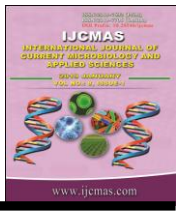
Int.J.Curr.Microbiol.App.Sci (2019) *8*(1): 271-280

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 8 Number 01 (2019)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2019.801.030

Effect of Integrated Nitrogen Management on Rice and Rice Fallow *Rabi* Crops

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Keywords

INM, Rice, Rice fallow cropping systems, Yield of rice, Rice fallow crops yield and Yield attributes

Article Info

Accepted:
04 December 2018
Available Online:
10 January 2019

A B S T R A C T

A field experiment was conducted at College Farm, Agricultural College, Bapatla during 2015-16 and 2016-17 of both *kharif* and *rabi* seasons. The results of the work indicated that the application of INM (Integrated nitrogen management) M_2 includes 50% RDN+ 25% N through FYM + 25% N through neem cake + recommended dose of microbial consortium (Azospirillum + PSB @ 2.5kg ha^{-1}) recorded significantly higher grain yield and straw yield of rice over M_1 (100% RDN) and residual effect of INM and 100% RDF (for each crop) gave higher yields of blackgram, maize, sorghum, sunflower and mustard. Significantly 25-30% higher yields were obtained in blackgram, maize, sorghum, sunflower and mustard crops.

Introduction

Rice based cropping system is a predominant cropping system in coastal Andhra Pradesh. Complementary use of organic and biological sources of plant nutrients along with chemical fertilizer is of great importance for the maintenance of soil health and productivity, especially under intensive cropping system. There is immense need to exploit the alternate source of nutrients viz., organic manure, use of legumes in crop rotation and biofertilizer to sustain the productivity, soil health and soil fertility with more environment friendly nutrient management system.

Materials and Methods

A field experiment was conducted for two consecutive years (2015-16 & 2016-17) on clay loam soils of Agricultural College Farm, Bapatla. The experiment was laid out in a two sample t-test for rice in *kharif* season with 2 treatments and replicated thrice. The treatments consists of M_1 100% RDN, M_2 (50% RDN + 25% N through FYM + 25% N Through neem cake + Azopsirillum + PSB @ 2.5 kg ha^{-1} (INM). During the immediate *kharif*, the experiment was laid out in a split plot design without disturbing the soil for succeeding *rabi* crops with the two treatments

given to *kharif* rice as main plot treatments and each of these divided into five sub-plots. The experiment was repeated in another field during *kharif* and *rabi* seasons. Popular cultivars of rice (BPT 5204), blackgram (PU 31), maize (Sandhya), sorghum (NSH-54), Sunflower (Shreshta) and Mustard (Konark) were used for this study.

The soil is vertisol with bulk density (1.42 & 1.43), porosity (43.50 and 43.80%) and water holding capacity (45.10 & 45.80%), slightly alkaline in reaction, (pH 7.70 and 7.50), two fields were non-saline in nature, cation exchange capacity (35.4 & 37.2), medium range of organic carbon (0.55 and 0.50%). Low nitrogen content (266 and 250 kg ha^{-1}), available phosphorus was (59 and 53 kg ha^{-1}) and available potassium (630 and 668 kg ha^{-1}). The initial soil analysis data is presented in table 1. The present investigation was undertaken during 2015-16 and 2016-17 of consecutive years.

The nutrients were applied through the fertilizers like urea, single super phosphate, muriate of potash. The farm yard manure and neem cake was applied at seven days before transplanting of rice on dry weight basis as per the treatment. The bacterial inoculants applied at the time of sowing as per recommended dosage (Azospirillum + PSB @2.5 kg ha^{-1}). The nutrient content in applied organics was given in the table 2 and 3 during first and second year of study, respectively.

The recommended fertilizer doss were applied as 120-40-40, 20-50-0, 200-60-50, 40-40-40, 60-60-30 and 60-60-40 kg N, P_2O_5 and K_2O ha^{-1} to rice, blackgram, maize, sorghum, sunflower and mustard crops, respectively. The soil samples were analysed as per standard procedures for soil physical and physico-chemical properties. Soil texture by Piper, 1966, bulk density by Dastane, 1967, water holding capacity by Sankaram, 1966, soil reaction and EC by Jackson, 1973, CEC by Bower *et al*., 1952 and organic carbon by Walkley and Black, 1934. The data obtained during *kharif* 2015-16 and 2016-17 were analysed statistically using two sample t-test analysis of variance (Panse and Sukhatme, 2000). The t-test value calculated for 12 replications and t-test value was 2.07. If the t-test value was >2.07, it was significant, while <2.07 includes non-significant. Whereas the data obtained during *rabi* 2015-16 and 2016-17 were analyzed statistically by following split plot design as suggested by Gomez and Gomez (1984). Wherever, the treatment differences were found significant, critical differences were worked out at five per cent probability level and furnished along with mean values of the parameter concerned in tables. Treatmental differences that were non-significant were denoted by "NS".

Results and Discussion

Effect of INM on yield of *kharif* rice

Rice yield is presented in table 4 indicated the grain yield of rice during both the years of study was significantly increased due to application of INM over 100% RDN. Application of organics along with 50% RDN produced the highest grain yield (5818 kg ha^{-1}) which was superior over inorganics i.e., 4473 kg ha^{-1} during 2015-16 and 5896 kg ha^{-1} superior over 100% RDF i.e., 4598 kg ha^{-1} during 2016-17 year. The increment of yield with INM treatment was 30.0% and 28.22% during first and second years, respectively. Shanmugan and Veeraputhran (2001), Bhattacharya *et al*., (2003) also reported beneficial effects of FYM on yield of rice due to better nutrition of crop. The effects of FYM and neem cake were similar and significantly increased the grain yield of rice over control. Application of nutrients like neem cake, different nitrogen levels and biofertilizers had a significant and vital effect on yield and quality attributes of crop.

Table.1 Initial properties of the experimental soil

Particulars	2015-16 Field No.13C	2016-17 Field No.14C	Class/ Group
I. Physical properties			
Mechanical composition			
1. Sand (%) **2. Silt (%)** **3. Clay (%)** **Textural class**	42 20 38 Clay loam	40 21 39 Clay loam	Clay loam
Bulk density (Mg m^{-3})	1.44	1.43	Normal
Porosity(%)	43.50	43.80	Normal
Water holding capacity (%)	45.10	45.80	Normal
II. Physico-chemical properties			
pH (1:2.5)	7.70	7.50	Neutral to slightly alkaline in nature
EC (dS m^{-1})	0.26	0.31	Non-saline
Cation exchange capacity (cmol (p+) kg^{-1})	35.4	37.2	Normal
Organic carbon (%)	0.55	0.50	medium
III. Available nutrients			
N (kg ha^{-1})	266	250	Low
P_2O_5 (kg ha^{-1})	59	53	High
K_2O (kg ha^{-1})	630	668	Very high
IV. Secondary nutrients			
Exchangeable Ca (cmol (p+) kg^{-1})	23.39	24.07	Normal
Exchangeable Mg (cmol (p+) kg^{-1})	5.80	5.70	Normal
SO_4^{-2} - Sulphur (mg kg^{-1})	15.00	15.50	Normal
V. Available micro nutrients (mg kg^{-1})			
Iron	27.50	25.00	Sufficient
Manganese	5.50	4.90	Sufficient
Zinc	2.55	2.65	Sufficient
Copper	0.59	0.65	Sufficient
VI. Biological properties			
Dehydrogenase activity (µg TPF g^{-1} $24h^{-1}$)	49.14	39.15	Normal
Microbial populations			
Bacteria count (10^5 x cfu g^{-1} soil)	20.0	25.0	Normal
Fungi (10^3x cfu g^{-1} soil)	10.0	8.0	Normal
Actinomycetes (10^3 x cfu g^{-1} soil)	15.0	15.0	Normal

Table.2 Nutrient content of organics applied during 1styear (2015-16)

Nutrient	FYM	Neem Cake
C(%)	25.8	31.5
Total N (%)	0.616	4.08
Phosphorus (%)	0.24	0.21
Potassium (%)	0.41	0.42
Calcium (%)	0.88	1.053
Magnesium (%)	1.20	1.35
Sulphur (%)	0.32	1.55
Iron (ppm)	11.72	8.11
Manganese (ppm)	0.534	0.862
Copper (ppm)	0.074	0.132
Zinc (ppm)	0.11	0.35
C:N	41.8	7.72

Table.3 Nutrient content of organics applied during 2ndyear (2016-17)

Nutrient	FYM	Neem Cake
C(%)	24.5	29.8
Total N (%)	0.58	4.89
Phosphorus (%)	0.35	0.42
Potassium (%)	0.48	0.43
Calcium (%)	0.95	1.02
Magnesium (%)	1.38	1.45
Sulphur (%)	0.28	1.05
Iron (ppm)	10.85	8.15
Manganese (ppm)	0.818	0.755
Copper (ppm)	0.080	0.115
Zinc (ppm)	0.15	0.78
C:N	42.24	6.09

Table.4 Effect of INM on yield attributes and yield of rice

Treatment	2015-16						2016-17					
	Productive tillers m^{-2}	Filled grains per panicle	1000 seed weight (g)	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Harvest Index (%)	Productive tillers m^{-2}	Filled grains per panicle	1000 seed weight (g)	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Harvest Index (%)
M_1: 100 % RDN	421	130	14.3	4473	5607	44.37	431	132	14.5	4598	5657	44.83
M_2: 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	433	142	15.4	5818	6332	47.88	449	145	15.5	5896	6350	48.14
t- value	2.08	6.11	3.70	7.34	3.61	3.09	2.34	6.26	3.87	8.95	3.61	2.95

Table.5 Residual effect of INM on yield attributes and yield of blackgram

Treatment	2015-16				2016-17			
	100 seed weight(g)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest Index (%)	100 seed weight(g)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest Index (%)
M_1 : 100 % RDN	3.98	917	1437	38.95	4.55	1096	1502	42.18
M_2 : 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	4.17	1118	1528	42.25	4.91	1210	1615	42.83
t-value	9.76	14.10	5.15	2.15	8.11	4.75	12.85	2.07

Table.6 Residual effect of INM on yield of maize

Treatment	2015-16				2016-17			
	100 kernel weight(g)	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	100 kernel weight (g)	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
M_1 : 100 % RDN	26.29	6326	7411	46.00	27.96	6100	7326	45.43
M_2 :50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	32.30	7192	8147	46.88	31.81	7682	8222	48.30
t-value	6.72	5.25	7.11	2.15	2.25	16.70	13.41	3.11

Table.7 Residual effect of INM on yield and yield attributes of sorghum

Treatment	2015-16				2016-17			
	1000 grain weight(g)	Stover yield (kgha^{-1})	Grain yield (kgha^{-})	Harvest Index (%)	1000 grain weight(g)	Stover yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest Index (%)
M_1 : 100 % RDN	23.90	6457	2612	28.80	24.75	5906	2850	31.05
M_2 : 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	24.55	7127	3618	33.67	29.00	8325	3750	32.50
t- value	3.05	4.86	5.44	3.05	2.55	18.36	3.73	2.35

Table.8 Residual effect of INM on yield of sunflower

Treatment	2015-16				2016-17			
	1000 seed weight(g)	Stover yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Harvest index (%)	1000 seed weight (g)	Stover yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Harvest index (%)
M_1 : 100 % RDN	32.5	2908	1024	26.04	36.5	2712	1125	29.32
M_2 : 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	42.0	3159	1507	32.30	44.8	3177	1780	35.90
t- value	2.15	2.08	17.14	4.55	3.08	6.61	3.69	3.11

Table.9 Residual effect of INM on yield of mustard

Treatment	2015-16				2016-17			
	1000 seed weight(g)	Stover yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Harvest index(%)	1000 seed weight(g)	Stover yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Harvest index(%)
M_1 : 100 % RDN	4.05	1515	815	34.97	4.26	1619	915	36.10
M_2 : 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	4.26	1805	1025	36.21	4.55	1695	1135	40.10
t - value	2.11	2.09	9.45	2.55	3.08	2.13	13.34	2.15

Residual effect of INM on yields of *rabi* crops

Seed yield of blackgram is presented in table 5. Significantly higher seed yield was obtained in residual effect of M_2 treatment with values of 1118 and 1210 kg ha^{-1} in the year 2015-16 and 2016-17, respectively. These yields were higher by 21.9% and 10.40% over M_1 during first and second years, respectively, which indicated the residual effect of INM treatment (M_2) imposed in rice during *kharif*. Similar results were obtained by Gajendrasingh *et al*., (2016) who reported that INM had showed the highest seed yield compared to inorganics only.

Residual effect of INM to rice increased the kernel yield of maize by 866 and 1582 kg ha^{-1} compared with 100% RDN (M_1) in first and second years, respectively. The maize grain yield is represented in table 6. The kernel yield was obtained 7192 kg ha^{-1} during 2015-16 and 7682 kg ha^{-1} in M2 during 2016-17 year. These results were in line with findings of Singh *et al*.(2000). Experiments performed by Negassa *et al*., (2001) exhibited that there was significant residual effects of FYM which influenced maize grain yields.

The increase of 38.5% was obtained during 2015-16 and 31.5% during 2016-17 in M_2 over M_1 of sorghum grain yield. The sorghum yield is represented in table 7. The grain yield of sorghum significantly improved with the application of INM. Organic and inorganic fertilizers are an efficient exogenous source of plant nutrients. When fertilizers are used as balanced fertilizer use, along with complementary use of organic and bio sources can help reverse environmental degradation by providing much needed nutrients to the soil, thereby increasing crop yields (Sudhanshu, 2013). The stover yield of sorghum significantly improved with the application of inorganic fertilizers @ 50% RDN+25% N through FYM + 25% N through neem cake + recommended dose of bacterial inoculants to the preceding rice crop. The increase might be a result of improvement in soil properties in terms of soil, which reflected on increasing biological yield as reported by Kachapur *et al*., (2001).

Significantly higher grain yields of sunflower were noticed in residual effect of M_2 treatment. The increase of 47.16% was obtained during first year and 58.2% during second year. Higher biomass production and large canopy spread would have induced the optimally fertilized plants to the increase in seed yield commensurate with large nutrient concentration in seed. Gudade *et al*., (2011) reported that the seed yield obtained under 100% RDF + organics was significantly higher than 50% and 100% RDF. Application of integrated nitrogen management to rice increased the stover yield of sunflower by 251(8.63%) and 465 (17.14%) compared with M1 in first and second years, respectively. The stover yield was increased from 2908 kg ha^{-1} to 3159 kg ha^{-1} during the year 2015-16 and it was increased from 2712 kg ha^{-1} to 3177 kg ha^{-1} during 2016-17. The yield of sunflower is represented in table 8. The increase in stover yield might be due to the fact that the applied FYM released the nutrients were in close conformity with the findings of Nanjudappa *et al*., (2001) and the applied FYM released the nutrients in adequate amount in the following season also.

Significantly higher seed yields of mustard was noticed in residual effect of M_2 treatment. The increase of 25% was obtained during 2015-16 and 24% during 2016-17. The mustard seed yield is represented in table 9. Similar results were found by Sonam Lecha, 2015. Thaneswar *et al*., (2017) exhibited that integrated application of 100% RDF along with vermicompost @ 5t/ha obtained higher

seed yield. Combination of organic and inorganic fertilizers was an efficient exogenous source of plant nutrients. When fertilizers were used insufficient and imbalanced, balanced fertilizer use, along with complementary use of organic and bio sources can helped reverse environmental degradation by providing much needed nutrients to the soil, thereby increasing crop yields (Sudhanshu, 2013). Application of integrated nitrogen management to rice increased the stover yield of mustard by 290 kg ha^{-1} and 76 kg ha^{-1} compared with NPK alone treatment (M_1) in first and second years, respectively.

In conclusion, plant height, dry matter yield, yield attributes, grain yield and straw yield of rice were recorded significantly higher in the treatment of M_2(50% RDN+ 25% N through FYM+ 25% N through neem cake + *Azospirillum* and PSB @ 2.5kg ha^{-1}). The increment of yield with INM treatment was 30.0% and 28.22% during 2015-16 and 2016-17 years, respectively. Growing of succeeding *rabi* crops on yield attributes and yield were significantly influenced by the INM which imposed to preceding rice crop. Plant height, dry matter yield, yield attributes, grain yield, stover yield, test weight and harvest index of *rabi* crops (blackgram, maize, sorghum, sunflower and mustard) recorded highest in all those plots, which received organics along with 50% RDN+ *Azospirillum* and PSB @ 2.5kg ha^{-1} to preceding rice were more than those received 100% RDN alone. Application of INM to preceding rice crop, increased the all *rabi* crop yields by 25-30% when compared to M_1.

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How to cite this article:

Latha, M., P. Ratna Prasad, P.R.K. Prasad, R. Lakshmipathy and Srinivasarao, V. 2019. Effect of Integrated Nitrogen Management on Rice and Rice Fallow *Rabi* Crops. *Int.J.Curr.Microbiol.App.Sci*. 8(01): 271-280. doi: https://doi.org/10.20546/ijcmas.2019.801.030