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RESEARCH PAPER

Effect of organic manures and liquid organic manures on growth, yield and economics of aerobic rice cultivation

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Abstract : Field experiment was conducted to know the response of organic manures on growth, yield, quality and economics of aerobic rice during *Kharif* 2011 at MARS, Dharwad. Results indicated that among organic treatments combined application of EC(1/3) + VC(1/3) + GLM(1/3) equivalent to RDF + FYM in combination with foliar application of jeevamrut @ 500 l ha^{-1} at planting, 30 and 60 DAS + panchagavya @ 5 per cent at panicle emergence and flowering stages recorded significantly higher growth parameters with higher grain yield (3837 kg ha^{-1}) and straw yield (5855 kg ha^{-1}) which was on par with control treatments *i.e.*, RDF + FYM and RDF only. But the net return (Rs.36,366) was higher with combined application of EC(1/3) + VC(1/3) + GLM(1/3) equivalent to RDF + FYM in a combination with foliar application of jeevamrut @ 500 l ha^{-1} at planting, 30 and 60 DAS + cow urine @ 10 per cent at panicle emergence and flowering stages and B:C (2.49) was higher with combined application of EC(1/3) + VC(1/3) + GLM(1/3) equivalent to RDN + cow urine @ 10 per cent at panicle emergence and flowering stages this might be due to lower cost of cultivation with these treatments.

Key Words : Aerobic rice, Jeevamrut, Panchagavya, Grain yield, Net returns

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INTRODUCTION

Rice (*Oryza sativa* L.) is a principal source of food for more than half of the world population, and more than 90 per cent of rice worldwide is grown and consumed in Asia (Amudha *et al.*, 2009).In world rice is cultivated over an area of 147 million ha with a production of 610 million tonnes and productivity of 3.75 tonnes per ha. India has the largest area among rice growing countries and it stands second in production. It produces 97.0 million tonnes of rice from an area of 43.18 million ha with a productivity of 2101 kg per ha (Anonymous, 2011).

Rice is grown under four major ecosystems mainly, irrigated (21.0 million ha), rainfed lowland (14 million ha), rainfed upland (6 million ha) and flood prone (3 million ha). Lowland rice production systems consume more water indicating 60 per cent utilization of total available irrigation water (Wang *et al.*, 2002). Aerobic rice systems, wherein the crop is established via direct seeding in non-puddled, non-flooded fields and managed intensively as an upland crop, are among the most promising approaches (Bouman *et al.*, 2002).

In aerobic rice among the various practices, optimizing the use of manures and fertilizers is one of the important strategies for increasing production of rice per unit area. Optimization of nutrient requirement of crop through integrated management of solid and liquid organic manures for sustainable production of aerobic rice needs priority. Using organic sources like FYM, compost, vermicompost, sheep and

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goat manure, poultry manure in combination with liquid organic manures like cattle urine, panchgavya, vermiwash, bio-digested liquid, jeevamrut etc. deserves priority for sustained production and better on farm resource recycling and utilization. Compared to chemical farming following organic method was self-sufficient and self-dependent as compared to modern chemical farming principles of nutrient capturing and relying more on organic inputs (Singh *et al.*, 2001) is need of the hour.

MATERIAL AND METHODS

A field experiment was carried out during *Kharif* season of 2011 at Main Agricultural Research Station (MARS), College of Agriculture, Dharwad (University of Agricultural Sciences, Dharwad). The soil was Red loamy in texture with a neutral pH (7.02), low EC (0.09 dSm^{-1}), medium organic carbon (0.59 %), low available N (191.2 kg ha^{-1}), medium available P_2O_5 (20.36 kg ha^{-1}), medium K_2O (283 kg ha^{-1}), low sulphur (11.17 kg ha^{-1}), Fe (6.02 ppm), Mn (10.45 ppm), Zn (0.59 ppm) and Cu (2.04 ppm). The experiment was laid out in split plot design with three replications involving two main plot treatments *i.e.*, M_1- EC(1/3)+VC(1/3)+GLM (1/3) equivalent to RDN and M_2-EC(1/3)+VC(1/3)+GLM(1/3) equivalent to RDF +FYM, eight sub plot treatments L_1- bio-digester @ 500 l ha^{-1} applied at planting, 30 and 60 DAS applied to soil, L_2-jeevamrut @ 500 l ha^{-1} applied at planting, 30 and 60 DAS applied to soil, L_3- panchagavya @ 5 per cent foliar application at panicle emergence and flowering stages, L_4-cow urine @ 10 per cent foliar application at panicle emergence and flowering stages, L_5-L_1 + panchagavya @ 5 per cent foliar application at panicle emergence and flowering stages, L_6-L_1+ cow urine @ 10 per cent foliar application at panicle emergence and flowering stages, L_7-L_2 + panchagavya spray @ 5 per cent at panicle emergence and flowering stages, L_8-L_2 + cow urine @ 10 per cent foliar application at panicle emergence and flowering stages and two controls *i.e.*, RDF only and RDF + FYM.

Fine grain and early duration variety of paddy MAS- 26 released in year 2008 from University of Agricultural Sciences, Bengaluru was adopted for cultivation (Gandhi *et al.*, 2012). At the time of sowing, 50 per cent of recommended dose of nitrogen and complete dose of P_2O_5 and K_2O (RDF: 100:50:50 N: P_2O_5: K_2O kg ha^{-1}) to RDF alone and RDF + FYM (10 t/ha) were applied to control treatments. GLM on green weight basis, FYM, enriched compost and vermicompost all applied as per the treatments at the time of sowing, bio-digester, jeevamrut, panchagavya and cow urine were applied as per the treatments at planting, 30 and 60 DAS and at panicle emergence and at flowering stages. The remaining 50 per cent of recommended nitrogen was applied 30 days after sowing as top dressing in control treatments (RDF and RDF + FYM). Before sowing seeds were soaked in water for 8 hours and seeds were treated with trichoderma, Pseudomonas and Azospirillum @ 4g per kg at the time of sowing. Two seeds were dibbled per hill at 30 cm apart. Sowing was done on 19-06-2011. Inter cultivation with rotary hoe was done at 20, 40 and 60 DAS and two hand weeding at 40 DAS and 60 DAS was done to manage weeds.

The growth parameters and yield parameters were recorded at different stages (30, 60, 90 and at harvest) of crop growth. The crop was harvested treatment wise at maturity and grain yield per hectare was computed.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Effect of solid organic manures on growth parameters, yield parameters and economics of aerobic rice :

Among organic manures application of M_2-EC(1/3)+VC(1/3)+GLM(1/3) equivalent to RDF +FYM recorded significantly higher plant height, number of tillers per hill and total dry matter production over M_1-EC(1/3)+VC(1/3)+GLM(1/3) equivalent to RDN (Table 1). This might be due integrated application of FYM which could be attributed to the availability of nutrients throughout the crop growth and its uptake by the crop apart from favourable effect of FYM on soil physico-chemical and biological properties Basavaraj (2007). These results are in conformity with the findings of Singh and Verma (1999). Yield of crop is the manifestation of yield attributing characters. The higher grain yield (3442 kg ha^{-1}) and straw yield (4566 kg ha^{-1}) with application of M_2-EC(1/3)+VC(1/3)+GLM(1/3) equivalent to RDF +FYM was due to higher yield parameters such as productive tillers per hill (33.86), filled grains per panicle (83.96), panicle length (22.55 cm), panicle weight (2.26 g) and thousand grain weight (21.45g) (Table 2, 3 and 4). The increased panicle length and panicle weight was noticed with the combined application of organics equivalent to RDF + FYM may be attributed to steady supply of nutrients which enhanced the dry matter production due to more availability of photosynthates (Donald, 1962 and Siddaram, 2009). As a result of application of nutrients in the form of organics resulted in higher number of grains per panicle Beena and Balachandran (2002). These results are in accordance with the findings of Singh *et al.* (2001), Sudha and Chandini (2003), Rao *et al.* (1996) and Babu and Reddy (2000). Significantly higher net return (Rs.30,272 ha^{-1}) was obtained with M_2-EC (1/3) + VC (1/3) + GLM (1/3) equivalent to RDF (100:50:50 N, P_2O_5, K_2O + 10 t FYM), which realized the lower B : C ratio (2.24) (Table 5). The lower B : C ratio was due to higher cost of cultivation in this treatment, similar findings were also observed by Mondal *et al.* (2003).

Effect of liquid organic manures on growth parameters, yield parameters and economics of aerobic rice :

Growth parameters like plant height, number of tillers

Table 1 : Plant height (cm), number of tillers and total dry matter production of aerobic rice as influenced by application of organic manures and liquid organic manures at harvest

Treatments	Plant height at harvest (cm)			No. of tillers at harvest ($hill^{-1}$)			Total dry matter production at harvest ($g\ hill^{-1}$)		
M × L	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
L_1	41.89	50.15	46.02	35.27	47.43	41.35	61.65	69.21	65.43
L_2	42.28	50.76	46.52	38.8	44.47	41.63	61.68	70.63	66.16
L_3	45.51	49.30	47.41	39.87	44.4	42.13	63.00	72.28	67.64
L_4	44.57	52.34	48.45	38.2	45.83	42.02	64.67	71.79	68.23
L_5	44.72	52.67	48.69	41.27	43.03	42.15	64.63	72.54	68.59
L_6	45.21	54.55	49.88	38.7	51.73	45.22	66.07	74.40	70.23
L_7	45.52	56.28	50.90	42.93	53.67	48.3	68.63	77.51	73.07
L_8	45.05	55.32	50.19	39.67	52.30	45.98	66.13	75.37	70.75
Mean	44.34	52.67		39.34	47.86		64.56	72.97	
C_1		54.79			51.03			75.52	
C_2		57.20			55.63			79.16	
Comparison means of	S.E. ±	LSD (P=0.05)		S.E. ±	LSD (P=0.05)		S.E. ±	LSD (P=0.05)	
Solid organic manures (S)	1.00	6.08		0.89	5.42		0.69	4.22	
Liquid organic manures (L)	0.46	1.35		1.09	3.16		0.99	2.86	
S × L	1.17	3.40		1.54	4.47		1.40	NS	
Interaction Vs control	0.96	2.76		1.68	4.83		1.37	3.94	

M_1- EC + VC + GLM equivalent to RDF + FYM: Enriched compost + vermicompost + Green leaf manure equivalent to Recommended dose of fertilizer (N, P_2O_5, K_2O @ 100:50:50 kg ha^{-1}) + 10 t FYM
M_2-EC + VC + GLM equivalent to RDN: Enriched compost + vermicompost + Green leaf manure equivalent to Recommended dose of Nitrogen (100 kg N ha^{-1})
L_1- Bio-digester @ 500 l ha^{-1} applied at planting, 30 and 60 DAS applied to soil
L_2 -Jeevamrut @ 500 l ha^{-1} applied at planting, 30 and 60 DAS applied to soil
L_3-Panchagavya @ 5% foliar application at panicle emergence and flowering stages
L_4- Cow urine @ 10% foliar application at panicle emergence and flowering stages
L_5-L_1+ Panchagavya @ 5% foliar application at panicle emergence and flowering stages
L_6 -L_1+ Cow urine @ 10% foliar application at panicle emergence and flowering stages
L_7- L_2 + Panchagavya spray @ 5% at panicle emergence and flowering stages
L_8-L_2 + Cow urine @ 10% foliar application at panicle emergence and flowering stages
C_1-RDF (N, P_2O_5, K_2O @ 100:50:50 kg ha^{-1}) , C_2- RDF (N, P_2O_5,K_2O @ 100:50:50 kg ha^{-1}) + 10 t FYM

Table 2 : Filled grains, unfilled grains and productive tillers of aerobic rice as influenced by application of organic manures and liquid organic manures at harvest

Treatments	Filled grains/ panicle			Unfilled grains/panicle			Productive tillers/hill		
M × L	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
L_1	71.18	72.51	71.84	15.61	10.21	12.36	27.07	33.60	30.33
L_2	62.07	78.77	70.42	15.04	9.10	11.72	28.10	30.97	29.53
L_3	72.45	80.12	76.28	11.07	8.40	11.07	27.87	31.13	29.50
L_4	69.13	80.80	74.96	8.82	11.07	9.44	28.63	31.80	30.22
L_5	71.43	77.71	74.57	10.05	10.07	10.34	29.67	32.00	30.83
L_6	62.47	89.63	76.05	10.52	10.62	9.71	28.73	35.73	32.23
L_7	68.50	97.62	83.06	10.53	8.90	7.90	28.07	38.20	33.13
L_8	69.47	94.54	82.01	15.61	5.27	8.44	27.93	37.47	32.70
Mean	68.34	83.96		11.48	8.76		28.26	33.86	
C_1		95.81			4.71			37.39	
C_2		101.61			4.87			40.00	
Comparison means of	S.E.±	LSD (P=0.05)		S.E.±	LSD (P=0.05)		S.E.±	LSD (P=0.05)	
Solid organic manures (S)	1.54	9.39		0.24	1.46		0.22	1.34	
Liquid organic manures (L)	1.42	4.11		0.59	1.72		0.68	1.98	
S × L	2.01	5.82		0.84	2.43		0.97	2.80	
Interaction Vs control	2.21	6.34		0.79	2.27		0.93	2.67	

Table 3 : Panicle length, panicle weight and 1000- grain weight of aerobic rice as influenced by application of organic manures and liquid organic manures at harvest

Treatments	Panicle length (cm)			Panicle weight (g)			Thousand grain weight (g)		
M × L	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
L_1	19.19	22.25	20.72	1.64	1.77	1.70	19.20	20.46	19.83
L_2	19.84	21.13	20.48	1.94	2.09	2.01	19.48	20.49	19.99
L_3	20.75	22.51	21.63	1.83	2.06	1.94	19.04	21.68	20.36
L_4	20.58	21.02	20.80	1.84	2.18	2.01	19.60	21.35	20.47
L_5	21.03	22.54	21.78	1.84	2.22	2.03	19.40	21.54	20.47
L_6	19.92	21.36	20.64	1.88	2.28	2.08	19.51	21.81	20.66
L_7	19.50	25.06	22.28	1.88	2.79	2.34	19.80	22.27	20.91
L_8	19.87	24.51	22.19	1.75	2.68	2.21	19.43	22.02	20.85
Mean	20.08	20.55		1.82	2.26		19.		
C_1		24.30			2.38			22.68	
C_2		26.62			2.95			22.69	
Comparison means of	S.E.±		LSD (P=0.05)	S.E.±	LSD (P=0.05)		S.E.±		LSD (P=0.05)
Solid organic manures (S)	0.26		1.57	0.03	0.16		0.20		1.23
Liquid organic manures (L)	0.39		1.14	0.09	0.26		0.51		NS
S × L	0.56		1.62	0.13	0.37		0.72		NS
Interaction Vs control	0.85		2.46	0.18	0.51		0.70		2.01

NS=Non-significant

Table 4 : Grain yield, straw yield and harvest index of aerobic rice as influenced by organic manures and liquid organic manures at harvest

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index		
M × L	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
L_1	2335	2995	2665	3421	3859	3640	0.406	0.437	0.422
L_2	2409	3169	2789	3575	3849	3712	0.403	0.452	0.428
L_3	2459	3084	2771	3478	4332	3905	0.414	0.416	0.415
L_4	2552	3161	2856	3464	4284	3874	0.424	0.425	0.425
L_5	2737	3733	3235	3602	4288	3945	0.432	0.465	0.449
L_6	2815	3739	3277	3425	4528	3976	0.451	0.452	0.452
L_7	2937	3837	3387	3410	5855	4632	0.463	0.396	0.433
L_8	2811	3819	3315	3562	5536	4549	0.441	0.408	0.423
Mean	2632	3442		3492	4566		0.430	0.432	
C_1		3648			5844			0.38	
C_2		3885			6023			0.39	
Comparison means of	S.E. ±		LSD (P=0.05)	S.E. ±		LSD (P=0.05)	S.E. ±		LSD (P=0.05)
Solid organic manures (S)	42		255	25		150	0.002		NS
Liquid organic manures (L)	54		156	151		438	0.010		NS
S × L	76		221	214		619	0.014		NS
Interaction Vs control	90		258	200		574	0.01		0.04

NS=Non-significant

per hill and total dry matter production (Table 1) was higher with soil application of of jeevamrut @ 500 l ha^{-1} at planting, 30 and 60 DAS + panchagavya foliar spray @ 5 per cent at panicle emergence and flowering stages increases the photosynthetic area due to which higher assimilation of photosynthates and their accumulation in plants was noticed. Also yield components like productive tillers per hill, filled grains per panicles, panicle length and panicle weight (Table 2 and 3) and grain yield (3387 kg ha^{-1}) and straw yield (4632 kg ha^{-1}), (Table 4) was higher with soil application of jeevamrut @ 500 l ha^{-1} at planting, 30 and 60 DAS + panchagavya foliar spray @ 5 per cent at panicle emergence and flowering stages and was on par with soil application of jeevamrut @ 500 l ha^{-1} at planting, 30 and 60 DAS + cow urine foliar spray @ 10 per cent at panicle emergence and flowering stages and soil application of bio digester @ 500 l ha^{-1} at planting, 30 and 60 DAS + cow urine @ 10 per cent foliar application at panicle emergence and flowering stages. These results are in conformity with the findings of the (Roul and Sarawagi, 2005); Rajeswari (1990) and Boomiraj (2003). The grain yield and straw yield increased due to application of liquid organic manures like panchagavya and cow urine spray at the time of panicle emergence and flowering in combination with jeevamrut and bio digester application to the soil might be due to the presence of growth promoting hormones and nutrients uric acid in cow urine. Their application at the time of panicle emergence and flowering stages increased growth, development and yield of the crop as their application coincides with higher nutrient demand for the crop. The net return was significantly higher with soil application of jeevamrut @ 500 l ha^{-1} at planting, 30 and 60 DAS + cow urine foliar spray @ 10 per cent at panicle emergence and flowering stages (Rs. 30,857) and was at par with bio- digester @ 500 l ha^{-1} applied at planting, 30 and 60 DAS applied to soil + cow urine @ 10 per cent foliar application at panicle emergence and flowering stages and soil application of jeevamrut @ 500 l ha^{-1} + panchagavya @ 5 per cent foliar application at panicle emergence and flowering stages (Table 5). The higher net return was due to higher grain yield and straw yield. Similarly, the benefit cost ratio was significantly higher with soil application of bio digester @ 500 l ha^{-1} at planting, 30 and 60 DAS + cow urine foliar spray @ 10 per cent at panicle emergence and flowering stages (2.48).

Effect of interactions on growth, yield and economics of aerobic rice :

The organic treatment combination EC (1/3) + VC (1/3) + GLM (1/3) equivalent to RDF + FYM with soil application of jeevamrut @ 500 l ha^{-1} at planting, 30 and 60 DAS + panchagavya foliar spray @ 5 per cent at panicle emergence and flowering stages (M_2L_7) recorded significantly higher growth components mainly plant height, number of tillers, total dry matter production (Table 1) and yield attributes mainly higher number of productive tillers per hill, panicle length, panicle weight and number of filled grains per panicle (Table 2 and 3). Similarly, grain yield and straw yield (3837 kg ha^{-1} and 5855 kg ha^{-1}) was also higher with the former treatment over other organic treatment combinations except it was at par with RDF + FYM, RDF only (3885 kg ha^{-1} and 6023 kg ha^{-1}, respectively) and organic treatments EC (1/3) + VC (1/3) + GLM (1/3) equivalent to RDF + FYM with soil application of jeevamrut @ 500 l ha^{-1} at planting, 30 and 60 DAS + cow urine foliar spray @ 10 per cent at panicle emergence and flowering stages (M_2L_8), EC (1/3) + VC (1/3) + GLM (1/3) equivalent to RDF + FYM with soil application of bio digester @ 500 l ha^{-1} at planting, 30 and 60 DAS + cow

Table 5 : Economics of aerobic rice cultivation as influenced by application of organic manures and liquid organic manures

Treatments	Net returns (` ha^{-1})			Benefit cost ratio		
M × L	M_1	M_2	Mean	M_1	M_2	Mean
L_1	20995	24269	22632	2.04	2.22	2.13
L_2	20327	25594	22960	2.05	2.11	2.08
L_3	20974	24871	22922	2.02	2.14	2.08
L_4	24773	27643	26208	2.22	2.49	2.36
L_5	24359	32217	28288	2.26	2.25	2.26
L_6	25981	35021	30501	2.48	2.48	2.48
L_7	24467	36198	30332	2.36	2.19	2.27
L_8	25349	36366	30857	2.47	2.35	2.41
Mean	23403	30272		2.28	2.24	
C_1		37787			3.71	
C_2		34671			2.74	
Comparison means of	S.E. ±		LSD (P=0.05)	S.E. ±		LSD (P=0.05)
Solid organic manures (S)	599		3646	0.03		NS
Liquid organic manures (L)	728		2108	0.03		0.10
S × L	1029		2982	0.05		0.14
Interaction Vs control	1156		3323	0.06		0.18

NS=Non-significant

urine foliar spray @ 10 per cent at panicle emergence and flowering stages (M_2L_6) and EC (1/3) + VC (1/3) + GLM (1/3) equivalent to RDF + FYM with soil application of bio- digester @ 500 l ha^{-1} at planting, 30 and 60 DAS + panchagavya foliar spray @ 5 per cent at panicle emergence and flowering stages (M_2L_5) (Table 5). This may be due to optimization of available nutrients such as nitrogen to the plants and also improvement in soil quality in terms of improvement in water stable aggregates in the soil. The organic manures have slow release of nitrogen due to its slow mineralization, which helped in the availability of nutrients commensurate with the growth and development of the plants and thus resulted in higher yield. These findings are in accordance with those of Shwetha and Babalad (2008). Significantly higher net returns was recorded with combined application of EC + VC + GLM equivalent to RDF + FYM with soil application of jeevamrut @ 500 l ha^{-1} at planting, 30 and 60 DAS + cow urine foliar spray @ 10 per cent (M_2L_8) at panicle emergence and flowering stages (Rs.36,366 ha^{-1}) and was on par with combined application of EC + VC + GLM equivalent to RDF + FYM with soil application of jeevamrut @ 500 l ha^{-1} at planting, 30 and 60 DAS + panchagavya @ 5 per cent at (M_2L_7) panicle emergence and flowering stages (Rs.36,198 ha^{-1}), combined application of EC + VC + GLM equivalent to RDF + FYM with soil application of bio- digester @ 500 l ha^{-1} at planting, 30 and 60 DAS + cow urine foliar spray @ 10 per cent (M_2L_6) at panicle emergence and flowering stages and RDF alone (Rs.37,787 ha^{-1}) (Table 5). This might be due to higher grain yield and straw yield. Significantly higher benefit cost ratio was recorded with EC + VC + GLM equivalent to RDN with foliar application of cow urine @ 500 l ha^{-1} at planting, 30 and 60 DAS + cow urine foliar spray @ 10 per cent at (M_1L_4) panicle emergence and flowering stages (2.49) (Table 5).

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