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Short Research Article

Evaluation of *Jeevamruta* as a Bio-resource for Nutrient Management in Aerobic Rice

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Abstract

In the wake of optimization in use of on-farm resources in crop cultivation a field experiment was conducted during summer season on a red sandy loam soil under irrigated conditions to evaluate the *jeevamruta* (organic liquid formulation consisting cattle excretions, jaggery, pulse flour and soil in water) for nutrient management in aerobic rice. The study involved *jeevamruta*, vermicompost and biofertilizer along with chemical fertilizers, on growth and yield of aerobic rice (*Oryza sativa* L.), soil properties and economics. Application of 100% recommended dose of fertilizers (RDF) along with *jeevamruta* (based on crop N requirement) and vermicompost being at par with RDF+vermicompost, RDF+*jeevamruta* and RDF+*jeevamruta*+biofertilizers (*Azospirillum brasilense*) gave significantly higher grain yield (5.27 t ha^{-1}) compared to other treatments. *Jeevamruta* could perform well in integration with chemical fertilizers (as addition) rather than when tried to substitute 50% or 100% recommended dose of nitrogen through it. Integrated nutrient management (INM) involving application of 100% RDF+*jeevamruta* (2000 L ha^{-1}) with or without biofertilizers gave higher benefit:cost ratio compared to other treatments. The study advocates that *jeevamruta* is an efficient bio-resource and could be a component of INM for aerobic rice.

1. Introduction

India's total bovine population is 304 million (GOI, 2013). Bovine excreta contains 1% N and 1.35% K_2O in urine and 0.40% N, 0.20% P_2O_5 and 0.10% K_2O in dung (Yawalkar, 2002). This indicates the greater potential of bovine excretion to provide nutrients in crop production. An estimate of the total dung and urine production by such a vast animal resource indicates that they have potential manurial value of 6.73 mt of N; 2.36 million tons of P_2O_5; and 4.14 million tons of K_2O which can replace around 27.78 million tons of chemical fertilizers in agriculture (Kasbe and Joshi, 2008). However, number of constraints such as problems in collection, poor awareness about their nutrient potentiality, improper and inefficient handling etc. restrict their prospective usage ultimately cause wastage of 50 to 60% dung and 90% urine on farm (Joshi and Prabhakarasetty, 2005; Reddy 2008). *Jeevamruta* is used by large number of farmers in different parts of Karnataka as it can be produced from available farm wastes like cattle dung and cattle urine along with other ingredients like jaggery, pulse flour and water, as an important input in crop production at low cost particularly in organic farming (Joshi, 2008). The philosophy behind the application of *jeevamruta* as a bio-resource is supplementation of essential plant nutrients and improvement of the soil health in economic and eco-friendly manner.

The availability of water for agriculture is declining steadily due to urbanization and rapid increase in population. Groundwater tables have dropped, on average, by 0.5-0.7 m $year^{-1}$ in the Indian states of Punjab, Haryana, Rajasthan, Maharashtra, Karnataka and northern Gujarat and by about 1 m $year^{-1}$ in Tamil Nadu and hard-rock southern region of India (Tuong and Bauman, 2003). Conventional rice farming involves transplanting in puddled soils with continuous submergence is most common method. This requires a large amount of water and labour. An alternative to this method of rice cultivation could be aerobic direct seeding because it requires less water, labour and capital input. Aerobic rice is a new system, wherein the crop is established via direct seeding in non-puddled and non-flooded field following a particular crop geometry, maintenance of one plant $hill^{-1}$ and alternate wetting and drying pattern of irrigation. Aerobic and alternate wetting-drying pattern of irrigation resulted in higher water productivity when compared with flooded condition (Castaneda et al., 2003). Aerobic rice systems can reduce water application by 44% relative to conventionally transplanted systems, by reducing percolation, seepage and evaporative losses, while maintaining yield at an acceptable level (Bouman et al., 2005). Kato et al. (2009) noted the rice yields similar or even higher under aerobic conditions compared to that achieved under flooded condition in Japan. However, Castaneda et al. (2003) observed the rice yields under aerobic conditions were 14 to 40% lower than under flooded conditions. It was necessary to develop location-specific integrated nutrient management modules for realizing higher rice yields.

Better performance of any crop is governed not only by adequacy of available water but by soil fertility also. In fact, both these factors show synergistic effect in terms of realization of higher and sustainable crop productivity. Rice is highly responsive to innate and created soil fertility (Jha et al., 2004). Efficient and location specific nutrient management is the need of the hour for aerobic rice. There is dearth of information on the nutritional composition of *jeevamruta* and its effects on crops. Hence, the present study was conducted to evaluate the effect of *jeevamruta* alone or in combination with chemical fertilizers and vermicompost on performance of aerobic rice and soil properties.

2. Materials and Methods

2.1. Study area

A field experiment was conducted on a red sandy loam soil under irrigated conditions at the agronomy field unit of University of Agricultural Sciences, Bengaluru ($12^0 58'$ N, $77^0 35'$ E and 930 m above mean sea level), Karnataka during the summer (January-May) season of 2008. Soil samples taken from the surface 15 cm before treatments imposition from different places of the site and their composite sample was used for further analysis. Soil had organic carbon content (SOC) of 0.49%, available N 214.3 kg ha^{-1}, available P_2O_5 23.7 kg ha^{-1}, available K_2O 217.2 kg ha^{-1}, and slightly acidic pH (6.3). The mean weekly minimum (13.2 to 21.2^{o}C) and maximum (28.8 to 34.2^{o}C) temperatures during the crop season explain the magnitude of variation in atmospheric temperature. Totally, 155 mm rainfall was received during crop season mainly during April to May months.

2.2. Preparation of jeevamruta

Results from the laboratory study by same authors (Kasbe et al., 2009) revealed that farmers' *jeevamruta* formulations comprising 10 kg:10 L:2 kg:2 kg:200 L of cattle dung: cattle urine: jaggery: pulse four : water respectively and one handful of fertile soil with 1 to 3 days incubation recorded highest total nitrogen percentage (0.94 and 0.36 respectively) as compared to other formulations having varying composition and increased incubation period. This characterization of *jeevamruta* was taken as the basis for its preparation in the present field experiment. However, jeevanruta was incubated for 36-40 h in a plastic drum at room temperature. *Jeevamruta* was stirred twice (morning and evening) in a day during its incubation period.

2.3. Treatment details and layout

Ten nutrient management treatments were tried, T_1:100% recommended dose of fertilizers (RDF), T_2: T_1+vermicompost (5 t ha^{-1}), T_3:T_1+*jeevamruta* (2000 L ha^{-1}), T_4:50% RDF+*jeevamruta* (2000 L ha^{-1}), T_5:*Jeevamruta* (2000 L ha^{-1})+vermicompost (5 t ha^{-1}), T_6:*Jeevamruta* (2000 L ha^{-1})+biofertilizer, T_7:T_1+T_6, T_8:*Jeevamruta* (2000 L ha^{-1}), T_9:*Jeevamruta* (based on N requirement), T_{10}: T_2+T_9. Performance of *jeevamruta* as sole and in different combinations was evaluated with vermicompost and chemical fertilizers in thrice replicated randomized completely block design.

2.4. Cultivation and management

Rice variety (cv. ES-18) was sown on flat bed at a spacing of 25×25 cm^2 on 20th January, 2008. One plant hill^{-1} was maintained by thinning. In the plots involving recommended dose of fertilizers (RDF), the crop was fertilized with 100, 50 and 50 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. Half the dose of N and full dose of P_2O_5 and K_2O was applied at sowing, while the remaining N was applied in two equal splits at 25 and 55 days after sowing (DAS). *Jeevamruta* was applied four times i.e. three hours before sowing, 25, 50 and 75 DAS. It was analyzed for nutrient content prior to its application and given in Table 1. Required quantity of *jeevamruta* was mixed in 10 L of water prior to application to achieve its uniform reach to all plants. *Jeevamruta* was applied as per the treatment in open furrows 10 cm away from crop row and then incorporated into soil immediately. Vermicompost @ 5 tonnes ha^{-1} was incorporated in soil during last harrowing about two weeks before to sowing. Vermicompost consisted 0.87% N, 0.53% P_2O_5 and 0.49% of K_2O. Biofertilizer (*Azospirillum brasilense*) was applied to soil @ 1.5 kg ha^{-1} at the time of sowing by mixing with soil. The amounts of nutrients (N-P-K) added in each treatment are given in Table 1. Alternate drying and wetting pattern was followed to water the crop. Irrigation

Table 1: Nutrient composition of *jeevamruta* at various time of application

Time of application	Nutrient composition of *Jeevamruta* (%)		
	N	P_2O_5	K_2O
Basal	0.36	0.103	0.148
25 DAS	0.48	0.137	0.252
50 DAS	0.38	0.066	0.132
75 DAS	0.40	0.116	0.139

was generally given at an interval of 3-7 days and escaped in case of rains. Weeds were managed by frequent manual intercultures. The grain yield data were recorded and adjusted to 14% of the moisture content.

2.5. Soil and plant analysis

Soil samples were collected from the surface layer (0-15 cm) and analyzed for different parameters by following the standard procedures for organic C (Walkley and Black, 1934), available N (Subbiah and Asija, 1956), available P_2O_5 (Bray's method by Jackson, 1973) and available K_2O (Jackson, 1973). The samples were analyzed for total bacterial population using Nutrient agar media adopting serial dilution method upto 10^{-6} dilutions, and expressed as, count×10^6 colony forming units per 10 grams of soil (×10^6 cfu 10 g^{-1}). Total plant N, P_2O_5 and K_2O contents were estimated using standard procedures (Piper, 1966). Nutrient uptake by crop was calculated by following formula,

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

2.6. Economic and statistical analysis

Monetary net returns to cost of cultivation ratio (B:C ratio) was used to estimate economics of growing aerobic rice. Experimental data were statistically analyzed using ANOVA procedures delineated by Gomez and Gomez (1984).

3. Results and Discussion

Application of recommended dose of fertilizers (RDF) coupled with *jeevamruta* (based on crop N requirement) and vermicompost gave the highest plant height than other treatments. However, the plant height was very poor in the treatments involving application of organic sources (*jeevamruta* and vermicompost) alone (Table 2). Similarly, application of RDF+*jeevamruta* (based on crop N requirement)+vermicompost recorded significantly higher leaf area and number of panicles m^{-2} compared to all other treatments except treatments involving RDF+vermicompost, RDF+*jeevamruta* and RDF+*jeevamruta*+biofertilizer (Table 2). Among the organic sources of nutrients, application of *jeevamruta*+vermicompost gave higher leaf area and number of panicles m^{-2} compared to other treatments at 100 DAS. However, all the treatments had similar effect on panicle length. Application of RDF coupled with *jeevamruta* (based on crop N requirement) and vermicompost recorded the highest number of grains $panicle^{-1}$. It was at par with RDF+vermicompost, RDF+*jeevamruta* and RDF+*jeevamruta*+biofertilizer but significantly superior to all other treatments (Table 2). Similarly to panicle length, the 1000-grain weight was not affected significantly due to different nutrient management treatments and was ranged between 17.4 g to 18.2 g. Synchronization of release of higher concentration of nutrients and the peak nutrient demands resulted in improved drymatter production and ultimately the growth of aerobic rice.

The highest grain yield (5.27 t ha^{-1}) was recorded with application of RDF+*jeevamruta* (based on crop N requirement)+vermicompost and the yield gain due to the treatment ranged from 9-161% compared to other treatments (Table 2). Improvement in grain yield by 17.6 to 30.7% over 100% RDF was due to vermicompost or *jeevamruta* or biofertilizer in different combinations. Improved grain yield by

Table 2: Effect of treatments on crop growth, yield attributes and grain yield of aerobic rice

Treatment	N-P-K applied (kg ha^{-1})	Plant height @ harvest (cm)	Leaf area @ 100 DAS (cm^2)	No. of panicles m^{-2}	Panicle length (cm)	No. of grains $panicle^{-1}$	1000-grain weight (g)	Grain yield (t ha^{-1})
T_1	100:22:42	39.0	1190	461	15.7	66.5	17.6	4.03
T_2	144:33:62	40.1	1359	527	15.9	72.1	18.2	4.83
T_3	108:23:44	39.2	1334	523	15.8	70.2	17.5	4.74
T_4	58:12:24	38.9	1031	411	15.5	64.0	17.4	3.50
T_5	52:12:23	33.1	596	301	15.3	59.3	18.1	2.76
T_6	8:1:3	33.1	575	281	15.3	57.7	17.7	2.41
T_7	108:23:44	39.8	1336	527	15.9	71.8	17.6	4.77
T_8	8:1:3	31.9	523	256	15.2	54.9	17.3	2.02
T_9	100:11:34	32.9	570	287	15.3	58.6	18.2	2.55
T_{10}	244:45:96	40.4	1366	541	16.1	74.5	18.1	5.27
LSD (p<0.05)	-	2.2	122	52	NS	5.2	NS	0.65

NS= Non significant

T_1: 100% recommended dose of fertilizers (RDF); T_2: T_1+vermicompost (5 t ha^{-1}); T_3: T_1+*jeevamruta* (2000 L ha^{-1}); T_4: 50% RDF+*jeevamruta* (2000 L ha^{-1}); T_5: *Jeevamruta* (2000 L ha^{-1})+vermicompost (5 t ha^{-1}); T_6: *Jeevamruta* (2000 L ha^{-1}) +biofertilizer; T_7: T_1+T_6; T_8: *Jeevamruta* (2000 L ha^{-1}); T_9: *Jeevamruta* (based on N requirement); T_{10}: T_2+T_9

integrated approaches was mainly due to the difference in total quantity of nutrients added (Table 2) in different treatments. The grain yield differences among these treatments were in proportion with the nutrients supplied in different treatments, which is confirmed by positive correlation between grain yield and nitrogen and phosphorus uptake ($r=0.99^{**}$). However, numerical superiority of these treatments in respect to grain yield as compared to 100% RDF alone, was masked by statistical equivalence among integrated treatments. The comparative study of nutrient supplied and grain yield revealed that, there was no proportionate increase in yield, as the nutrient supply was more; this could be due to difference in nutrient availability pattern of organic sources (Burger and Venterea, 2008) and also due to varietal limits to be responsive to added fertilizers. Reduction in 50% RDF in combination with *jeevamruta* (2000 L ha^{-1}) caused yield reduction to the tune of 35%, indicating synergistic benefits of using *jeevamruta* with 100% RDF. J ha^{-1} et al. (2004) also reported that integrated nutrient management gave higher yield of scented rice compared to other treatments. The next best treatments in terms of higher grain yield were RDF+vermicompost, RDF+*jeevamruta*+biofertilizer and RDF+*jeevamruta*. All these treatments recorded insignificantly similar (4.74 to 5.27 t ha^{-1}) but significantly higher grain yield than other treatments. Increase in grain yield in these treatments may be attributed to better crop growth and yield attributes due to higher rates of NPK application (Table 2) and improved nutrient availability in the soil (Table 3). Provision of carbonic substrate through organic matter and adequate nitrogen through chemical fertilizer avoids immobilization of nutrients by micro-organisms and hasten nutrient mineralization (Mohammadi et al., 2012). This in turn results in improved uptake by crop at critical stages. Moreover, addition of manures to the soil activates soil enzymes through plant growth promoting rhizobacteria (Zaman et al., 2002; Liang et al., 2003)

Among sole organic treatments, supply of *jeevamruta* on N basis which was comparable with that of 100% RDF should have resulted in high grain yield, but, the grain yield was less by 1.48 tonnes than 100% RDF. This could be due to more losses of N from urine and dung in liquid form, as large volume of *jeevamruta* (23470 L ha^{-1}) could have been subjected to more volatilization losses as ammonia (Majumdar et al., 2006). In addition to this P_2O_5 and K_2O levels supplied by such a huge quantity of *jeevamruta* were less than 100% RDF.

The soil pH and electrical conductivity (EC) after crop harvest ranged from 6.15-6.24 and 0.19-0.24, respectively (Table 2). However, different treatments had no significant effect on both soil pH and EC. Owing to incorporation of large amount of organic matter, RDF+*jeevamruta* (based on crop N requirement)+vermicompost resulted in the highest soil organic C and it was significantly superior to all other treatments except application of *jeevamruta* based on N requirement. Kesarwani (2007) observed significant improvement in soil organic carbon with the conjunctive use of fertilizers and *Jeevamruta* plus Beejamruta.

The available N, P_2O_5 and K_2O in soil were significantly higher with application of RDF+*jeevamruta* (based on crop N requirement)+vermicompost compared to all other treatments. Application of RDF+vermicompost was the next best treatment which registered significantly higher soil N and P_2O_5 than other treatments (Table 3). It was being at par with application of *jeevamruta* (based on crop N requirement) recorded significantly higher available K_2O than other treatments. Addition of *jeevamruta* was highly beneficial in

Table 3: Effect of treatments on soil properties and nutrient uptake by aerobic rice

Treatment	pH	EC (ds m^{-1})	Organic C (%)	Available nutrients (kg ha^{-1})			Bacterial population (10^6 cfu 10 g $soil^{-1}$)	Nutrient uptake by crop (kg ha^{-1})		
				N	P_2O_5	K_2O		N	P_2O_5	K_2O
T_1	6.24	0.19	0.47	211.5	43.6	184.5	66.3	71.1	17.8	86.2
T_2	6.19	0.20	0.53	236.0	67.5	204.5	118.7	89.6	21.7	100.5
T_3	6.20	0.20	0.50	208.2	44.9	179.5	129.7	84.5	21.0	97.9
T_4	6.20	0.19	0.50	186.3	28.6	175.1	108.3	61.9	15.1	75.5
T_5	6.19	0.21	0.52	192.1	43.1	187.5	125.7	50.0	11.8	64.7
T_6	6.21	0.19	0.49	167.1	16.9	167.9	110.3	44.6	10.2	57.5
T_7	6.20	0.20	0.49	210.4	45.8	177.7	137.7	85.9	21.3	99.6
T_8	6.20	0.19	0.51	170.5	18.8	173.9	88.3	37.0	8.5	48.3
T_9	6.17	0.22	0.57	217.7	36.9	201.1	174.7	48.8	11.2	61.0
T_{10}	6.15	0.24	0.62	260.9	86.9	227.5	201.3	100.9	23.9	106.1
LSD ($p<0.05$)	NS	NS	0.08	9.7	2.4	13.0	-	11.5	2.8	12.7

NS= Non significant

T_1: 100% recommended dose of fertilizers (RDF); T_2: T_1+vermicompost (5 t ha^{-1}); T_3: T_1+*jeevamruta* (2000 L ha^{-1}); T_4: 50% RDF+*jeevamruta* (2000 L ha^{-1}); T_5: *Jeevamruta* (2000 L ha^{-1})+vermicompost (5 t ha^{-1}); T_6: *Jeevamruta* (2000 L ha^{-1}) +biofertilizer; T_7: T_1+T_6; T_8: *Jeevamruta* (2000 L ha^{-1}); T_9: *Jeevamruta* (based on N requirement); T_{10}: T_2+T_9

improving bacterial population of soil (Table 3). Application of *jeevamruta* (based on crop N requirement) either alone or in combination with RDF and vermicompost recorded higher bacterial population compared to all other treatments. Similarly, Zaman et al. 2002; Majumdar et al. 2006 inferred that application of dairy shed effluents/urine to the soil resulted in increased microbial biomass carbon and nitrogen indicating higher activity of soil microflora.

Higher grain yields in integrated treatments which resulted in higher uptake caused depletion of K_2O as compared to initial (217.2 kg ha^{-1}) status. But, N and P_2O_5 were either retained or improved (Table 2). Application of RDF+*jeevamruta* (based on crop N requirement)+vermicompost recorded significantly higher N uptake by crop compared to other treatments except application of RDF+vermicompost (Table 2). Similarly, the former treatment being at par with application of RDF+vermicompost and RDF+*jeevamruta*+biofertilizer registered significantly higher uptake of P_2O_5 than other treatments. The uptake of K_2O by rice was significantly higher with application of RDF+*jeevamruta* (based on crop N requirement)+vermicompost compared to other treatments except integrated application of RDF with either vermicompost or *jeevamruta*. Singh (2007) recorded highest N, P and K uptake with integrated use of fertilizers and organic manures to the aerobic rice.

In general, the cost of aerobic rice cultivation was higher with different treatments involving vermicompost (data not presented). It was highest with the application of RDF+*jeevamruta* (based on crop N requirement)+vermicompost due to higher input cost of vermicompost and *jeevamruta*. Integrated nutrient management involving application of 100% RDF+*jeevamruta* (2000 L ha^{-1}) with or without biofertilizer gave higher monetary returns compared to other treatments. The benefit:cost (B:C) ratio was negative (-0.03) for the treatment involving application of *jeevamruta* and vermicompost, mainly due to higher input costs and lower grain yield (Figure 1). Although integrated treatments with

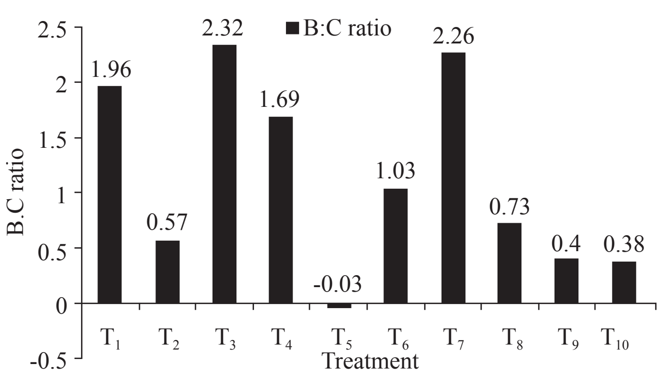

Figure 1: Effect of treatments on benefit:cost ratio (B:C) of summer aerobic rice

100% RDF resulted in statistically similar grain yield, the treatments involving *jeevamruta* among them recorded higher B:C ratio (2.26 to 2.32) as compared to treatments involving vermicompost (0.38 to 0.57). This was mainly due to the high cost of vermicompost and minimum cost involved in preparation of *jeevamruta*.

4. Conclusion

Integrated nutrient management involving application of 100% RDF along with *jeevamruta* (2000 L ha^{-1}) and biofertilizer (*Azospirillum brasilense*) was found superior in realizing higher productivity of aerobic rice and higher net returns than other treatments. Complete substitution of fertilizer oriented N through organic source like *jeevamruta* resulted in significantly lower yields as compared to chemical fertilizers in short term. However, the study revealed that *jeevamruta* is a cheap and efficient substitute for other manures like vermicompost in integrated nutrient management for aerobic rice.

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