Productivity and Nutrient Uptake of Aerobic Rice as Influenced by Methods of Establishment and Sources of Organic Nutrients

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Abstract- Field experiment was conducted during *kharif* 2005 and 2006 at Zonal Agricultural Research Station, Mandya to study the effect of organic nutrient sources on productivity and uptake of nutrients by Aerobic rice in Cauvery command area. Soil of the experimental site was red sandy loam in texture, low in organic carbon (0.43%) and available nitrogen (270.60 kg ha^{-1}), medium in available P_2O_5 (32.25 kg ha^{-1}) and K_2O (149.80 kg ha^{-1}). Treatments consisted of 12 treatment combinations, two main plot treatments of establishment methods and six nutrient sources in sub plot were laid out in split plot design with three replications. The results indicated that puddled method of rice cultivation recorded significantly higher grain yield (4600 kg ha^{-1}), straw yield (4325 kg ha^{-1}) and total N, P_2O_5 and K_2O uptake (105.12, 21.0 and 79.85 kg ha^{-1}, respectively) as compare to the aerobic method of cultivation. Among the different organic nutrient sources application of poultry manure 125 kg N equivalent + 25% of recommended N equivalent poultry manure a top dressing recorded significantly higher grain yield (4375 kg ha^{-1}), straw yield (4139 kg ha^{-1}) and Total N, P_2O_5 and K_2O (99.91, 20.05 and 75.95 kg ha^{-1}, respectively) uptake both in puddled and aerobic condition which was on par with application of sewage sludge 125 kg N equivalent + 25% of recommended N equivalent poultry manure at top dressing.

Index Terms- Rice, poultry manure, nutrient uptake, sewage sludge, yield

I. Introduction

Rice (*Oryza sativa* L.) is the staple food of more than half of the world population. Among the rice growing countries, India has the largest area (43.0 m ha) and is the second largest producer (109.15 mt) of rice next to china (197 mt). The rice productivity in India is 3.37 t ha^{-1}, while the world average is 4.25 t ha^{-1} (IRRI, 2011). In Karnataka, rice is grown in an area of 1.32 m ha with an annual production of 4.24 m t and productivity is 3338 kg ha^{-1} (Anon., 2015). At the current population growth rate (1.5%), the rice requirement of India by the year 2025 would be around 125 million tons (Kumar *et al.,* 2009). To meet the food requirement of the growing population, the rice production has to enhance with good management practices with shrinking availability of land and water resources condition. Increasing water scarcity is becoming real threat for rice cultivation. Hence water saving technologies which also maintain soil health and sustainability and economically beneficial needs to be developed. Rice cultivation is most water consuming system and utilizes about 60 per cent of total available irrigation water. Traditional low land rice grown with continuous flooding in Asia has relatively high water input. To meet the water crisis, there is a need of alternate means of rice cultivation which require less water. Aerobic rice assumes greater importance in the light of the water scarcity and increasing demand for rice. Aerobic rice is a production system in which specially developed aerobic rice varieties are grown in well drained, non-puddled and non saturated soils. With appropriate management, the system aims for yields of at least 4.0 to 6.0 t ha^{-1}.

The essence of practicing organic farming lies in the use of naturally available resources. Using organic sources like farm yard manure (FYM), vermicompost, poultry manure, sewage sludge and urban compost etc., deserves priority for sustained production and better resource utilization compared to chemical farming (Muneshwar Singh *et al.,* 2001). The application of organic source along with inorganic fertilizer leads to increase in productivity of the system and also sustained the soil health for longer period. Organic sources of nutrients applied to the preceding crop benefits the succeeding crop to a great extent (Hegde and Dwivedi, 1992) and system productivity becomes sustainable. A long term field trial on finger millet at Bangalore revealed that FYM or NPK fertilizers alone could not produce high yields and not sustainable. Many essential plant nutrients became deficit after two-three decades with them (Gajanana *et al*., 2005). Therefore, an investigation was under taken to study the effect of organic nutrient sources on productivity and nutrient uptake by aerobic rice under different establishment methods.

II. Material and Methods

Field experiment was conducted during *kharif* 2005 and 2006 at Zonal Agricultural Research Station, Mandya, University of Agricultural Sciences, Bengaluru to “Study the effect of

organic nutrient sources on productivity and uptake of nutrients by Aerobic rice in Cauvery command area". Soil of the experimental site was red sandy loam in texture, low in organic carbon (0.43%) and available nitrogen (270.60 kg ha^{-1}), medium in available P_2O_5 (32.25 kg ha^{-1}) and K_2O (149.80 kg ha^{-1}). Treatments consisted of 12 combinations of two main plot treatments (methods of cultivation) and six nutrient sources in sub plot (T_1: Recommended fertilizer dose (FYM 10 t + 100:50:50 N:P2O5:K2O kg ha^{-1}), T_2: FYM @ 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing, T_3: Pressmud 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing, T_4: Poultry manure 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing, T_5: Sewage sludge 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing, T_6: Urban compost 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing) were laid out in split plot design with three replications. The variety used was IR30864; it was developed at Zonal Agricultural Research Station, Visweshwaraiah Canal Farm, Mandya, University of Agricultural Sciences, Bengaluru by using Mandya Vijay and Bilimukthi varieties. This is a medium duration variety and comes to harvest in 130 to 135 days. The variety produces bold seeds having attractive colour. The variety is capable of producing higher grain and straw yields and resistant to blast disease.

The relevant yield was recorded at harvest and subjected to statistical analysis, results were then analyzed statistically for drawing conclusion using analysis of variance (ANOVA) procedure (Gomez and Gomez, 1984). 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 and expressed in percentage. Nutrient uptake (kg ha^{-1}) by crop was calculated for each treatment separately using the following formula

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)}}{100} \times \text{Dry weight (kg ha}^{-1}\text{)}$$

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 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 and expressed in kg per ha as explained in nitrogen estimation.

III. Results and Discussion

Grain and straw yield: Results of the experiments indicated that, significantly, higher seed yield and straw yield of rice was registered with puddle method of establishment (4600 kg ha^{-1} and 4325 kg ha^{-1}, respectively) as compared to aerobic method of establishment (3658 kg $ha^{-1}$and 3433 kg ha^{-1}, respectively) (Table 1). The higher yield in puddle condition is due to continuous availability of water and nutrients that resulted in higher uptake of nutrients which resulted in higher leaf area and higher dry matter as compared to aerobic situation. Continuous availability of moisture throughout crop growth period leads to optimum leaf moisture content and had high leaf turgidity leading to maximum stomatal aperture and minimum stomatal resistance. This might be related to higher photosynthetic efficiency of crop and higher nutrient uptake and assimilation in source and translocation to the sink, which ultimately resulted in higher yield (Shekhara *et al*., 2010).

Application of recommended dose of fertilizer recorded significantly higher grain yield of rice and straw yield (4858 and 4761 kg ha^{-1}, respectively) as compared to organic source of nutrients. Among different organic source of nutrients application of poultry manure 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing recorded significantly higher grain yield (4375 and 4139 kg ha^{-1}, respectively) and which was on par with application of sewage sludge 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing (4188 and 3931 kg ha^{-1}, respectively) as compared to all other source of nutrients. The increased grain yield in poultry manure applied plot might be due to higher nitrogen content in poultry manure (1.96 % N) which was much readily available as compared to other organic manures. Poultry manure contains about 60 per cent of its nitrogen as uric acid, 30 per cent as more stable organic form of N and less than 10 per cent as mineral N. The uric acid N changes rapidly to ammonical form. Poultry manure contains growth promoting hormones and produce better root growth than fertilizer (Garg *et al.*, 1971).

IV. Nutrients Uptake by Rice

Among rice establishment methods, rice grown under puddled situation recorded significantly higher nitrogen (61.19, 35.85 and 105.12 kg ha^{-1}, respectively), phosphorous (15.53, 5.53 and 21.00 kg ha^{-1}, respectively) and potassium (19.94, 59.91 and 79.85 kg ha^{-1}, respectively) uptake in grain, straw and total uptake as compared to aerobic condition. Among different nutrient sources, application of recommended dose of fertilizer recorded significantly higher nitrogen (73.07, 37.86 and 110.93 kg ha^{-1}, respectively), phosphorous (16.40, 5.86 and 22.26 kg ha^{-1}, respectively) and potassium (21.06, 63.27 and 84.33 kg ha^{-1}, respectively) uptake in grain, straw and total uptake as compared to organic source of nutrients (Table 2, 3 and 4). Among different organic source of nutrients, application of poultry manure 125 kg N equivalent + 25 per cent of recommended N equivalent poultry manure as top dressing recorded significantly higher nitrogen (65.81, 34.10 and 99.10 kg ha^{-1}, respectively), phosphorous (14.78, 5.28 and 20.05 kg ha^{-1}, respectively) and potassium (18.97, 56.98 and 75.95 kg ha^{-1}, respectively) uptake in grain, straw and total uptake and was on par with application of sewage sludge 125 kg N equivalent + 25 per cent of recommended N equivalent poultry manure as top dressing as compared to all other source of nutrients. Application of different

sources of organic manures increased the soil organic carbon content. This was mainly attributed to the slow decomposition rate of organic matter under poultry manure. Increase in uptake of nitrogen could be due to increase in dry matter production. Since the nitrogen added through organic manure was in organic form which releases throughout the crop growth and thus contributed for higher concentration in aerobic rice. This might be further attributed to increased root growth, which was added to soil after death of plant. Similar results were obtained by Ranjan Bhattacharya *et al*. (2004).

V. Conclusion

Among different organic nutrient management practices application of poultry manure 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing has been found superior with respect to yield and nutrients uptake by the aerobic rice.

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Table 1: Grain yield (kg ha^{-1}) and straw yield of rice as influenced by methods of establishment and organic sources of nutrients

Note: M_1: Puddled rice cultivation
M_2: Aerobic rice cultivation

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
	Pooled					
	M_1	**M_2**	**Mean**	**M_1**	**M_2**	**Mean**
T_1: Recommended fertilizer dose	5412	4303	4858	5379	4144	4761
T_2: FYM @ 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing	4309	3460	3884	4195	3245	3720
T_3: Pressmud 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing	3904	3063	3483	3694	2753	3224
T_4: Poultry manure 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	4852	3898	4375	4626	3652	4139
T_5: Sewage sludge 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	4688	3688	4188	4350	3512	3931
T_6: Urban compost 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	4434	3535	3984	3705	3292	3498
Mean	4600	3658	4129	4325	3433	3879
	M	T	MxT	M	T	MxT
S.Em±	234.76	77.33	796.12	266.84	120.67	884.33
CD@5%	694.32	232.18	NS	795.32	359.50	NS

RDF: Recommended Dose of Fertilizer (100:50:50 kg N:P_2O_5:K_2O ha^{-1}+ FYM 4t ha^{-1})
NS: Statistically not-significant

Table 2: Nutrients uptake by grain of rice as influenced by methods of establishment and organic source of nutrients

Treatments	Nutrients uptake by grain (kg ha^{-1}) (pooled)								
	N			P_2O_5			K_2O		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1: Recommended fertilizer dose	81.41	64.73	73.07	18.27	14.53	16.40	23.46	18.66	21.06
T_2: FYM @ 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing	64.81	52.04	58.43	14.55	11.68	13.12	18.68	15.00	16.84
T_3: Pressmud 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing	58.72	46.07	52.40	13.18	10.34	11.76	16.92	13.28	15.11
T_4: Poultry manure 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	72.99	58.64	65.81	16.39	13.16	14.78	21.04	16.90	18.97
T_5: Sewage sludge 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	70.52	55.97	63.25	15.83	12.76	14.29	20.33	16.29	18.31
T_6: Urban compost 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	66.70	53.17	59.94	14.98	11.93	13.46	19.23	15.33	17.28
Mean	69.19	55.10	62.15	15.53	12.40	13.94	19.94	15.86	17.90
	M	T	MxT	M	T	MxT	M	T	MxT
S.Em±	4.04	0.94	11.94	0.64	0.21	2.68	1.26	0.26	3.49
CD@5%	12.13	2.85	NS	1.97	0.63	NS	3.79	0.79	NS

Note: M_1: Puddled rice cultivation
M_2: Aerobic rice cultivation
RDF: Recommended Dose of Fertilizer (100:50:50 kg N:P_2O_5:K_2O ha^{-1}+ FYM 4t ha^{-1})
NS: Statistically not-significant

Table 3: Nutrients uptake by straw of rice as influenced by methods of establishment and organic source of nutrients

Treatments	Nutrients uptake by straw (kg ha^{-1}) (pooled)								
	N			P_2O_5			K_2O		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1: Recommended fertilizer dose	42.18	33.53	37.86	6.53	5.19	5.86	70.49	56.05	63.27
T_2: FYM @ 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing	33.58	26.96	30.27	5.20	4.18	4.69	56.12	45.06	50.59
T_3: Pressmud 125 kg N equivalent + 25% of recommended N	30.42	23.87	27.15	4.71	3.70	4.20	50.84	39.89	45.37

equivalent poultry manure as top dressing									
T_4: Poultry manure 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	37.82	30.38	34.10	5.86	4.71	5.28	63.20	50.77	56.98
T_5: Sewage sludge 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	36.53	29.24	32.88	5.66	4.60	5.13	61.06	48.03	54.54
T_6: Urban compost 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	34.56	27.55	31.05	5.22	4.27	4.74	57.75	46.04	51.89
Mean	35.85	28.59	32.22	5.53	4.44	4.98	59.91	47.64	53.77
	M	T	MxT	M	T	MxT	M	T	MxT
S.Em±	1.86	0.48	6.19	0.25	0.09	1.04	3.29	0.94	10.91
CD@5%	5.58	1.45	NS	0.77	0.28	NS	9.89	2.82	NS

Note: M_1: Puddled rice cultivation
M_2: Aerobic rice cultivation
RDF: Recommended Dose of Fertilizer (100:50:50 kg N:P_2O_5:K_2O ha^{-1}+ FYM 4t ha^{-1})
NS: Statistically not-significant

Table 4: Total nutrients uptake by rice as influenced by methods of establishment and organic source of nutrients

Treatments	**Total nutrients uptake by rice (kg ha^{-1}) (pooled)**								
	N			**P_2O_5**			**K_2O**		
	M_1	**M_2**	**Mean**	**M_1**	**M_2**	**Mean**	**M_1**	**M_2**	**Mean**
T_1: Recommended fertilizer dose	123.59	98.26	110.93	24.81	19.73	22.26	93.95	74.70	84.33
T_2: FYM @ 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing	98.39	79.00	88.69	19.75	15.86	17.80	74.80	60.06	67.43
T_3: Pressmud 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing	89.14	69.94	79.54	17.89	14.04	15.96	67.76	53.17	60.47
T_4: Poultry manure 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	110.80	89.01	99.91	22.24	17.87	20.05	84.23	67.67	75.95
T_5: Sewage sludge 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	107.55	86.21	96.88	21.49	16.90	19.20	81.38	66.02	73.70
T_6: Urban compost 125 kg N equivalent + 25% of recommended N equivalent poultry manure as top dressing.	101.25	80.72	90.98	19.83	16.20	18.01	76.98	61.36	69.17
Mean	105.12	83.86	94.49	21.00	16.77	18.88	79.85	63.83	71.84
	M	T	MxT	M	T	MxT	M	T	MxT
S.Em±	4.39	1.13	18.15	0.96	0.32	3.73	4.28	0.83	13.71

CD@5%	13.17	3.40	NS	2.89	0.97	NS	12.85	2.50	NS

Note: M_1: Puddled rice cultivation
M_2: Aerobic rice cultivation
RDF: Recommended Dose of Fertilizer (100:50:50 kg $N:P_2O_5:K_2O$ ha^{-1}+ FYM 4t ha^{-1})
NS: Statistically not-significant