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Effect of integrated use of organic and inorganic fertilizers on soil fertility and uptake of nutrients in aerobic rice (*Oryza sativa* L.)

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Abstract
A field study was initiated in 2014 at Agricultural and Horticulture Research Station, Bavikere, University of Agricultural And Horticultural Sciences, Shivamogga to study the effect of combination of organic and inorganic fertilizers on yield, fertility status and uptake pattern of nutrients in Aerobic rice. The results of experimentation revealed that significantly higher nitrogen phosphorus and potassium uptake (131.32, 26.95 and 113.07 kg ha^{-1} respectively) was observed with application of RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia and also higher available nitrogen (269.40 kg ha^{-1}) available phosphorus (86.95 kg ha^{-1}) was observed with the application of RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia. However, it was followed by the application of RDF + FYM + PSB + 25% Nitrogen through Glyricidia (262.62 kg ha^{-1}).

Keywords: Organic and inorganic fertilizers, integrated nutrient management, soil fertility and uptake of nutrients

Introduction
Rice (*Oryza sativa*. L.) is the staple food for nearly half of the world's population and most of them living in developing countries. The crop occupies one third of the world total area and provides, 35-60 per cent of the calories consumed by 2.7 billion people. Rice occupies the enviable prime place among the food crops cultivated around the world, and is cultivated in an area of 161.4 million hectare with a production of 730.2 million tonnes and average productivity of 4480 kg per hectare (Anon, 2014a) [3]. In India, rice occupies an area of 43.95 million hectare with production of 106.54 million tonnes with an average productivity of 2424 kg per hectare (Anon, 2014b) [2], which is half of the global average. In Karnataka, it is grown in an area of 1.33 million hectare with an annual production of 3.76 million tonnes with productivity of 2828 kg ha^{-1} (Anon., 2014b) [2]. Aerobic rice increases the productivity per unit area with proactive interactions between the plant, soil, water and nutrient. Building up of soil organic matter and acceleration of microbial activity to increase the nutrient availability and uptake are the strategy of research. Hence supply, availability and uptake of nutrients, changes in the soil profile and the changes occurring in the soil and crop scenario in aerobic rice under organic manure and inorganic fertilizer applications have been studied. For maintenance of soil fertility and productivity, nourishing the soil by addition of organic manures along with biofertilizers apart from nutrient supply through fertilizers in right amount and proper balance is necessary to get higher production on sustainable basis (Inderjeet *et al*., 2014) [5].
It is estimated that the NPK removal by crops in India was about 28 million tons against the fertilizer consumption of 18 million tonnes creating a gap of 10 million tonnes in 2000 (Tiwari, 2002) [25]. The higher the grain yield targeted, the greater the amount of nutrient required for rice plant. It is reported that the nutrient use efficiency of N, P and K is 30-50, 15-20 and 60-70 per cent, respectively (Pathak, *et al.*, 2002) [17]. Further the NPK ratio of 4:2:1 considered optimum but in reality a wide ratio of 10:2.9:1 is prevalent in the country (Tandon, 2001) [24]. Using organic sources such as FYM, vermicompost, and green manuring deserves priority for sustained production and better resource utilization in integrated nutrient management. INM technology is sustainable as compared to modern chemical farming as the farmer relies more on organic sourcs (Muneshwar Singh *et al*., 2001) [13]. Addition of organic manure improves overall physical condition of the soil which is very essential under aerobic condition. Animal manures are valuable sources of nutrients and yield-increasing effect of

manure is well established (Wakene *et al.*, 2005; Silvia *et al.*, 2006) [26]. Organic matter in the soil improves soil physical conditions by improving soil structure, increases water holding capacity, and improves soil structure and aeration, as well as regulating the soil temperature. So the objective of this study was to know the combined effect of both organic and inorganic fertilizers on soil available nutrient (N P_2O_5 and K_2O).

Material and methods

A long term field experiment was conducted in 2014 at Agricultural and Horticulture Research Station, Bavikere, to study the effect of integrated nutrient management on soil fertility status and productivity of rice under permanent plot experiment in moderately shallow, Red clay loam soil. The initial soil fertility levels were (pH - 5.50, EC - 0.20 dSm^{-1}, organic carbon - 5.6 g ha^{-1}) available phosphorus - 77.92 kg ha^{-1}, available potash - 153.73 kg ha^{-1}) taken as reference. The experiment was laid out in a randomized complete block design with eleven treatments with different organic and inorganic sources of nutrients and replicated three times. The organic sources of nitrogen used were FYM (Farm yard manure), Vermicompost, glyricidia with nitrogen content of 0.62 per cent, 1.18 per cent and 2.4 per cent on dry weight basis respectively. Nutrient equivalent basis of organic sources to meet the required quantity of N were incorporated in the soil 15 days before planting. Entire dose of P and K and 50 per cent of inorganic N were applied at the time of planting in the form of DAP, Murate of Potash and Urea respectively. The remaining dose of nitrogenous fertilizer was applied in three split doses *viz.* 50 per cent as basal, 25 per cent at 30 days after sowing and remaining 25 per cent at 60 days after sowing.

Aerobic rice crop was analyzed for different parameters like pH by Buckman's Zero metric pH meter (Piper, 1966) [18], electrical conductivity by Conductometry (Jackson, 1973) [6], organic carbon by Wet digestion method (Walkley and Black, 1934) [27]. Plant analysis was done by taking five randomly selected plants from each net plot and were oven dried and used for chemical analysis after grinding. Nitrogen content was determined by digesting the plant samples with concentrated sulphuric acid and digestion mixture. The digested samples were distilled by micro kjeldhal method in an alkaline condition and titrated against standard acid (Piper, 1966) [18]. Phosphorus and potassium contents were determined after the samples were digested with diacid mixture (Nitric acid + Perchloric acid). Phosphorus content was determined by Vanadomolybdo phosphoric yellow colour method and observation was recorded at 430 nm using Spectrophotometer instrument (Piper, 1966) [18]. Potassium content was determined from the same diacid digested extract with the Digital Flame Photometer (Piper, 1966) [18]. Soil samples were collected from 0-30 cm depth, dried under shade. The samples were analyzed for available nitrogen, available phosphorus and available potassium by using alkaline potassium permanganate method, Bray's method and Neutral normal ammonium acetate method, respectively. All the results were then analyzed statistically for drawing conclusion using standard statistical analysis tools.

Results and discussion

Ability of a crop to yield better depends on its ability in making use of the available resources. The production and translocation of synthesized photosynthates depends upon mineral nutrition supplied either by soil or through external application. Higher nutrient uptake by plant may increase the metabolic activity of the plant leading to a greater accumulation of dry matter and subsequently increased grain yield. Nutrient uptake was varied with the application of different organic manures and inorganic fertilizrs. The higher uptake of nutrients was found with application of RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia

Significantly higher nitrogen uptake (131.32 kg ha^{-1}) (Table 1) was observed with application of RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia, this might be due to the improved physical conditions of the soils with better availability of N and also other essential nutrients added with these organic sources to rice crop. The combined effect of these produced higher grain and straw yield as observed in these treatments. These findings are in accordance with the findings reported by Laxminarayana and Patiram (2006) [6]. It may also due to higher mineralization of nitrogen from applied organic source of nutrients. As nitrogen is key element required at early growth stages of crop and hence nutrient uptake was greatly influenced by availability of N in soil. Vermicompost stimulates the uptake of nutrients, due to enhanced activity of nitrogenase and nitrate reducates enzyme in the soil under congenial soil physical condition. Similar results are in line with the findings of Paikaray *et al.* (2001) [15] and Nandan (2006) [14] who stated that use of higher dose of nitrogen through organic sources and liquid organic sources might have helped for good vegetative growth and root system, which increased the higher N uptake by plants and hence increased yield and yield components of rice.

Significantly higher phosphorus uptake (26.95 kg ha^{-1}) (Table 2) was taken up by crop with application of RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia.This might be due to favourable effect of combined application of NPK with vermicompost and PSB resulting in higher availability and uptake of P to meet the need of growing plants in these treatments which produced higher grain and straw yield. Similar observations were also reported by Laxminarayana and Patiram (2006) [10], Laxminarayana (2006) [9] and Baskar (2003) [3]. Phosphorus increases root growth and its deficiency reduce overall plant growth. Phosphorus being a constituent of compounds *viz.*, ATP, ADP and NADP etc essential for energy changes involved in photosynthesis, the interconversion of carbohydrates and related compounds, glycolysis, amino acid metabolism, fat metabolism and biological oxidation and a host of other life processes in the plant. This is in conformity with the findings of Setty (2005) and noticed that application of goat manure was superior than application of FYM in improving nutrient uptake of P, K, Ca and Mg from soils with low organic matter status. The higher uptake of NPK might be due to the fact that Glyricidia, FYM and vermicompost act as sources of nutrients and also enhances the availability of nutrients. Further, it has a favorable effect on uptake of N, P and K by rice with goat manure, FYM and vermicompost application as reported by Dravid and Biswas (2006) [4].

Significantly higher total potassium uptake (113.07 kg ha^{-1}) (Table 3) was taken up by the crop with application of RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia. The significant increase in K uptake in these treatments might be due to the relatively higher K availability, improvement in physical environment of the soil conducive to higher plant growth, grain and straw yield resulting higher K uptake similar results were obtained by Baskar (2003) [3]. Potassium has a role in enzyme activation, photosynthesis, protein and starch synthesis. It regulates stomatal activity, enhances the transport of sugars, water and nutrients. The beneficial effect of application of organics have resulted in increasing exchangeable K leading to increased concentration of K in available form, thereby increasing absorption of K. Further it was due to increased CEC. The results are corrugated the findings of Raju (2004) [19], Meek *et al.* (2009) [12] and Yamagatha (2009) [29] they observed that manures improves the uptake due to less loss and less fixation of potassium in paddy soils.

Increased uptake of NPK may be attributed to improved nutrient availability as a consequence of synergistic relationship between the organic manures and inorganic sources. Similar results were reported by Subramanian and Kumaraswamy (2007) [23], Katyal and Sharma (1979) [8] and Jadhav *et al.* (2008) [7]. Soil health in general refers to the soil productivity and sustainability on long run basis. It is measured in terms of improvement in physical, chemical and biological properties of soil.

Available N in soil differed significantly due to application of different organic and inorganic fertilizers. Significantly higher available nitrogen (269.40 kg ha^{-1}) (Table 4) after the crop harvest was observed with the application of RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia. However, it was followed by the application of RDF + FYM + PSB + 25% Nitrogen through Glyricidia (262.62 kg ha^{-1}). This increase may be attributed to higher microbial activity in the integrated nutrient management practices which favoured the conversion of the organically bound nitrogen to inorganic form (Panwar and Munda, 2007) [16]. Similar increase in available N in soil due to addition of organics was observed in wheat (Singh and Verma, 2000) [22]. Application RDF + vermicompost + PSB + 25% Nitrogen through Glyricidia increased the available phosphorus (86.95 kg ha^{-1}). This could be due to release of organic acids during the decomposition of organic matter, which helped in the solubility of native phosphates as a result of which the available phosphorus content in the soil was increased. Applied organic matter leads to the formation of a coating on sesquioxides, resulting in reduction of phosphate fixing capacity of soil (Sheshadri Reddy *et al*., 2005) [21]. Similar, results was found by Laxminarayana, (2006) [9] and Maitra *et al.*, (2008) [11], who reported that Organic manures, on decomposition, solubilize insoluble organic P fractions through release of various organic acids, thus resulting into a significant improvement in available P status of the soil.

Table 1: Nitrogen uptake (kg ha^{-1}) as influenced by integrated nutrient management practices in aerobic rice

Treatments	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total uptake (kg ha^{-1})
T$_1$: RDF	49.87	37.06	86.93
T$_2$: RDF + FYM (POP)	53.81	37.91	91.71
T$_3$: RDF + Vermicompost (FYM equivalent)	54.38	38.58	92.96
T$_4$: RDF + FYM +25% Nitrogen through FYM	62.99	46.22	109.21
T$_5$: RDF + FYM + 25% Nitrogen through Vermicompost	63.36	47.16	110.52
T$_6$: RDF + FYM + 25% Nitrogen through Glyricidia	56.41	45.13	101.54
T$_7$: RDF + Vermicompost + 25% Nitrogen through Glyricidia	59.92	45.69	105.61
T$_8$: RDF + FYM + PSB + 25% Nitrogen through Glyricidia	76.89	48.65	125.54
T$_9$: RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia	80.65	50.67	131.32
T$_{10}$: RDF + FYM + PSB	65.32	47.54	112.86
T$_{11}$: RDF + Vermicompost + PSB	71.6	47.99	119.59
S.Em ±	1.97	1.92	2.77
C.D. at 5%	5.82	5.65	8.18

RDF: Recommended Dose of Fertilizer (100 : 50 : 50 NPK kg ha^{-1})
FYM: Farm yard manure: 7.5 t ha^{-1}, Vermicompost: 5 t ha^{-1}
POP: Package of Practice.

Table 2: Phosphorus uptake (kg ha^{-1}) as influenced by integrated nutrient management practices in aerobic rice

Treatments	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total uptake (kg ha^{-1})
T$_1$: RDF	7.81	5.45	13.26
T$_2$: RDF + FYM (POP)	8.38	6.72	15.1
T$_3$: RDF + Vermicompost (FYM equivalent)	9.4	7.01	16.41
T$_4$: RDF + FYM +25% Nitrogen through FYM	13.25	7.66	20.91
T$_5$: RDF + FYM + 25% Nitrogen through Vermicompost	12.58	7.58	20.16
T$_6$: RDF + FYM + 25% Nitrogen through Glyricidia	11.47	7.57	19.04
T$_7$: RDF + Vermicompost + 25% Nitrogen through Glyricidia	11.71	7.71	19.42
T$_8$: RDF + FYM + PSB + 25% Nitrogen through Glyricidia	16.68	8.34	25.28
T$_9$: RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia	18.62	8.61	26.95
T$_{10}$: RDF + FYM + PSB	15.11	7.41	22.52
T$_{11}$: RDF + Vermicompost + PSB	14.82	7.7	22.53
S.Em ±	0.88	0.66	1.04
C.D. at 5%	2.59	NS	3.07

RDF: Recommended Dose of Fertilizer (100 : 50 : 50 NPK kg ha^{-1})
FYM: Farm yard manure: 7.5 t ha^{-1}, Vermicompost: 5 t ha^{-1}
POP: Package of Practice.

Table 3: Potassium uptake (kg ha^{-1}) as influenced by integrated nutrient management practices in aerobic rice.

Treatments	Grain (kg ha^{-1})	Straw (kg ha^{-1})	Total uptake (kg ha^{-1})
T$_1$: RDF	21.74	63.72	85.46
T$_2$: RDF + FYM (POP)	23.78	67.39	91.16
T$_3$: RDF + Vermicompost (FYM equivalent)	24.14	69.69	93.83
T$_4$: RDF + FYM +25% Nitrogen through FYM	25.57	75.56	101.13
T$_5$: RDF + FYM + 25% Nitrogen through Vermicompost	25.74	76.62	102.36
T$_6$: RDF + FYM + 25% Nitrogen through Glyricidia	24.09	73.93	98.02
T$_7$: RDF + Vermicompost + 25% Nitrogen through Glyricidia	24.62	74.69	99.32
T$_8$: RDF + FYM + PSB + 25% Nitrogen through Glyricidia	27.24	84.73	111.97
T$_9$: RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia	27.95	85.12	113.07
T$_{10}$: RDF + FYM + PSB	25.53	83.74	109.27
T$_{11}$: RDF + Vermicompost + PSB	26.73	84.7	111.43
S.Em ±	0.7	1.37	1.5
C.D. at 5%	2.06	4.05	4.42

RDF: Recommended Dose of Fertilizer (100 : 50 : 50 NPK kg ha^{-1})
FYM: Farm yard manure: 7.5 t ha^{-1}, Vermicompost: 5 t ha^{-1}
POP: Package of Practice.

Table 4: Available soil nutrient status (kg ha^{-1}) of soil after harvest of the crop as influenced by integrated nutrient management practices in aerobic rice

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T$_1$: RDF	255.14	76.81	94.46
T$_2$: RDF + FYM (POP)	256.62	77.62	98.23
T$_3$: RDF + Vermicompost (FYM equivalent)	257.18	78.02	103.15
T$_4$: RDF + FYM +25% Nitrogen through FYM	258.67	81.66	117.46
T$_5$: RDF + FYM + 25% Nitrogen through Vermicompost	259.42	83.76	118.64
T$_6$: RDF + FYM + 25% Nitrogen through Glyricidia	256.15	82.92	106.98
T$_7$: RDF + Vermicompost + 25% Nitrogen through Glyricidia	258.16	83.35	107.93
T$_8$: RDF + FYM + PSB + 25% Nitrogen through Glyricidia	262.62	85.69	141.46
T$_9$: RDF + Vermicompost + PSB + 25% Nitrogen through Glyricidia	269.4	86.95	145.7
T$_{10}$: RDF + FYM + PSB	260.55	84.47	122.13
T$_{11}$: RDF + Vermicompost + PSB	261.3	85.76	129.7
S.Em ±	4.65	1.89	2.15
C.D. at 5%	NS	5.57	6.57

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