acharya N.G. Ranga Agricultural University, Bapatla, Andhra Pradesh, to evaluate the economics of the rice (*Oryza sativa* L.)–zero tillage finger millet [*Eleusine coracana* (L.) Gaertn.] cropping system. The experiment was laid out in a randomized block design and replicated thrice during rainy season rice, and in winter each rainy season treatment was subdivided into 4 subtreatments and hence, split-plot design was adopted in winter season. The highest grain yield (5,343, 5,465 and 5,404 kg/ha) was recorded with 50% recommended dose of fertilizer (RDF) + FYM @ 10 t/ha + $ZnSO_4$ @ 50 kg/ha in rice, while in winter season, 100% RDF resulted in the maximum grain yield (1,935, 2,038 and 1,986 kg/ha) of finger millet (ragi) in both the years. The maximum gross returns (₹100,010) net returns (₹54,947) and returns/rupee invested (1.24) were recorded with the application of 50 RDF + FYM @ 10 t/ha+ $ZnSO_4$ @ 50 kg/ha. In zero tillage finger millet, the maximum gross returns (₹52,172) was recorded with 50% RDF + FYM @ 10 t/ha + soil application of $ZnSO_4$ @ 50 kg/ha. The highest net returns (₹28,539) and returns per rupee invested (1.28) were recorded with the application of 50% RDF + poultry manure @ 1.6 t/ha + soil application of $ZnSO_4$ @ 50 kg/ha to rainy season rice. Among the different fertilizer levels, the highest gross returns (₹56,072), net returns (₹32,157) and returns per rupee invested (1.34) were recorded with 100% RDF treatment in finger millet in both the years and in pooled data.

***Key words*:** Finger millet, FYM, Rice, Net returns, Poultry manure, Zinc, Zero tillage ragi

In intensive cropping systems, maintenance of soil fertility is the major criterion to sustain the crop yields for longer period, as these systems deplete substantial amount of nutrients from the soil throughout year. The main principle of maintaining the soil-fertility status is to annually replenish those nutrients which are removed by the crops from the field. The excessive reliance on chemical fertilizers and the negligence on soil-health regarding the conservation and use of organic sources of nutrients have not only caused the exhaustion of soil-nutrient reserves but also resulted in soil-health problems which is not conducive to achieve consistent increase in agricultural production. Moreover, Indian soils are poor in organic matter content and also in major plant nutrients. Soil organic matter is the key to soil fertility and productivity. The beneficial influence of organic matter on the physical, chemical and biological properties of the soil is well known, the full appreciation of the same remains which is unfortunately ignored in modern agriculture. The regular recycling of organic wastes in the soil is the most efficient method of maintaining optimum levels of soil organic matter. Rice (*Oryza sativa* L.)–pulse crop sequence is more predominant in Krishna Godavari and North coastal Zone of Andhra Pradesh. But, the area under this sequence (rice–pulse) is recently declining due to late planting of rice because of delay in onset of monsoon and severe incidence of yellow mosaic virus (YMV) on pulse crop which lead to complete failure of pulse crop. To enhance farmer net returns, addressing the YMV problem in pulses and effective utilization of residual moisture and nutrients in the soil, finger millet [*Eleusine coracana* (L.) Gaertn.], popularly known as *ragi,* is an alternative crop in the rice–fallows in place of pulse crops.

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MATERIALS AND METHODS

The present experiment was conducted at Agricultural College, Acharya N.G. Ranga Agricultural University, Bapatla (15º 54' N, 80º 25' E, 5.49 m above the mean sea-level and about 8 km away from the Bay of Bengal coast), Andhra Pradesh. The soil was sandy loam, slightly alkaline (*p*H 8.1), low in organic carbon (0.41%), available nitrogen (221 kg/ha) and available phosphorus (24 kg/ha) and medium in available potassium (273 kg/ha). The experiment having 7 treatments, viz. T_1, 100% recommended dose of fertilizer (RDF) 100-60-40 kg N-P-K/ha; T_2, 100% RDF + soil application of $ZnSO_4$ @ 50 kg/ha; T_3, 125% RDF + soil application of $ZnSO_4$ @ 50 kg/ha; T_4, 75% RDF + poultry manure @ 0.82 t/ha + soil application of $ZnSO_4$ @ 50 kg/ha; T_5, 75% RDF + FYM @ 5.0 t/ha + soil application of $ZnSO_4$ @ 50 kg/ha; T_6, 50% RDF + poultry manure @ 1.6 t/ha + soil application of $ZnSO_4$ @ 50 kg/ha; and T_7, 50% RDF + FYM @ 10 t/ha + soil application of $ZnSO_4$ @ 50 kg/ha. The experiment was laid out in a randomized block design with 7 treatments and replicated thrice during *kharif* rice and in *rabi* each *kharif* treatment was subdivided into 4 subtreatments (S_1, no fertilizer; S_2, 100% RDF; S_3, 75% RDF; and S_4, 50% RDF) and hence, the split-plot design was adopted in *rabi.* For this trial, 'BPT 5204' (145 days duration) and 'Sri Chaitanya' (110–115 days duration) varieties of rice and finger millet, respectively, were choosen. The grain yield from 5 tagged hills was also included in respect of net plot yield and expressed as yield in kg/ha. The gross returns were calculated by considering the prices of rice and finger millet grain and straw yield, prevailing in the local market. The net returns/ha was calculated by deducting the cost of cultivation from the gross returns /ha.

The data were statistically analyzed following the analysis of variance method as described by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Rice

Grain yield: Grain yield of rice in both the years showed significant differences among the treatments. During the first year, significantly highest grain yield (5,343 kg/ha) was recorded with the 50% recommended dose of inorganic fertilizers + FYM 10 t/ha + $ZnSO_4$ @ 50 kg/ha (T_7) over the other treatments, but it was found at par with 125% RDF + $ZnSO_4$ @ 50 kg/ha, i.e. T_3 (4881 kg/ha) which was significantly superior to the remaining treatments (Table 1). The remaining treatments were found at par with one another in the first year of study. In the second year also, significantly highest grain yield was recorded with T_7 (50% RDF+ FYM 10 kg/ha + $ZnSO_4$ @ 50 kg/ha), i.e. 5,465 kg/ha, followed by T_3 (125% RDF + $ZnSO_4$ @ 50 kg/ha), i.e. 5021 kg/ha. The treatment T_3 remained at par with T_4, T_5 and T_6; however, it was significantly superior to the T_1 and T_2 treatments. The grain yield increase with T_7 and T_3 treatments over T_1 was 32 and 20%, respectively, in the first year and 31 and 20%, respectively, during the second year. The significant yield increase in T_7 treatment was owing to highest growth parameters like plant height (105 cm), number of leaves (60/hill) and total number of tillers/m^2 (402) along with highest number of panicles/m^2 (352).

Combined application of organic and inorganic sources of nutrients to the rice leds to improved overall growth of the crop in terms of dry-matter production, morphological and photosynthetic components along with nutrient accumulation. This shows greater availability of nutrients and metabolites for growth and development of reproductive structures, which ultimately might have led to realization of higher productivity of individual plant. The increased availability of nutrients and photosynthates might have

Table 1. Effect of nutrient management interventions on grain and starw yield (kg/ha) at harvesting of rainy season rice

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)		Pooled data	
	2017	2018	2017	2018	Grain	Straw
T_1, 100% RDF (100-60-40 kg N : P : K/ha)	4,036	4,165	4,506	5,112	4,100	4,809
T_2, 100% RDF + $ZnSO_4$ @ 50 kg/ha	4,162	4,299	4,671	5,115	4,230	4,893
T_3, 125% RDF + $ZnSO_4$ @ 50 kg/ha	4,881	5,021	5,696	6,007	4,951	5,851
T_4, 75% RDF + PM @ 0.82 t/ha + $ZnSO_4$ @ 50 kg/ha	4,253	4,416	4,820	5,190	4,334	5,005
T_5, 75% RDF + FYM @ 5.0 t/ha + $ZnSO_4$ @ 50 kg/ha	4,319	4,500	4,988	5,441	4,409	5,214
T_6, 50% RDF + PM @ 1.6 t/ha + $ZnSO_4$ @ 50 kg/ha	4,360	4,595	4,926	5,494	4,477	5,210
T_7, 50% RDF + FYM @ 10 t/ha + $ZnSO_4$ @ 50 kg/ha	5,343	5,465	6,089	6,476	5,404	6,282
SEm±	173.1	118.9	163.8	145.9	146	154.8
CD (P=0.05)	519.0	356.8	490.2	437.5	437.9	463.8
CV (%)	8.6	10.4	7.7	8.2	9.5	7.9

RDF, Recommended dose of fertilizer; PM, poultry manure

enhanced the yield attributes. The highest grain yield in treatment T_7 might be owing to improvement in yield-attributing characters, i.e. number of productive tillers, test weight and number of filled grains/panicle, which were recorded with this treatment comparatively T_3 and other treatments in the study. These results are in agreement with the findings of Premalatha and Angadi (2017), Singh and Singh (2018) and Kiran kumar *et al.,* (2020).

Straw yield of rice: Straw yield of *kharif* rice revealed significant differences among the treatments because of application of fertilizer doses along with organics and zinc.

Significantly highest straw yield (6,089 kg/ha) was recorded with the application of 50% RDF + FYM 10 t/ha + $ZnSO_4$ @ 50 kg/ha (T_7), followed by T_3 (125% RDF + $ZnSO_4$ @ 50 kg/ha), i.e. 5,696 kg/ha in the first year. In the second year also, almost similar trend was noticed. Higher straw yields recorded in INM treatments over the chemical fertilizer plots might be attributed to increased availability of nutrients and photosynthates that might have increased the total tillers/hill and number of leaves/hill of rice plant during all the phenophases of the crop. While combination of chemical fertilizers, with organic manures might have increased the nutrient supply directly from the chemical fertilizers and organic manures are responsible for hold the nutrients against the various losses, i.e. run off, leaching etc., and hence, nutrients are available for longer period to the crops that in turn increased straw yield of crop, as also reported by Kiran Kumar *et al.,* (2020).

The application of organic sources and fertility levels significantly affected the grain and straw yields of rice owing to their positive influence on growth and yield attributes. Pandey *et al.,* (2001) observed increased efficiency of inorganic N fertilizer, when it was applied along with organic manures and showed a beneficial effect on rice grain yield. Though FYM, vermicompost and poultry manure are applied on equivalent nitrogen basis, the organic matter content in FYM is higher than the rest. Higher organic matter content would have favourably influenced the grain and straw yields of rice. These results confirms the findings of Malik and Singh (2016), Sireesha (2017) and Singh and Singh (2018).

Finger millet

Grain yield: The data pertaining to grain yield under zero till finger millet was significantly influenced by the different nutrient sources applied to rice and fertilizers doses imposed to finger millet during both the years (Table 2). Significantly highest grain yield of finger millet was recorded with T_7 (1,823 kg/ha) treatment followed by T_6 (1,735 kg/ha). The treatments T_4 and T_5 were at par with each other and treatments T_1, T_2 and T_3 were also at par with each other. In the second year, the highest grain yield was recorded with T_7 (1,880 kg/ha), being statistically at par with T_6 (1,857 kg/ha) and superior to rest of the treatments. Similar trend was noticed in pooled data.

Among the different fertilizer levels, treatment S_2 (1,935

Table 2. Grain and straw yield (kg/ha) of zero till *rabi* finger millet as influenced by nutrient management interventions

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)		Pooled data	
	2017–18	2018–19	2017–18	2018–19	Grain	Starw
Residual effect of nutrient interventions imposed to rainy season rice						
T_1, 100% RDF (100-60-40 kg N: P: K/ha)	1,529	1,594	2,205	2,465	1,561	2,335
T_2, 100% RDF + $ZnSO_4$ @ 50 kg/ha	1,542	1,684	2,340	2,617	1,613	2,478
T_3, 125% RDF + $ZnSO_4$ @ 50 kg/ha	1,573	1,639	2,426	2,571	1,606	2,498
T_4, 75% RDF + PM @ 0.82 t/ha + $ZnSO_4$ @ 50 kg/ha	1,625	1,711	2,438	2,645	1,668	2,541
T_5, 75% RDF + FYM @ 5.0 t/ha + $ZnSO_4$ @ 50 kg/ha	1,650	1,765	2,517	2,691	1,707	2,604
T_6, 50% RDF + PM @ 1.6 t/ha + $ZnSO_4$ @ 50 kg/ha	1,735	1,857	2,616	2,801	1,796	2,708
T_7, 50% RDF + FYM @ 10 t/ha + $ZnSO_4$ @ 50 kg/ha	1,823	1,880	2,760	2,995	1,851	2,877
SEm±	22.9	23.3	55.3	57.9	23.1	56.6
CD (P=0.05)	70.5	71.8	170.7	178.4	71.15	174.5
CV (%)	8.4	6.7	7.6	7.4	7.5	7.5
Fertilizer doses applied to ragi						
S_1, No fertilizer	1,393	1,451	2,080	2,236	1,422	2,158
S_2, 100% RDF (30–30–20 Kg N : P : K/ha)	1,935	2,038	3,030	3,212	1,986	3,121
S_3, 75% RDF	1,647	1,751	2,385	2,637	1,699	2,511
S_4, 50% RDF	1,583	1,692	2,392	2,649	1,637	2,520
SEm±	1,7.3	19.1	49.4	60.7	18.2	55.05
CD (P=0.05)	49.3	54.4	141.1	173.3	51.85	157.2
CV (%)	12.3	11.1	9.1	10.3	11.7	9.7
Interaction	NS	NS	NS	NS	NS	NS

RDF, Recommended dose of fertilizer; PM, poultry manure

kg/ha) recorded significantly the highest grain yield followed by S_3 (1,647 kg/ha). The treatment, S_3 (1,647 kg/ha) was superior to S_4 and S_1 treatments, which received 50% RDF and no fertilizer respectively. Ahiwale *et al*., (2013), and Kumar *et al*., (2017) also reported similar results.

Finger millet: The data pertaining to straw yield under no-till finger millet was significantly influenced by the different nutrient sources applied to rice and fertility doses applied to finger millet during both the years (Table 2).

Significantly the highest straw yield of ragi was recorded with T_7 (2,760 kg/ha) which was followed by T_5 (2,517 kg/ha). The treatments T_6 and T_5 were remained at par with each other. Treatments T_4, T_3 and T_2 were found statistically identical with one another. Similar trend was noticed in the second year and pooled data.

Among the different fertilizer levels, treatment S_2 recorded significantly the highest straw yield (3,030 kg/ha) followed by S_3 (2,385 kg/ha). The treatments S_3 and S_4 were statistically at par with one another. Lower straw yield was recorded with treatment S_1 (2,080 kg/ha). Similar trend was observed in the second year and in pooled data.

Higher straw yields recorded in INM treatments over the chemical fertilizer plots which might be owing to the increased availability of nutrients and photosynthates that might have increased the total tillers/hill and number of leaves/hill of rice plant during all the phenophases of the crop. While combination of chemical fertilizers with organic manures might have increased the nutrient supply directly from the chemical fertilizers and organic manures are responsible for store/or hold the nutrients against the various losses i.e. run off, leaching, etc. and hence, nutrients are available for longer period of time to the crops that in turn increased straw yields of the crop. The maximum straw yield in organic and inorganic nutrient combination treatments might be attributed to the increased nutrient mobility, absorption and translocation of nutrient leading to increased production of photosynthates resulting in increased biomass accumulation. This could be ascribed to its positive influence on both vegetative and reproductive growth of the crop which led to increase in stover yield of finger millet. Such observations were also reported by Kumar *et al*., (2017) and Kiran Kumar *et al*., (2020).

Economics

Finger millet: The maximum gross returns (₹100,010), net returns (₹54,947) and returns per rupee invested (1.24) were recorded with the application of 50 RDF + FYM @ 10 t/ha + $ZnSO_4$ @ 50 kg/ha in both the years (Table 3). These results confirm the findings of Murthy *et al*., (2015), and Dalvi *et al*., (2017) and Kiran Kumar *et al.,* (2020).

Zero-till finger millet: Gross returns, net returns and returns per rupee invested is calculated and the data revealed that, the maximum gross returns (₹56,072) were recorded with 50% RDF + FYM @ 10 t/ha + $ZnSO_4$ @ 50 kg/ha (Table 4). The highest net returns (₹28,539) and returns per rupee invested (1.28) were recorded with the application of 50% RDF + PM @ 1.6 t/ha + $ZnSO_4$ @ 50 kg/ha to *kharif* rice in both the years and in pooled data.

Among the different fertilizer levels, the highest gross returns (₹56,072), net returns (₹32,157) and returns/rupee invested (1.34) were recorded with 100% RDF treatment in finger millet in both the years and pooled data. These results are in conformity with the findings of Gavade (2010) and Kiran Kumar *et al.,* (2020).

It can be concluded that, treatment $T_7 S_2$ (50% RDF + FYM @ 10 t/ha + $ZnSO_4$ @ 50 kg/ha to rice and 100% RDF applied to succeeding finger millet) may be recom-

Table 3. Cost of cultivation, gross returns, net returns and returns/rupee invested of rainy season rice as influenced by nutrient management interventions

Treatment	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Returns/ rupee investment
T_1, 100% RDF (100–60–40 kg N : P : K/ha)	39,200	75,978	36,778	0.93
T_2, 100% RDF + $ZnSO_4$ @ 50 kg/ha	40,287	78,273	38,073	0.94
T_3, 125% RDF + $ZnSO_4$ @ 50 kg/ha	42,123	91,805	49,682	1.18
T_4, 75% RDF + PM @ 0.82 t/ha + $ZnSO_4$ @ 50 kg/ha	40,593	80,190	39,597	0.97
T_5, 75% RDF + FYM @ 5.0 t/ha + $ZnSO_4$ @ 50 kg/ha	42,953	81,796	38,843	0.90
T_6, 50% RDF + PM @1.6 t/ha + $ZnSO_4$ @ 50 kg/ha	40,726	82,938	42,212	1.03
T_7, 50% RDF + FYM @ 10 t/ha + $ZnSO_4$ @ 50 kg/ha	45,063	100,010	54,947	1.24
SEm±	-	2,611	2,611	0.06
CD (P=0.05)	-	7,828	7,828	0.18

RDF, Recommended dose of fertilizer; PM, poultry manure

Table 4. Gross returns, net returns and returns per rupee invested of winter season finger millet as influenced by nutrient management interventions in rice–finger millet sequence

Treatment	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Returns/ rupee invested
Residual effect of nutrient interventions imposed to rainy season rice				
T_1, 100% RDF (100–60–40 kg N : P : K/ha)	20,523	43,901	23,378	1.13
T_2, 100% RDF + $ZnSO_4$ @ 50 kg/ha	21,610	45,528	23,918	1.1
T_3, 125% RDF + $ZnSO_4$ @ 50 kg/ha	23,446	45,284	21,838	0.92
T_4, 75% RDF + PM @ 0.82 t/ha + $ZnSO_4$ @ 50 kg/ha	21,916	46,977	25,061	1.13
T_5, 75% RDF + FYM @ 5.0 t/ha + $ZnSO_4$ @ 50 kg/ha	24,276	48,142	23,866	0.97
T_6, 50% RDF + PM @ 1.6 t/ha + $ZnSO_4$ @ 50 kg/ha	22,049	50,588	28,539	1.28
T_7, 50% RDF + FYM @ 10 t/ha + $ZnSO_4$ @ 50 kg/ha	26,386	52,172	25,785	0.96
SEm±	-	626	626	0.03
CD (P=0.05)	-	1,928	1,928	0.08
Fertilizer doses applied to finger millet				
S_1, No fertilizer	21,563	40,020	18,457	0.86
S_2, 100% RDF (30–30–20 Kg N : P : K/ha)	23,915	56,072	32,157	1.34
S_3, 75% RDF	23,327	47,768	24,440	1.05
S_4, 50% RDF	22,739	46,192	23,452	1.03
SEm±	-	516	516	0.02
CD (P=0.05)	-	14,73	1,473	0.06
Interaction	NS	NS	NS	NS

RDF, Recommended dose of fertilizer; PM, poultry manure

mended for rice–no-till finger millet cropping sequence to farming community in the coastal lands for the better response in term of yield, gross, net returns and returns/rupee investment.

REFERENCES

Ahiwale, P.H., Chavan, L.S., Jagtap, D.N., Mahadkar, U.K and Gawade, M.B. 2013. Effect of establishment methods and nutrient management on yield attributes and yield of fingermillet (*Eleusine coracana* G.). *Crop Research* **45**(1, 2 and 3): 141–145.

Gavade, M.S. 2010. Effect of organic manures and sources and levels of fertilizers on growth, yield and quality of finger millet (*Eleusine corocana* L.). M.Sc. Thesis, Dr Balasaheb Swant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India (unpublished).

Kiran Kumar, S., Pulla Rao, Ch., Murthy, V.R.K., Ashoka Rani, Y. and Prasad, P.R.K. 2020. Effect of nutrient management interventions on system productivity of rice–ragi sequence in Coastal Andhra Pradesh. *Oryza* **57**(3): 219–229.

Kumar, K.S., Rao, P.Ch., Rekha, S.M. and Prasad, R.P. 2017. Growth and yield of finger millet [*Eleusine coracana* (L.)] as influenced by phosphorus management practices. *The Andhra Agricultural Journal* **64**(1): 40–45.

Malik, R.V.S and Singh, C. 2016. Effect of integrated nutrient management practices on crop yield and change in physico-chemical properties of soil in rice–wheat cropping system. *Agriways* **4**(2): 185–193.

Pal, S., Paul, S. K., Sarkar, M.A.R and Gupta, D.R. 2016. Response on yield and protein content of fine aromatic rice varieties to integrated use of cowdung and inorganic fertilizers. *Journal of Crop and Weed* **12**(1): 01–06.

Panse, V.G. and Sukhatme, P.V. 1978. *Statistical Methods for Agricultural Workers*, pp. 145–152. Indian Council of Agricultural Research, New Delhi.

Premalatha, B.R and Angadi, V.V. 2017. Influence of integrated nutrient management and leaf color chart (LCC) based nitrogen management in rice (*Oryza sativa* L.) yield and yield attributes, nitrogen uptake and soil available nitrogen status. *Environment and Ecology* **35**(3B): 2,012–2,020.

Singh, B. and Singh, A.P. 2018. Response of wheat (*Triticum aestivum* L.) to FYM and phosphorus application in alluvial soil. *International Journal of Current Microbiology and Applied Sciences* **7**(6): 418–423.

Sireesha, G.P.V., Padmaja, G., Rao, P.C. and Ramana, V.M. 2017. Long term studies on soil properties and productivity of rice–rice system as influenced by INM in Southern Telangana Zone. *Environment and Ecology* **35**(3): 1,739–1,744.

Trivedi, V.K., Dimree, S., Pathak, R.K and Tripathi, M. 2016. To study the effect of integrated nutrient management of rice (*Oryza Sativa* L.) in central plain zone of U.P. *International Journal of Technical Research and Applications* **4**(4): 108–112.