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Nutrient Uptake and Economics of Aerobic Rice as Influenced by Farmyard Manure and Bio-Digester Liquid Manure

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ABSTRACT

Field experiments were conducted during kharif 2010 and 2011 at Zonal Agricultural Research Station, Mandya to study the effect of farmyard manure and bio-digester liquid manure on the performance of aerobic rice. Soil was red sandy loam in texture, low in organic carbon (0.38 %) and available nitrogen (215.5 kg ha^{-1}), medium in available P_2O_5 (26.2 kg ha^{-1}) and K_2O (162.3 kg ha^{-1}). Treatment consisted of three levels of FYM (7.5, 10 & 12.5 t ha^{-1}) and four levels of bio-digester liquid manure equivalent (BDLME) to (75, 100, 125 & 150 kg N ha^{-1}) and compared with recommended practice (FYM 10 t + 100:50:50 N:P_2O_5:K_2O kg ha^{-1}) and absolute control. It was laid out in Randomized Complete Block Design with three replications. Significantly higher total nitrogen, phosphorus and potassium (118.1, 27.9 and 92.0 kg ha^{-1}, respectively) were taken up by the crop with the application of FYM 12.5 t + BDLME to 150 kg N ha^{-1}. However, it was on par with FYM 12.5 t + BDLME to 125 kg N ha^{-1} (115.2, 26.9 and 90.8 kg ha^{-1}, respectively) and recommended practice (FYM 10 t + 100:50:50 N:P_2O_5:K_2O kg ha^{-1}) (124.2, 29.4 and 96.9, respectively). Higher net returns and B:C ratio (Rs. 28,355 ha^{-1} and 2.35, respectively) was received from FYM 12.5 t + BDLME to 150 kg N ha^{-1} and it was followed by FYM 12.5 t + BDLME to 125 kg N ha^{-1} (Rs. 28,075 ha^{-1} and 2.37, respectively).

Key words: *Nutrient uptake, Economics, Rodale Institute (USA), Bio-digester liquid manure and Aerobic rice.*

INTRODUCTION

Now, the agricultural research is focused on evolving ecologically sound, biologically sustainable and socio-economically viable technologies. There is need for a fresh look to exploit the organic farming approaches using the local manurial and bio-pesticide sources for nutrient management of organic crops. Organic farming minimizes environmental pollution and maintains sustainability of soil by maintaining high soil organic matter. Bio-digester is a low cost technology for the production of organic liquid manure using on farm organic crop wastes, animal wastes, green manures and weeds. It replaced the inorganic fertilizers and boosted the organic crop yields. Rice (*Oryza sativa* L.) is the principal food crop to billions of people around the world. India occupies a pride place in rice production among the food crops cultivated in the world.

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Uptake of nutrients is associated with the metabolic activities of plants and with the concentration and distribution of ions in the external medium. It has been proved that, application of micronutrients through various liquid manures along with recommended FYM improves the absorption and utilization of major nutrients. Further, any technology has to be technically feasible and economically viable to reach farmer's fields. Therefore, the economics of cultivation of crops is very important. This also gives a clear idea about the optimum level of inputs that could be recommended to obtain maximum profit. Keeping these points in view, the field trials were carried out to study the nutrient uptake and economics of aerobic rice as influenced by farmyard manure and bio-digester liquid manure.

MARERIALS AND METHODS

Field experiments were conducted during *kharif* 2010 and 2011 at Zonal Agricultural Research Station, Mandya of the University of Agricultural Sciences, Bengaluru to study the "Nutrient uptake and economics of aerobic rice as influenced by farmyard manure and bio-digester liquid manure". Soil of the experimental site was red sandy loam in texture, low in organic carbon (0.38 %) and available nitrogen (215.5 kg ha^{-1}), medium in available P_2O_5 (26.2 kg ha^{-1}) and K_2O (162.3 kg ha^{-1}). Treatment consisted of three levels of FYM (7.5, 10 & 12.5 t ha^{-1}) and four levels of bio-digester liquid manure equivalent (BDLME) to (75, 100, 125 & 150 kg N ha^{-1}) and compared with recommended practice (FYM 10 t + 100:50:50 N:P_2O_5:K_2O kg ha^{-1}) and absolute control. It was laid out in Randomized Complete Block Design with three replications.

The plant samples used for recording dry matter production at harvest were used for analyzing nutrients present in the plant. After recording the dry weight from each treatment the samples were powdered in a micro Willey mill. The samples were analyzed for concentration (%) of different macronutrients (N, P_2O_5 & K_2O) present in aerobic rice plant parts.

Nitrogen content of grain and straw was estimated by modified micro-kjeldhal's method as outlined by Jackson[5] and expressed in percentage. Nitrogen uptake (kg ha^{-1}) by crop was calculated for each treatment separately using the following formula.

$$\text{Nitrogen uptake (kg ha}^{-1}) = \frac{\text{Nitrogen concentration (\%)}}{100} \times \text{Biomass (kg ha}^{-1})$$

The sum of uptake of nutrients in grain and straw was considered as the total uptake by the crop.

The phosphorus content of grain and straw was determined by Vanadomolybodo phosphoric acid yellow colour method and absorbance of the solution was recorded at 430 nm using spectrophotometer[5] and then computed to total uptake by crop as same as that of N uptake.

Potassium content in plant sample (grain and straw separately) was determined by Flame photometer method[5] and expressed in kg per ha as explained in nitrogen estimation.

The price of inputs that were prevailing at the time of their use was considered for working out the cost of cultivation.

Gross returns = Total value of the produce (grain and straw).

Cost of cultivation = Cost of inputs, labour, power *etc.*

Net returns = Gross returns - Cost of cultivation.

The benefit cost ratio was worked out by using the following formula.

$$\text{Benefit Cost ratio} = \frac{\text{Gross returns (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

RESULTS AND DISCUSSION

Nutrient uptake:

Uptake of nutrients is associated with the metabolic activities of plants and with the concentration and distribution of ions in the external medium. It has been proved that, application of micronutrients through various liquid manures along with recommended FYM improves the absorption and utilization of major nutrients. Significantly higher total nitrogen, phosphorus and potassium (118.1, 27.9 and 92.0 kg ha^{-1}, respectively) were taken up by the crop with the application of FYM 12.5 t + BDLME to 150 kg N ha^{-1}. However, it was on par with FYM 12.5 t + BDLME to 125 kg N ha^{-1} (115.2, 26.9 and 90.8 kg ha^{-1}, respectively) and recommended practice (124.2, 29.4 and 96.9, respectively) (Table 1 to 3).

Increase in uptake of nitrogen could be due to increase in dry matter production. Since the nitrogen added through liquid manure was in organic form which releases throughout the crop growth and thus contributed for higher concentration in aerobic rice. These results are in conformity with the findings of Yamagata and Otani[12] from Tsukuba, Japan revealed that nitrogen uptake by upland rice and potato supplied with organic nitrogen was higher than control. High phosphorus uptake could be attributed to conversion of fixed phosphorus into readily available form by organic acids released during decomposition of FYM and BDLM and consequent improvement in the available P in soil. While, high potassium uptake might be due to less loss and less fixation in the soil.

These results corroborate with the findings of Niru Kumari *et al.*[9] who revealed that among various organic sources of nutrients, application of green manure 5 t + FYM 10 t ha^{-1} had significantly higher nutrient uptake of paddy (64:12:73 kg N:P:K ha^{-1}) than other treatments. However, high uptake of nitrogen, phosphorus and potassium by rice was observed at Bramhavar, Naganahally, Mandya and Kathalagere[11] and Hanumathappa *et al.*,[4]. Further, Davari and Sharma[2] also indicated that application of FYM significantly increased the quantity of N, P, K, Zn, Fe, Mn and Cu removed by rice grain over control.

Economics

Higher gross returns (Rs. 51,221 ha^{-1}) was obtained with the recommended practice followed by the application of FYM 12.5 t + BDLME to 150 kg N ha^{-1} (Rs. 49,405 ha^{-1}) and FYM 12.5 t + BDLME to 125 kg N ha^{-1} (Rs. 48,525 ha^{-1}). The higher gross returns were mainly due higher grain and straw yields in the respective treatments. Similar findings were also observed by Mehla and Panwar[7].

Higher net returns and B:C ratio (Rs. 28,355 ha^{-1} and 2.35, respectively) was received from FYM 12.5 t + BDLME to 150 kg N ha^{-1} and it was followed by FYM 12.5 t + BDLME to 125 kg N ha^{-1} (Rs. 28,075 ha^{-1} and 2.37, respectively). However, recommended practice resulted in 2.18 B:C ratio as the cost of cultivation was high (Table 4). The higher B:C ratio may be due to lower cost of cultivation and higher net returns. Similar views were expressed by Mondal *et al.*[8], Reddy *et al.*[11] who obtained higher B:C ratio of 2.57 in rice by the application of FYM 10 t + cattle urine (equivalent to 125 kg N ha^{-1}). At Rodale institute, Kutztown, USA, organic system increased the income, returns and reduced the expenditure in the cultivation of corn and wheat crops besides giving 28 per cent higher production efficiency than inorganic system[1]. Further, higher income from organic cropping has been reported by Delate *et al.*[3], Lotter *et al.*[6] and Pimentel *et al.*[10].

Table 1: Nitrogen uptake (kg ha^{-1}) of aerobic rice as influenced by farmyard manure and bio-digester liquid manure

Treatment	Grain uptake			Straw uptake			Total uptake		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
T_1	48.8	50.8	49.8	29.6	31.8	30.7	78.4	82.6	80.5
T_2	50.6	52.6	51.6	30.3	33.2	31.7	80.9	85.8	83.4
T_3	60.3	62.8	61.5	34.6	37.4	36.0	94.8	100.2	97.5
T_4	61.8	64.1	63.0	36.1	39.0	37.5	97.9	103.1	100.5
T_5	53.8	56.8	55.3	31.2	33.7	32.4	84.9	90.5	87.7
T_6	55.0	57.6	56.3	32.2	35.3	33.8	87.2	92.9	90.0
T_7	61.9	64.6	63.3	36.8	39.8	38.3	98.8	104.4	101.6
T_8	63.1	67.2	65.1	38.5	42.3	40.4	101.6	109.5	105.5
T_9	56.5	58.4	57.5	33.2	35.9	34.6	89.7	94.3	92.0
T_{10}	58.8	60.1	59.4	33.7	36.6	35.1	92.4	96.7	94.6
T_{11}	68.6	74.2	71.4	42.6	45.0	43.8	111.2	119.3	115.2
T_{12}	70.2	75.1	72.6	43.7	47.2	45.5	113.9	122.3	118.1
T_{13}	74.5	78.2	76.4	46.2	49.5	47.8	120.7	127.7	124.2
T_{14}	27.7	26.5	27.1	16.4	15.2	15.8	44.1	41.7	42.9
S.Em±	2.9	2.5	2.7	1.8	2.0	1.9	4.0	3.4	3.7
C.D. at 5%	8.6	7.3	7.7	5.3	5.8	5.3	11.5	10.0	10.4

T_1 : FYM 7.5 t + BDLME to 75 kg N ha^{-1}
T_2 : FYM 7.5 t + BDLME to 100 kg N ha^{-1}
T_3 : FYM 7.5 t + BDLME to 125 kg N ha^{-1}
T_4 : FYM 7.5 t + BDLME to 150 kg N ha^{-1}
T_5 : FYM 10 t + BDLME to 75 kg N ha^{-1}
T_6 : FYM 10 t + BDLME to 100 kg N ha^{-1}
T_7 : FYM 10 t + BDLME to 125 kg N ha^{-1}
T_8 : FYM 10 t + BDLME to 150 kg N ha^{-1}
T_9 : FYM 12.5 t + BDLME to 75 kg N ha^{-1}
T_{10} : FYM 12.5 t + BDLME to 100 kg N ha^{-1}
T_{11} : FYM 12.5 t + BDLME to 125 kg N ha^{-1}
T_{12} : FYM 12.5 t + BDLME to 150 kg N ha^{-1}
T_{13} : FYM 10 t + 100:50:50 kg N:P_2O_5:K_2O ha^{-1}
T_{14} : Absolute control
BDLME - Bio-Digester Liquid Manure Equivalent
FYM - Farmyard manure

Table 2: Phosphorous (P_2O_5) uptake (kg ha^{-1}) of aerobic rice as influenced by farmyard manure and bio-digester liquid manure

Treatment	Grain uptake			Straw uptake			Total uptake		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
T_1	12.10	13.00	12.55	3.70	3.83	3.77	15.8	16.8	16.3
T_2	12.73	13.93	13.33	3.80	3.95	3.88	16.5	17.9	17.2
T_3	15.20	16.90	16.05	4.13	4.48	4.31	19.3	21.4	20.4
T_4	15.60	18.27	16.93	4.18	4.40	4.29	19.8	22.7	21.2
T_5	13.17	14.53	13.85	3.90	4.10	4.00	17.1	18.6	17.8
T_6	13.87	15.20	14.53	3.93	4.15	4.04	17.8	19.4	18.6
T_7	17.40	19.93	18.67	4.25	4.48	4.37	21.7	24.4	23.0
T_8	17.83	20.37	19.10	4.40	4.63	4.52	22.2	25.0	23.6
T_9	14.20	15.90	15.05	4.08	4.25	4.17	18.3	20.2	19.2
T_{10}	14.37	16.40	15.38	4.11	4.31	4.21	18.5	20.7	19.6
T_{11}	20.23	23.37	21.80	4.80	5.47	5.14	25.0	28.8	26.9
T_{12}	21.04	24.04	22.54	4.95	5.80	5.38	26.0	29.8	27.9
T_{13}	22.37	25.07	23.72	5.30	6.03	5.67	27.7	31.1	29.4
T_{14}	7.90	7.50	7.70	2.42	2.21	2.32	10.3	9.7	10.0
S.Em±	0.98	1.24	1.11	0.19	0.22	0.21	1.0	1.2	1.08
C.D. at 5%	2.84	3.60	3.14	0.55	0.65	0.58	2.8	3.4	3.06

T_1 : FYM 7.5 t + BDLME to 75 kg N ha^{-1}
T_2 : FYM 7.5 t + BDLME to 100 kg N ha^{-1}
T_3 : FYM 7.5 t + BDLME to 125 kg N ha^{-1}
T_4 : FYM 7.5 t + BDLME to 150 kg N ha^{-1}
T_5 : FYM 10 t + BDLME to 75 kg N ha^{-1}
T_6 : FYM 10 t + BDLME to 100 kg N ha^{-1}
T_7 : FYM 10 t + BDLME to 125 kg N ha^{-1}
T_8 : FYM 10 t + BDLME to 150 kg N ha^{-1}
T_9 : FYM 12.5 t + BDLME to 75 kg N ha^{-1}
T_{10} : FYM 12.5 t + BDLME to 100 kg N ha^{-1}
T_{11} : FYM 12.5 t + BDLME to 125 kg N ha^{-1}
T_{12} : FYM 12.5 t + BDLME to 150 kg N ha^{-1}
T_{13} : FYM 10 t + 100:50:50 kg N:P_2O_5:K_2O ha^{-1}
T_{14} : Absolute control
BDLME - Bio-Digester Liquid Manure Equivalent
FYM - Farmyard manure

Table 3: Potassium (K_2O) uptake (kg ha^{-1}) of aerobic rice as influenced by farmyard manure and bio-digester liquid manure

Treatment	Grain uptake			Straw uptake			Total uptake		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
T_1	13.8	14.5	14.2	50.0	52.7	51.4	63.8	67.2	65.5
T_2	14.2	15.1	14.6	50.9	54.2	52.6	65.1	69.3	67.2
T_3	17.2	18.3	17.7	57.6	61.8	59.7	74.8	80.1	77.4
T_4	17.6	18.9	18.3	58.7	62.6	60.7	76.3	81.5	78.9
T_5	15.5	16.3	15.9	52.9	55.8	54.4	68.4	72.2	70.3
T_6	15.6	16.9	16.3	53.6	58.1	55.9	69.2	75.0	72.1
T_7	18.4	20.6	19.5	60.1	64.3	62.2	78.4	84.9	81.7
T_8	19.3	21.7	20.5	62.6	66.5	64.6	81.9	88.2	85.0
T_9	16.0	17.1	16.6	55.0	58.7	56.8	71.0	75.8	73.4
T_{10}	16.4	17.8	17.1	56.5	59.9	58.2	72.9	77.7	75.3
T_{11}	21.8	23.5	22.7	65.8	70.4	68.1	87.6	93.9	90.8
T_{12}	22.3	24.3	23.3	66.4	71.0	68.7	88.7	95.3	92.0
T_{13}	23.4	25.1	24.3	70.1	75.2	72.7	93.6	100.3	96.9
T_{14}	9.2	8.7	8.9	26.5	24.1	25.3	35.7	32.8	34.3
S.Em±	0.7	0.7	0.7	2.2	2.7	2.6	2.6	2.8	2.8
C.D. at 5%	2.0	2.1	2.1	6.5	7.7	7.4	7.5	8.2	8.0

T_1 : FYM 7.5 t + BDLME to 75 kg N ha^{-1}
T_2 : FYM 7.5 t + BDLME to 100 kg N ha^{-1}
T_3 : FYM 7.5 t + BDLME to 125 kg N ha^{-1}
T_4 : FYM 7.5 t + BDLME to 150 kg N ha^{-1}
T_5 : FYM 10 t + BDLME to 75 kg N ha^{-1}
T_6 : FYM 10 t + BDLME to 100 kg N ha^{-1}
T_7 : FYM 10 t + BDLME to 125 kg N ha^{-1}
T_8 : FYM 10 t + BDLME to 150 kg N ha^{-1}
T_9 : FYM 12.5 t + BDLME to 75 kg N ha^{-1}
T_{10} : FYM 12.5 t + BDLME to 100 kg N ha^{-1}
T_{11} : FYM 12.5 t + BDLME to 125 kg N ha^{-1}
T_{12} : FYM 12.5 t + BDLME to 150 kg N ha^{-1}
T_{13} : FYM 10 t + 100:50:50 kg $N:P_2O_5:K_2O$ ha^{-1}
T_{14} : Absolute control
BDLME - Bio-Digester Liquid Manure Equivalent
FYM - Farmyard manure

Table 4: Economics of aerobic rice cultivation as influenced by farmyard manure and bio-digester liquid manure

Treatment	Gross returns (Rs. ha^{-1})			Cost of cultivation (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			B:C ratio		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
T_1	31811	33395	32603	14590	14590	14590	15061	16645	15853	1.90	1.99	1.95
T_2	32510	34352	33431	15088	15088	15088	15260	17102	16181	1.88	1.99	1.94
T_3	38656	40715	39686	15590	15590	15590	20906	22965	21936	2.18	2.29	2.24
T_4	39105	41425	40265	16088	16088	16088	20855	23175	22015	2.14	2.27	2.21
T_5	35145	37499	36322	17088	17088	17088	17695	20049	18872	2.01	2.15	2.08
T_6	35658	38246	36952	17610	17610	17610	17708	20296	19002	1.99	2.13	2.06
T_7	39831	42508	41170	18450	18450	18450	21381	24058	22720	2.16	2.30	2.23
T_8	41381	44923	43152	18950	18950	18950	22431	25973	24202	2.18	2.37	2.28
T_9	36123	39069	37596	19588	19588	19588	16673	19619	18146	1.86	2.01	1.93
T_{10}	37011	39951	38481	20088	20088	20088	17061	20001	18531	1.86	2.00	1.93
T_{11}	45955	51095	48525	20588	20588	20588	25505	30645	28075	2.25	2.50	2.37
T_{12}	46763	52047	49405	21088	21088	21088	25713	30997	28355	2.22	2.47	2.35
T_{13}	49796	52645	51221	23457	23457	23457	26340	29188	27764	2.12	2.24	2.18
T_{14}	17835	17214	17524	9487	9487	9487	8348	7727	8037	1.88	1.81	1.85

T_1 : FYM 7.5 t + BDLME to 75 kg N ha^{-1}
T_2 : FYM 7.5 t + BDLME to 100 kg N ha^{-1}
T_3 : FYM 7.5 t + BDLME to 125 kg N ha^{-1}
T_4 : FYM 7.5 t + BDLME to 150 kg N ha^{-1}
T_5 : FYM 10 t + BDLME to 75 kg N ha^{-1}
T_6 : FYM 10 t + BDLME to 100 kg N ha^{-1}
T_7 : FYM 10 t + BDLME to 125 kg N ha^{-1}
T_8 : FYM 10 t + BDLME to 150 kg N ha^{-1}
T_9 : FYM 12.5 t + BDLME to 75 kg N ha^{-1}
T_{10} : FYM 12.5 t + BDLME to 100 kg N ha^{-1}
T_{11} : FYM 12.5 t + BDLME to 125 kg N ha^{-1}
T_{12} : FYM 12.5 t + BDLME to 150 kg N ha^{-1}
T_{13} : FYM 10 t + 100:50:50 kg $N:P_2O_5:K_2O$ ha^{-1}
T_{14} : Absolute control
BDLME - Bio-Digester Liquid Manure Equivalent
FYM - Farmyard manure

CONCLUSION

Significantly higher total nitrogen, phosphorus and potassium uptake by the crop was noticed with FYM 12.5 t + BDLME to 150 kg N ha^{-1}, FYM 12.5 t + BDLME to 125 kg N ha^{-1} and recommended practice (FYM 10 t + 100:50:50 $N:P_2O_5:K_2O$ kg ha^{-1}) because of higher grain and straw yields. Similarly, higher net returns and B:C ratio (Rs. 28,355 ha^{-1} and 2.35, respectively) was received from FYM 12.5 t + BDLME to 150 kg N ha^{-1} followed by FYM 12.5 t + BDLME to 125 kg N ha^{-1} (Rs. 28,075 ha^{-1} and 2.37).

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