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Effect of integrated nitrogen management on macronutrient content and uptake by rice crop

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Abstract
A field experiment was conducted on the effect of INM on rice major nutrient content and uptake by rice. It was conducted at College Farm, Agicultural College, Bapatla during the *kharif* season of two years 2015 and 2016. The treatments consists of M_1(100% RDN) and 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}). Nitrogen content in rice was ranged from 1.71 to 2.22% and 1.58 to 2.18%, phosphorus content was ranged from 0.34 to 0.51% and 0.14 to 0.58% and potassium content was ranged from 1.65 to 2.20% during 2015 and 2016 years respectively (from active tillering to grain filling stage). Nitrogen uptake was ranged from 49.48 to 156.23 kg ha^{-1}, 49.70 to 135.2 kg ha^{-1}, phosphorus uptake ranged from 10.84 to 36.31 kg ha^{-1} and potassium uptake ranged from 55.03 to 146.94 kg ha^{-1}during 2015 and 2016 years, respectively (from active tillering to grain filling stage).

Keywords: INM-rice-nutrient content-nutrient uptake- different growth stages

Introduction
In recent years there has been adverse effect of continuous and indiscriminate use of inorganic fertilizers on deterioration of soil structure, soil health and environment. Intensive cultivation, monocropping, use of imbalanced fertilization accompanied by restricted use of organic manures and bio-fertilizers have made the soils not only deficient in the nutrients but also deteriorated the soil health resulting in decline of crop response to the recommended dose of fertilizers. The high cost of fertilizers and unstable crop production call for substituting part of the inorganic fertilizers by locally available organic sources like farmyard manure, neem cake in an integrated manner for sustainable production and to maintain soil health. Integrated nitrogen management involving conjunctive use of organic, inorganic and crop residues may improve the soil productivity and system productivity become sustainable. Boosting yield, reducing production cost and improving soil health are three interlinked components of the sustainability triangle. Therefore, combined use of chemical fertilizers, organic manures and bio fertilizers is essential.

Hence, the present experiment is formulated to find out the influence of different fallow crops on soil properties and using of inorganics in conjunction with organics and biofertilizers and conducted at college farm, Agricultural College, Bapatla during *kharif* and *rabi* seasons of 2015 and 2016.

Material and Methods
Collection and processing of plant samples
Plant samples of *kharif* rice crop of two years was collected from five randomly selected plants at different growth stages. The samples were first dried in shade and then in hot air oven at 65°C. The plant samples were ground in willey mill and stored in labeled brown paper bags for analysis. The grain samples were also processed and stored in similar fashion.

Nitrogen
Nitrogen content in plant samples was determined by micro Kjeldahl method (Piper, 1966) [1].

Preparation of di-acid mixture
Di-acid extract was prepared as per the method outlined by Jackson (1973) [2].

It was carried out using a 9:4 mixture of HNO_3: $HClO_4$. The pre-digestion of sample was done by using 10ml of HNO_3 g^{-1} sample. This di-acid extract was used to determine P, K, Ca, Mg, Fe, Mn, Cu and Zn content in the plant and grain samples.

Phosphorus

It was determined spectrophotometrically by vanadomolybdate phosphoric acid yellow color method as described by Jackson (1973) [2] from di-acid extract

Potassium

It was estimated from di-acid extract by using flame photometer (Jackson, 1973) [2].

Nutrient uptake

From the chemical analytical data, uptake of the each nutrient was calculated as shown below.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) x dry matter in kg ha}^{-1}}{100}$$

Results and Discussion

Nitrogen content in rice

Nitrogen content in rice at active tillering, panicle initiation, Grain filling and harvest (straw and grain) are presented in table 1. Nitrogen content was ranged from 1.71 to 2.22% and 1.58 to 2.18% during first and second years, respectively (from active tillering to grain filling stage). At harvest, nitrogen content in straw was ranged from 0.46 to 0.76% and 0.52 to 0.62% during 2015-16 and 2016-17 years, respectively. The nitrogen content in grain was ranged from 1.65 and 1.83% during first and 1.59 and 1.73% during second years of study.

Irrespective of growth stage of rice and year of the study, INM (M_2) treatment significantly increased the nitrogen content over the treatment that received 100% RDN alone. The improvement in nitrogen content in organic treatment along with inorganic source might be due to slow release of nutrients from organics, which amended the nutrients to the soil along with inorganic source and made it available throughout the growing season (Goutam *et al*., 2013). Rahaman *et al.* (2007) also stated the increase in nitrogen content with INM due to delayed maturity of rice which could tap up more nitrogen for longer period as consequence higher content at different phenological stages.

Kadu *et al.* (1991) [5] reported that nitrogen content in rice increased significantly with NPK + FYM application. The increased nitrogen content in rice grain and straw with the application of NPK + FYM over NK application was also reported earlier by Ranjha *et al.* (2001) [6]. Gautampriyanka *et al*. (2013) also concluded that the INM treatment gave the highest straw and grain nutrient content of nitrogen in rice.

The nitrogen content was gradually decreased with advancement of stage of crop. The periodical declining trend of N content in plants with rice crop stage advancement was in agreement with Shinde *et al*. (2017) [8]. It was attributed to dilution effect. Higher N content in tillering compared to panicle initiation and at harvest was recorded in rice by Shahi *et al*. (2017) [9].

Phosphorus content in rice

Data on phosphorus content in rice at different growth stages are presented in table 1. Phosphorus content was ranged from 0.34 to 0.51% and 0.14 to 0.58% during first and second years, respectively (from active tillering to grain filling stage). At harvest, phosphorus content in straw was ranged from 0.18 to 0.29 % and 0.14 to 0.15% in grain it was ranged from 0.42 to 0.58% and 0.31 to 0.41% during 2015-16 and 2016-17, respectively.

Irrespective of growth stage of rice and year of the study, the treatment received INM significantly increased the phosphorus content over the treatment that received 100% RDN alone. The highest phosphorus content was observed in the treatment received M_2 i.e at active tillering stage of 0.51 and 0.58% during 2015 and 2016 years, respectively. These results were in conformity with the findings of Shinde *et al*., (2017) [8] who recorded higher phosphorus content by the application of NPK + FYM over NK application.

Progressive decline in P concentration with advancement of crop age in rice plants was observed in both the treatments during both the years of study. This decrease might be due to three reasons viz., dilution effect, caused by higher dry matter production, low P status of soil and fixation of applied P.

When compared to rice straw, the phosphorus content in grain was recorded high in both the years of study. These results were in line with the findings of Islam *et al.* (2010) [4], who found higher phosphorus content (0.29-0.32%) in grain than that of straw (0.15-0.19%). The INM treatment (M_2) recorded 38% and 32.2% higher phosphorus content in grain during 2015-16 and 2016-17 years over the treatment M_1.

Table 1: Effect of INM on macronutrient content in rice

Treatment	2015-16					2016-17				
	Active tillering	Panicle initiation	Grain filling	Straw	Grain	Active tillering	Panicle initiation	Grain filling	Straw	Grain
Nitrogen (%)										
M_1: 100 % RDN	1.87	1.79	1.71	0.46	1.65	1.89	1.68	1.58	0.52	1.59
M_2: 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	2.22	2.01	1.85	0.76	1.83	2.18	1.76	1.60	0.62	1.73
t- value	7.00	7.25	6.01	7.37	5.51	6.50	3.87	2.08	3.44	6.68
Phosphorus (%)										
M_1: 100 % RDN	0.41	0.39	0.34	0.18	0.42	0.47	0.42	0.30	0.14	0.31
M_2: 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	0.51	0.45	0.43	0.29	0.58	0.58	0.45	0.42	0.15	0.41
t- value	7.10	11.48	5.27	11.81	8.07	4.98	2.88	2.55	2.28	8.88
Potassium (%)										
M_1: 100 % RDN	2.14	1.88	1.65	1.23	0.64	2.40	2.18	1.72	1.73	0.64
M_2: 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	2.20	1.96	1.83	1.38	0.74	2.53	2.37	1.83	1.89	0.74
t- value	2.55	11.37	7.39	3.36	4.76	2.10	8.87	3.11	2.55	2.95

Potassium content in rice

Table 1 presented potassium content at active tillering, panicle initiation, grain filling stages and at harvest (straw and grain). The potassium content was ranged from 1.65 to 2.20% during 2015-16 and 1.72 to 2.53% during 2016-17 year. At harvest, potassium content in straw was ranged from 1.23 to 1.38 % and 1.73 to 1.89% during first and second years, respectively and in grain it was ranged from 0.64 to 0.74% during 2015-16 and 0.64 to 0.74% during 2016-17.

In contrary to phosphorus content, the potassium content recorded in grain was low in both the treatments when compared to straw. These results were in close conformity with the findings of Islam *et al.* (2010) [10] who reported that the potassium content in rice straw recorded was higher than that of rice grain in all treatments. The highest K content in straw was obtained with 100% RDN through FYM (Shinde *et al*., 2017) [8].

Progressive decline in K concentration with advancement of crop age in rice plants was observed in both the treatments during both the years of study. Shahi *et al*., (2017) [9] also stated that nutrient content showed its superiority at active tillering stage and later on it was decreased. This decrease might be due to three reasons viz., dilution effect, caused by higher dry matter production, low K status of soil and fixation of applied K.

Nitrogen uptake by rice

Data pertaining to nitrogen uptake by rice as influenced by organic and inorganic treatment are presented in table 2. Nitrogen uptake was ranged from 49.48 to 156.23 kg ha^{-1}, 49.70 to 135.2 kg ha^{-1} during 2015-16 and 2016-17 years, respectively. At harvest, the nitrogen uptake by straw was ranging from 65.79 to 68.12 and 59.37 to 69.41 during first and second years, respectively. The nitrogen uptake by grain was ranged from 85.80 to 106.46 and 73.10 to 102.0 kg ha^{-1}during first and second years of study, respectively.

Irrespective of growth stage of rice and year of the study, the treatment that received INM (M_2) recorded significantly higher nitrogen uptake over the treatment that received 100% RDN alone (M_1). These results were in agreement with the findings of Verma (1991) [11] who found that incorporation of FYM and neem cake significantly increased the nitrogen uptake compared to other composts. Hossain *et al.* (2010) [12] also reported higher nitrogen uptake in rice with FYM application over inorganic fertilizer application. The increase in nitrogen uptake could be ascribed to slow and continued supply of the nutrients, coupled with reduced nitrogen losses (via denitrification or leaching) which might have improved the synchrony between plant nitrogen demand and supply from the soil (Haile *et al.*, 2012; Tilahun *et al.*, 2013) [13, 19]. Application of organics in combination with inorganic fertilizers, exhibited better response in nutrient uptake over chemical fertilizer due to steady supply of nutrients throughout the growing period of crops (Laxminarayana, 2006) [15]. These results were in consonance with the findings of Sharma and Mitra (1990) [16]. The favourable effect of FYM and neem cake in soil and thereby removal of N through plant uptake by rice was earlier reported by Gupta *et al.* (2006).

Nitrogen uptake was gradually increased with advancement of age of the crop and reached maximum at harvest.

Table 2: Effect of INM on macronutrient uptake by rice crop

Treatment	2015-16					2016-17				
	Active tillering	**Panicle initiation**	**Grain filling**	**Straw**	**Grain**	**Active tillering**	**Panicle initiation**	**Grain filling**	**Straw**	**Grain**
Nitrogen (kg ha^{-1})										
M_1: 100 % RDN	49.48	126.69	139.29	65.79	85.80	49.70	109.26	129.07	59.37	73.10
M_2: 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	62.73	149.42	156.23	68.12	106.46	61.23	129.39	135.2	69.41	102.0
t- value	10.36	5.35	4.82	7.65	10.807	7.05	3.704	2.19	5.19	9.15
Phosphorus (kg ha^{-1})										
M_1: 100 % RDN	10.84	27.60	27.69	10.09	18.78	7.10	15.02	16.33	7.91	14.25
M_2: 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	14.41	33.45	36.31	18.36	33.74	7.86	24.99	25.35	9.52	24.17
t- value	7.41	13.82	6.11	13.60	19.66	5.27	3.31	2.080	3.84	12.51
Potassium (kg ha^{-1})										
M_1: 100 % RDN	55.03	123.8	136.03	95.07	45.49	56.28	128.38	134.78	89.58	49.42
M_2: 50% RDN+25% N - FYM+ 25% N - neem cake + bacterial consortium	62.17	140.50	146.94	99.91	50.98	61.79	144.09	154.63	97.63	60.63
t- value	6.54	6.35	7.32	4.37	9.68	2.95	5.99	3.83	2.43	6.533

Phosphorus uptake by rice

Results pertaining in table 2 indicated that the P uptake at tillering, panicle initiation, grain filling and harvest (straw and grain) stage. Phosphorus uptake ranged from 10.84 to 36.31 during first year and 7.10 to 25.35 kg ha^{-1} during second year. At harvest, phosphorus uptake by straw was ranged from 10.09 to 18.36 and 7.91 to 9.52 and in grain it ranged from 18.78 to 33.74 and 14.25 to 24.17 during 2015-16 and 2016-17 years, respectively.

The treatment that received FYM, neem cake, along with the 50% RDN (M_2) significantly improved the P uptake over the treatment that received RDF alone (M_1). The higher phosphorus uptake as in case of P content at all growth stages of rice was observed in the treatment M_2.These results were in agreement with the findings of Singh *et al.* (2004) who found that incorporation of FYM significantly increased the P uptake. Hossain *et al.* (2010) [12] also reported higher phosphorus uptake in rice with FYM application over inorganic fertilizer application. Available phosphorus in soil was significantly enhanced due to application of organic manures. The increased availability of phosphorus resulted in more uptake of phosphorus by the plant. The pH of the soil also indicated a positive change i.e. a shift towards neutrality. This positive change enhanced the solubility of different nutrients especially phosphorus in the soil. The form of orthophosphate ion might have converted from PO_4^{3-} to HPO_4^{-2} or even $H_2PO_4^-$ for short periods, which resulted in increased concentration of P in the plants (Das, 2000) [18]. The higher P uptake attributed to the increased P availability and increased root growth of the crop (Tilahun *et al.*, 2013) [19]. According to Aziz *et al.* (2010) [22], root growth in plants receiving FYM was higher dense hence resulted in increased nutrient uptake. Yassen *et al.* (2010) [23] and Sabina Ahmed *et al*., (2014) further suggested that FYM application increased the transfer of elements between the solid phase and soil solution which again could be a reason for the higher nutrient uptake. The maximum P uptake was noted when 75% RDF with vermicompost at the rate of one t ha^{-1} and PSB followed by the integration of 75% RDF with vermicompost at the rate of one t ha^{-1} by Nandinidevi *et al*. (2013) [20]. Similar results were quoted by Imade *et al*., (2015) [21] and Jeyajothi and Nalliahdurairaj, (2016) and Vidyavathi *et al*., (2012) [26].

Phosphorus uptake was gradually increased from active tillering to harvest stage in both the treatments and in both the years due to increased dry matter production with stage.

Potassium uptake by rice

Results pertaining in table 2 indicated the K uptake at active tillering, panicle initiation, grain filling and harvest stage (straw and grain). Potassium uptake ranged from 55.03 to 146.94 kg ha^{-1} during 2015-16 year and 56.28 to 154.63 kg ha^{-1} during 2016-17. At harvest, potassium uptake by straw was ranged from 95.07 to 99.91 kg ha^{-1} and 89.58 to 97.63 kg ha^{-1} and in grain ranged from 45.49 to 50.98 kg ha^{-1} and 49.42 to 60.63 kg ha^{-1} during first and second years, respectively.

Irrespective of growth stage of rice and year of the study the treatments those received FYM, neem cake, along with the 50% RDN significantly increased the P uptake over the treatment received RDF alone. Singh *et al.* (2004) reported that application of 10t FYM ha^{-1} in rice significantly increased potassium uptake by 7.6 per cent over control. Pradeep *et al.* (2012) [27] also concluded that application of recommended dose of fertilizer + FYM @ 10t ha^{-1} recorded significantly higher (94.0kg ha^{-1}) potassium uptake. Similar results were quoted by Imade *et al*., (2015) [21] and Jeyajothi and Kadeshwari and Thavaprakash, (2016).

The increased availability of potassium resulted in more uptake of potassium by the plant. Similarly, production of hydrogen ions during decomposition of organic materials would have helped the release of potassium from exchange sites or from the fixed pool. Decomposition of organic manures was accompanied by the release of appreciable quantities of CO_2, which dissolved in water to form carbonic acid. Carbonic acid was capable of decomposition of certain primary minerals and release of nutrients and favours higher biomass production and nutrient uptake Dahama, (2003) [29]. Similar observations were reported for NPK uptake by Singh *et al.* (2006) and Singh *et al.* (2008). Selvakumari *et al.* (2000) [32]; and Sarwar *et al.* (2003) [33] also observed increased uptake of N, P and K by various crops when inorganic and organic sources of nutrients in the form of chemical fertilizer, FYM, compost were applied to the soil.

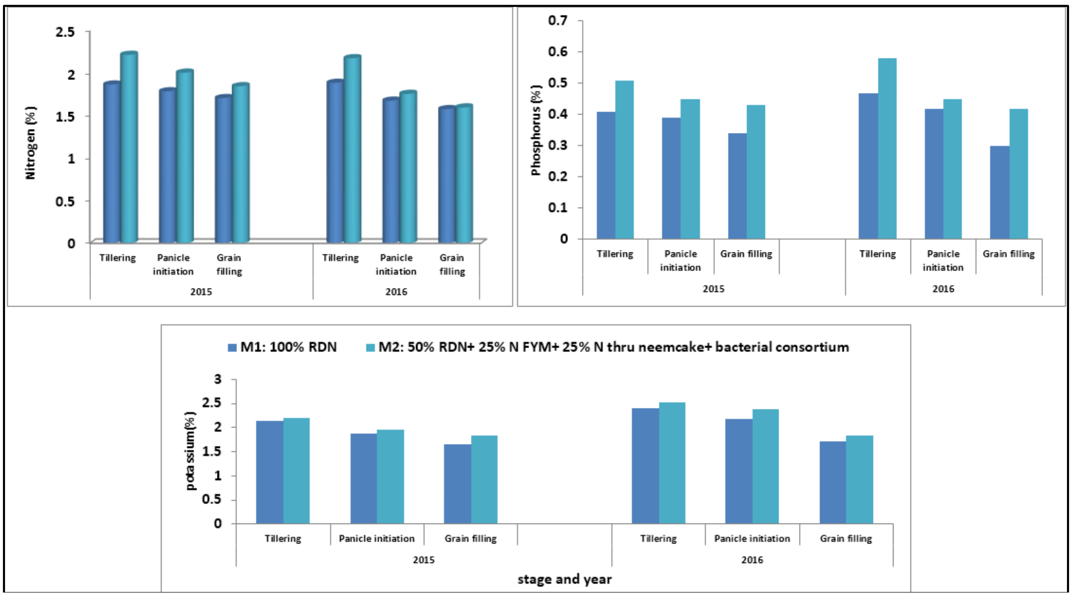
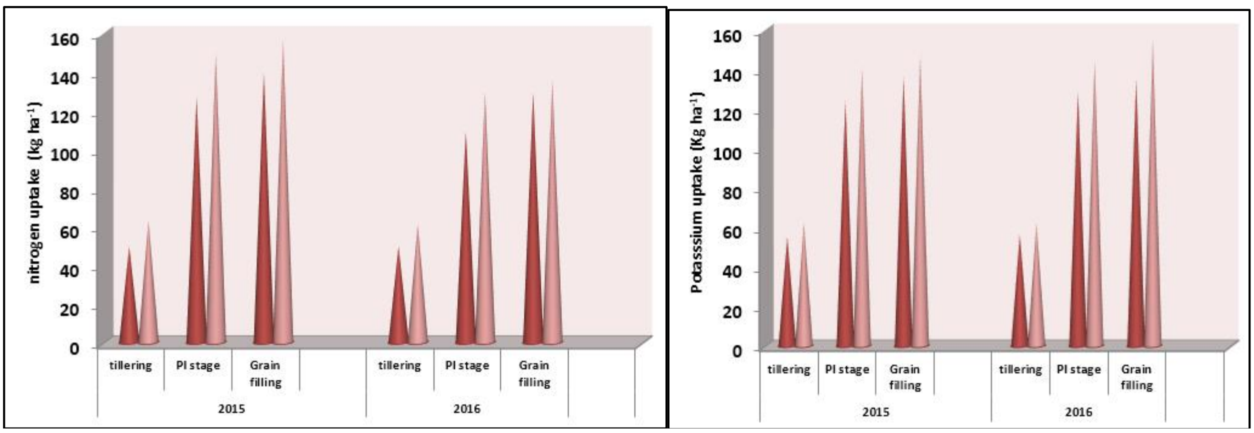


Fig 1: Effect of INM on macronutrient content in rice



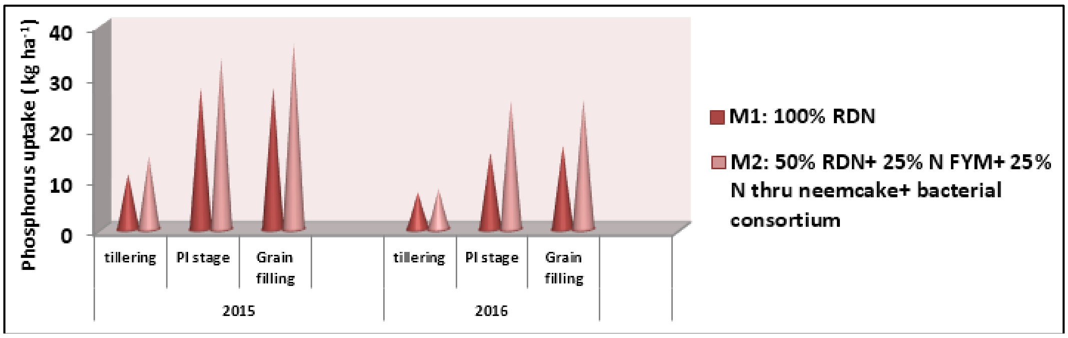


Fig 2: Effect of INM on macronutrient uptake by rice crop

Conclusion

Application of integrated nitrogen management during *kharif* season improved the macronutrient content of rice and uptake of rice. M_1 (100% RDN) and 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}). Nitrogen content in rice was increased upto 32%, phosphorus content was increased upto 61% and 31% potassium content was increased. Nitrogen uptake was increased upto 90%, phosphorus uptake increased upto 85-90% and potassium uptake increased upto 75-90% (from active tillering to grain filling stage).

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