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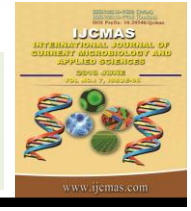

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Integrated Nutrient Management in Paddy at Coastal Zone of Karnataka, India

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A B S T R A C T

Significantly higher grain and straw yield (5159 kg ha^{-1}) of paddy was recorded in package of practice (POP- FYM 5 t + 60:30:45 kg N:P_2O_5:K_2O ha^{-1}) +50 per cent N through vermicompost, respectively, followed by POP + 50 per cent N through poultry manure (5101 kg ha^{-1}) as compared to package of practice (4425 and 5509 kg ha^{-1}, respectively). Significantly higher total nitrogen and phosphorus uptake was observed in package of practice (POP) + 50 per cent N through vermicompost (109.85 and 45.51 kg ha^{-1}, respectively) followed by POP + 50 per cent N through poultry manure (107.96 and 44.92 kg ha^{-1}, respectively). Total potassium uptake was recorded highest in POP + 50 per cent N through eupatorium (60.23 kg ha^{-1}), it was followed by POP + 50 per cent N through poultry manure (59.33 kg ha^{-1}). Maximum available nitrogen (375.90 kg ha^{-1}) was observed in POP + 50 per cent N through gliricidia followed by POP + 50 per cent N through eupatorium (375.03 kg ha^{-1}). Available P_2O_5 (74.60 kg ha^{-1}) was more with POP + 50 per cent N through poultry manure followed by POP + 50 per cent N through goat manure (73.26 kg ha^{-1}). Application of recommended dose of nutrients *i.e.* POP (FYM 5 t + 60:30:45 kg N: P_2O_5: K_2O ha^{-1}) + 50 per cent N through eupatorium and POP + 50 per cent N through vermicompost resulted in higher available K_2O (135.43 and 134.13 kg ha^{-1}, respectively). Significantly higher population of bacteria, fungi and actinomycetes (27.27 cfu x 10^5 g^{-1}, 34.86 cfu X 10^3 g^{-1} and 13.24 cfu X 10^4 g^{-1} of soil, respectively) was found with POP + 50 per cent N through vermicompost.

Introduction

The slogan of "Rice is life'' is the staple food for over three billion people of Asia, which accounts for the production and consumption of 90 per cent of world rice. In India rice crop plays vital role in our national food security and is a means of livelihood for millions of rural households. India is the world's second largest producer (129.2 million tonne) of rice on an area of 43 million ha and with the productivity of 3 tonnes per ha (Anon. 2012-13) and ranks next to china. At the accelerating current growth rate of 1.8 per cent of population in India rice requirement by 2020 AD is projected around 140 million tonnes. India is one of the largest producers of oilseeds in the world accounting for 8% of the global oilseeds production using 14% of the world land area and notified as the second largest producer of groundnut (*Arachis hypogeal* L.). As per Indian Council of Medical Research (ICMR) recommended consumption of 20 g edible oil/day/person, by 2020 A D, India requires around 20.3 million tonnes of edible oil. To meet this demand, it is essential to enhance the productivity of prominent crops of the country like paddy, wheat, pulses, groundnut through location specific nutrient management practices. To augment major food crops production, Food and Agriculture Organization (FAO) conceptualized the idea of plant nutrients in a crop and cropping system for better resource use. It is not only a reliable way of obtaining fairly higher yields with substantial fertilizer economy, but also a concept that is ecologically sound leading to sustainable agriculture.

The rapid increasing in food production over the past three decades was at the cost of corresponding increase in the removal of nutrient from the soil. The negligence shown to the conservation and use of organic sources of nutrients has not only caused the exhaustion of soil nutrient reserves but also resulted in an imbalance among the available nutrients leading to soil problems. In acidic soils less availability of nutrients (N, P, K, Ca, Mg and S) besides inadequate organic matter. Paddy and groundnut are exhaustive crops and removes large amount of macro and micro nutrients from soil. None of the sources of nutrient alone can meet the total plant nutrients from chemical, organic, bio-fertilizer is the most efficient way to supply plant nutrients for sustained crop productivity and improved of soil fertility (Singh and Singh, 2002).

Paddy-legume crop sequence plays a significant role in food security of India. Growing of two crops in a year involves heavy removal of plant nutrients, which diminishes the soil fertility. It is therefore necessary to judiciously manage the inflow of organic sources of nutrients, and their integration with fertilizers, biofertilizers and organic manure. Application of organic materials along with inorganic fertilizers leads to increased productivity of the system and sustained soil health for a longer period (Gawai and Pawar, 2006).

Though many nutrient management studies have been carried out in paddy -legume cropping sequence, the location specific study on integrated nutrient management in rice based cropping sequence (rice-legume) for the farmers of coastal region of Karnataka is lacking. Keeping the above points in view, a field investigation has been carried out to study the effect of supplemental addition of organics along with package of practice through integrated nutrient management in paddy-groundnut cropping sequence at Coastal zone of Karnataka.

Materials and Methods

A field experiment was conducted during *kharif* season of 2014 and 2015 at Zonal Agricultural and Horticultural Research Station, Brahmavar, Udupi district, Karnataka, to study the of integrated nutrient management in paddy-groundnut cropping sequence. The experimental site is situated between 74^0 45’ to 74^0 46' East longitude and 13^0 24' 45’’ to 13^0 25’ 30’’ North latitude and an altitude of 10 meters above mean sea level. Soil type is sandy loam in texture and pH was acidic (4.62). The soil was medium in available nitrogen (348.70 kg ha^{-1}), high in available phosphorus (59.10 kg ha^{-1}) and medium in available potassium (106.80 kg ha^{-1}). The organic carbon content was high (1.32 %) in range. MO-4 (Red rice) a popular medium duration variety was transplanted in July with a spacing of 20 cm X 10 cm. Experiment included twelve treatments consisted of T_1 – Package of practice (POP- FYM 5 t +

60:30:45 kg N:P_2O_5:K_2O ha^{-1}), T_2- POP + 25 per cent N through eupatorium, T_3- POP + 25 per cent N through gliricidia, T_4- POP + 25 per cent N through vermicompost, T_5- POP + 25 per cent N through poultry manure, T_6- POP + 25 per cent N through goat manure, T_7- POP + 50 per cent N through eupatorium, T_8 - POP + 50 per cent N through gliricidia, T_9- POP + 50 per cent N through vermicompost, T_{10}- POP + 50 per cent N through poultry manure, T_{11}- POP + 50 per cent N through goat manure and T_{12}- Control were laid out in Randomized Complete Block Design (RCBD) with three replications. All organics were applied 25 days before transplanting of paddy. Yield (biological and economical) was recorded from individual plots at harvest and converted to kg/ha. Composite soil sample were used to assess soil nutrient status. Standard statistical methods were used for comparing the treatment means.

Results and Discussion

Yield attributes of paddy

Among various INM treatments, average data indicated that significantly higher productive tillers per hill (18.10, 17.68, 16.81 and 16.40), panicle length (20.19, 19.52, 19.15 and 18.63 cm) and panicle weight (3.96, 3.64, 3.51 and 3.47 g) were resulted by the application recommended dose of nutrients (POP) + 50 per cent N through vermicompost followed by POP + 50 per cent N through poultry manure and POP + 50 per cent N through eupatorium and goat manure applied treatments (T_{11} and T_7), respectively. Whereas, test weight was not significantly influenced by the different INM practices. However, it ranged from 22.45 g in control to 25.48 g in POP + 50 and 25 per cent N through different organic and green manures treatments (Table 1). Combined application of organic manure with recommended dosage of nutrients showed a significant improvement in different yield attributes which resulted in better yield and economics. The beneficial effect of these attributes seemed to be due to better availability of nutrients and their translocation from source to sink. An improvement in soil microbial activities lead to sympathetic physico-chemical properties which facilitate improved availability and uptake of nitrogen resulted in positive conversion of source to sink escorted to higher panicle length, panicle weight and test weight of rice (Mamta Meena *et al.*, 2013).

Yield of paddy

Pooled data on grain yield showed that significantly higher grain yield (5159 kg ha^{-1}) was recorded in POP + 50 per cent N through vermicompost, followed by POP + 50 per cent N through poultry manure (5101 kg ha^{-1}) which was on par with POP + 50 per cent through eupatorium (4940 kg ha^{-1}). The data on straw yield showed that application of recommended dose of nutrients (POP) +50 per cent N through vermicompost (6679 kg ha^{-1}) followed by POP + 50 per cent N through poultry manure (6562 kg ha^{-1}) and POP + 50 per cent N through eupatorium (6342 kg ha^{-1}) recorded significantly higher straw yield as compared to rest of the treatments (Table 2). Higher yields with application of vermicompost might be due to increased availability of nutrients, presence of beneficial micro flora such as nitrogen fixers (Lee, 1992) and presence of biologically active metabolites like gibberilins, cytokinins, auxins and group B vitamins (Tomati *et al.*, 1991). The increase in yield owing to the application of poultry manure may be attributed to the fact that poultry manure being important constituents of nucleotides, proteins, chlorophyll and enzymes, involve in various metabolic processes which have direct impact on vegetative and reproductive phases of plants (Rajput *et al.*, 2008). Combined application of inorganic potassium fertilizer with K rich organic manures like, eupatorium and poultry manures are the alternate way to overcome the potassium deficiency rather than the sole application of inorganic K fertilizer.

The consequences of inadequate K can be severe for crop growth and efficient utilization of other nutrients such as N and P. Maintenance of adequate K is essential for both organic and conventional crop production. Large amounts of K are required for paddy to maintain plant health and vigor. These results are in agreement with Robert Mikkelsen., 2007.

Uptake of nutrients

Nitrogen

Significantly higher total nitrogen uptake was observed in POP + 50 per cent N through vermicompost (109.85 kg ha^{-1}) followed by POP + 50 per cent N through poultry manure and eupatorium applied treatments *i.e.* T_{10} and T_7 (107.96 and 104.62 kg ha^{-1}, respectively). Increase in available N might be attributed to the direct addition of nitrogen through vermicompost and farmyard manure and multiplication of soil microbes, which could convert organically bound N to inorganic form to the available pool of the soil. Poultry manure contained 60 per cent of N in the form of uric acid, which changed rapidly to $NH4^+$ form for utilization by rice plants (Prabhakaran, 2000). *Chromolaena* relatively high C/N ratio (12.1) indicates a faster decomposition and also listed high N content and soluble fraction and moderate lignin content resulting in high biodegradation as the strong point organic matter (Taiwo Agbede and Lawrence Afolabi, 2014).

Phosphorus (P_2O_5)

Results pertaining to the total uptake of phosphorus at harvest were found significant. Significantly higher phosphorus uptake (45.51 kg ha^{-1}) was observed in the former treatment (T_9) followed by POP + 50 per cent N through poultry manure and POP + 50 per cent N through goat manure (44.92 and 45.12 kg ha^{-1}, respectively). It is evident that the application of organic manure with poultry manure resulted in an increase in available phosphorus content in soil.

The built up of available phosphorus was higher in these organic manures that might be due to release of organic acid during microbial decomposition of organic matter which might have helped in the solubility of native phosphates thus increasing available phosphorus pool in the soil (Stein-Bachinger and Wemer, 2011).

Potassium (K_2O)

Recommended nutrient practice (POP) + 50 per cent N through eupatorium resulted significantly higher total uptake of potassium (60.23 kg ha^{-1}), it was followed by POP + 50 per cent N through poultry manure (59.33 kg ha^{-1}), POP + 50 N per cent vermicompost (57.58 kg ha^{-1}) (Table 3). Eupatorium contains higher amount of K, this nutrient in the simple cationic K^+ form. Most soluble inorganic fertilizers and organic manures are virtually interchangeable as sources of K for plant nutrition (Li *et al.*, 2006).

Availability of nutrients

High yield was accompanied by high uptake of nutrients which could be attributed to better availability matching the rhythm of crop growth and high nutrient use efficiency. Improved microbial population in soil under organic condition would have promoted nutrient Maximum available nitrogen (375.90 kg ha^{-1}) was noticed in POP + 50 per cent N through gliricidia followed by POP + 50 per cent N through eupatorium (375.03 kg ha^{-1}).

Table.1 Yield parameters of paddy as influenced by integrated nutrient management

	No. of productive tillers hill^{-1}	Panicle length (cm)	Panicle weight (g)	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
T_1 – Package of practice (POP)	11.65	15.84	2.27	24.33	4425	5509	0.446
T_2 - POP + 25 % N through eupatorium	12.78	16.24	3.08	23.80	4627	5719	0.447
T_3 - POP + 25 % N through gliricidia	12.02	16.17	2.48	24.37	4468	5548	0.446
T_4 - POP + 25 % N through VC	13.96	17.04	3.23	24.17	4732	5917	0.444
T_5 - POP + 25 % N through PM	13.25	16.60	3.07	24.10	4660	5803	0.445
T_6 - POP + 25 % N through GM	12.59	16.10	2.77	24.20	4551	5620	0.447
T_7 - POP + 50 % N through eupatorium	16.40	18.63	3.47	24.61	4940	6342	0.438
T_8 - POP + 50 % N through gliricidia	15.37	18.25	3.34	25.15	4753	6174	0.435
T_9 - POP + 50 % N through VC	18.10	20.19	3.96	25.48	5159	6679	0.436
T_{10} - POP + 50 % N through PM	17.68	19.52	3.64	25.27	5101	6562	0.438
T_{11}- POP + 50 % N through GM	16.81	19.15	3.51	24.63	4865	6251	0.438
T_{12} – Control	7.86	11.09	1.54	22.45	2891	3521	0.450
S. Em±	**0.90**	**0.90**	**0.22**	**0.88**	**196**	**293**	**0.015**
CD (P=0.05)	**2.64**	**2.64**	**0.65**	**NS**	**576**	**859**	**NS**

VC- Vermicompost PM-Poultry manure	GM- Goat manure POP- FYM 5 t + 60:30:45 kg N:P_2O_5:K_2O ha^{-1}	25 & 50% N through RDN RDN- Recommended dose of nitrogen NS- Non significant

Table.2 Nutrients uptake (kg ha^{-1}) of paddy as influenced by integrated nutrient management

Treatments	Nitrogen (kg ha^{-1})			Phosphorus (P_2O_5) (kg ha^{-1})			Potassium K_2O (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1 – Package of practice (POP)	42.74	36.56	**79.30**	16.20	14.53	**30.72**	20.62	20.04	40.66
T_2 - POP + 25 % N through eupatorium	49.36	43.78	**93.14**	14.79	14.63	**29.43**	26.23	26.63	52.86
T_3 - POP + 25 % N through gliricidia	41.60	34.97	**76.57**	18.37	15.19	**33.57**	19.26	18.33	37.59
T_4 - POP + 25 % N through VC	48.92	39.49	**88.41**	20.52	15.72	**36.24**	25.26	25.60	50.86
T_5 - POP + 25 % N through PM	49.57	44.39	**93.96**	21.61	15.64	**37.27**	26.27	26.98	53.25
T_6 - POP + 25 % N through GM	45.68	39.41	**85.09**	21.60	15.25	**36.85**	22.92	22.55	45.47
T_7 - POP + 50 % N through eupatorium	56.11	48.51	**104.62**	22.03	16.59	**38.62**	29.24	30.99	60.23
T_8 - POP + 50 % N through gliricidia	50.28	42.95	**93.23**	21.09	16.72	**37.81**	25.96	26.96	52.92
T_9 - POP + 50 % N through VC	58.47	51.38	**109.85**	27.51	18.00	**45.51**	27.87	29.71	57.58
T_{10} - POP + 50 % N through PM	57.84	50.12	**107.96**	27.23	17.69	**44.92**	28.92	30.41	59.33
T_{11}- POP + 50 % N through GM	50.55	45.71	**96.26**	26.47	17.03	**43.50**	26.78	28.83	55.61
T_{12} – Control	27.09	22.62	**49.71**	9.75	9.06	**18.81**	12.64	12.06	24.70
S. Em±	**2.96**	**2.73**	**5.96**	**2.00**	**0.92**	**2.23**	**1.97**	**2.17**	**3.89**
CD (P=0.05)	**8.71**	**8.01**	**17.24**	**5.87**	**2.72**	**6.54**	**5.79**	**6.36**	**11.43**

VC- Vermicompost **PM-Poultry manure**	**GM- Goat manure** **POP- FYM 5 t + 60:30:45 kg N:P_2O_5:K_2O ha^{-1}**	**25 & 50% N through RDN** **RDN- Recommended dose of nitrogen**

Table.3 Nutrient status of soil and microbial population after harvest of paddy as influenced by integrated nutrient management

Treatments	Available nutrients (kg ha^{-1})			Population of soil microorganisms		
	N	P_2O_5	K_2O	Bacteria (cfu x 10^5 g^{-1} of soil)	Fungi (cfu x 10^3 g^{-1} of soil)	Actinomycetes (cfu x 10^4 g^{-1} of soil)
T_1 – Package of practice (POP)	328.73	70.48	115.96	15.55	24.12	9.10
T_2 - POP + 25 % N through eupatorium	360.63	65.25	125.73	18.78	27.23	10.14
T_3 - POP + 25 % N through gliricidia	359.12	71.20	121.59	17.60	26.24	9.56
T_4 - POP + 25 % N through VC	362.70	70.90	123.36	18.71	29.70	10.70
T_5 - POP + 25 % N through PM	359.10	69.40	124.38	18.07	27.90	9.58
T_6 - POP + 25 % N through GM	360.40	70.43	123.40	20.23	28.38	10.16
T_7 - POP + 50 % N through eupatorium	375.03	60.31	135.43	22.57	30.54	11.53
T_8 - POP + 50 % N through gliricidia	375.90	70.37	123.97	21.30	29.10	11.07
T_9 - POP + 50 % N through VC	365.30	68.10	134.13	27.27	34.86	13.24
T_{10} - POP + 50 % N through PM	367.80	74.60	130.60	24.23	30.90	11.30
T_{11}- POP + 50 % N through GM	370.30	73.26	128.68	26.30	33.60	12.70
T_{12} – Control	312.37	45.33	80.71	8.30	13.38	6.26
S. Em±	**12.31**	**3.49**	**1.77**	**1.77**	**2.11**	**0.74**
CD (P=0.05)	**36.11**	**10.24**	**5.21**	**5.21**	**6.20**	**2.17**

VC- Vermicompost **PM-Poultry manure**	**GM- Goat manure** **POP- FYM 5 t + 60:30:45 kg N:P_2O_5:K_2O ha^{-1}**	**25 & 50% N through RDN** **RDN- Recommended dose of nitrogen**

Available P_2O_5 (74.60 kg ha^{-1}) was more with POP + 50 per cent N through poultry manure followed by POP + 50 per cent N through goat manure (73.26 kg ha^{-1}) and POP + 25 per cent N through gliricidia (71.20 kg ha^{-1}). Application of recommended dose of nutrients (FYM 5 t + 60:30:45 kg N: P_2O_5: K_2O ha^{-1}) + 50 per cent N through eupatorium resulted in higher available K_2O (135.43 kg ha^{-1}) as compared to other treatments (Table 4). Similar observations were resulted by Vadivel *et al.,* (2001) and Rawat and Pareek (2003).

Significantly higher population of bacteria (27.27 cfu x 10^5 g^{-1} of soil) was found with POP + 50 per cent N through vermicompost followed by POP + 50 per cent N through goat manure (26.30) and POP + 50 per cent N through poultry manure (24.23). Significantly higher population of fungi was found with POP + 50 per cent N through vermicompost and POP + 50 per cent N through goat manure (34.86 & 33.60 cfu X 10^3 g^{-1} of soil, respectively) that on par with POP + 50 per cent N through poultry manure (30.90). Recommended practice + 50 per cent N through vermicompost, POP + 50 per cent N through goat manure and POP + 50 per cent N through eupatorium produced significantly higher population of actinomycetes (13.24, 12.70 and 11.53 cfu X 10^4 g^{-1} of soil, respectively) as compared to other treatments. These results are in conformity with findings of Badole and More (2001) who reported that application of FYM 25 t ha^{-1} recorded higher population of *Rhizobium*, *Azatobacter,* fungi, actinomycetes, PSB and bacteria (10.5 x 10^3, 0.38 x 10^3, 6.7 x 10^3, 14.9 x 10^4, 29.1 x 10^4 and 62.5 x 10^4 cells g^{-1} soil, respectively) as compared to control treatment.

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