Production Potential, Nutrient Uptake and Factor Productivity of Scented Rice in Rice-wheat Cropping System Alongwith Physico-chemical and Microbiological Properties Under Site Specific Integrated Plant Nutrient Management

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In India, green revolution forced farmers to use huge amount of chemical nutrient which not only posed serious concern on microbial activities and nutrients efficiency but also agricultural system and environment sustainability. Therefore, a four replicated field experiment was conducted during *kharif* season 2012 at Crop Research Centre of SVPUA&T Meerut, Uttar Pradesh to evaluate SSIPNM on performances, nutrient uptake of scented rice and physico-chemical and microbiological properties in rice-wheat cropping sequence by using "F" test. Findings revealed that aapplication of 66 % of RDN + RDPK + 34% N by *Sesbania Rostreta* - 0.9 t ha^{-1} noticed significantly maximum plant height (137.52 cm), tillers (304.50 m^{-2}) and dry weight in grain (3999.33 kg ha^{-1}) at harvest and N, K, Zn uptake in grain and straw only, P uptake at all stages, available P and K at all stages and microbial population *viz.*, Bacteria (76.55x10^{5} cfu) and Fungus (30.42x10^{2} cfu), whereas minimum Actinomycetes (10.97x10^{4} cfu), even soil pH and EC at all stages were fetches in above treatments. Moreover, chemical fertilizer alone results its superiority over other treatment in terms of N uptake at 30 and 60 DAT, B uptake and organic carbon at all stages in both. Furthermore, soil pH and EC and available N, P, K, Zn & B were improved at 30 DAT from initial and afterward it decline steadily on further growth stages. However, organic carbon emerged as exception as improved positively initial to harvest stages. Besides, above findings customized fertilizer (TATA PARAS) also significantly done tremendous improvement to achieved highest values of panicle length (28.08 cm), biological yield (103.72 q ha^{-1}) and harvest index (39.1), Zn uptake at 30 and 60 DAT and available N and B at all stages. Though, all the treatments have shown its superiority, except control as compared to farmer practices. It means there is an urgent need to replenish farmer practices on community basis by SSIPNM.

Key words: SSIPNM, Customized Fertilizer (CF), Performance, Nutrient Uptake, Physico-Chemical and Microbiological Properties, Scented Rice.

Globally rice is one of the most important staple food crops. In India, rice is being grown on an area of 44.62 million hectares with a production of 93.08 million tones. Though, scented rice occupies a prime position due to its unique behavior like extra long super fine cylinder, pleasant and exquisite aroma, fine cooking quality, soft texture, length, sweet taste and breadth wise elongation on cooking (Chander and Pandey, 2001). Moreover, Aromatic varieties gained a higher price in rice market than the non-aromatic ones. Demand for aromatic rice in now a days has increased to a

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great extent for internal consumption as well as for export to other countries.

Mean while, the response to fertilizers use has decreased rapidly from 17 kg grain kg^{-1} nutrient in 1951 to 5-6 kg grains now, which ideally should be in the range of 18-25 kg/kg nutrient. The recovery efficiency of fertilizer nutrients is about 20-40, 15-20 and 40 -50% for N, P and K, respectively while for secondary and micronutrients, it is substantially low ranging 5-12%. Major factors which contributes to the low and declining crop responses to fertilizer are continuous nutrient depleting from the soil due to imbalanced nutrient use (6:2.9:1 NPK) leading to depletion of some of the major, secondary and micro nutrients like N, K, S, Zn, Mn, Fe, B etc., decreasing use of organic nutrient sources such as FYM, compost and integration of green manures in the crop leading to serious soil degradation.

Customized fertilizer is the mixed-up of location specific different grade which include primary, secondary and micronutrients as per the deficient of respective, location (Shikhon *et al.*, 2012). Integrated use of customized fertilizers with organic sources could be the best option to minimize the multi nutrient deficiencies and other problems arising due to application of imbalance fertilizers and maximize the sustainability and farmers profit by reducing the cost of production and finally good for food security of India.

Highest yield attributes and yield of rice were recorded under residual fertility of Sesbania aculeata and application of 2.0% zinc enrichment urea (Pooniya *et al.,* 2012). Highest N, P and K uptake was also associated with the conjunctive use of soil test based application of N, P, K and S, FYM and green manuring treatment.

Bacterial and fungal populations increased significantly in the soils treated with vermicompost+recommended dose of fertilizer and vermicopost at 15 t/ha over the other treatments (Shewtha *et al.*, 2011). Furthermore, The physical properties such as the pH, electrical conductivity (EC), porosity, moisture content, water holding capacity and chemical properties like nitrogen, phosphorous, potassium, calcium and magnesium were found distinctly enhanced in vermicompost treated soil (Tharmaraj *et al.*, 2011). Moreover, DTPA extractable Zn, Fe, Mn and Cu were significantly influenced by integrated nutrient management practice (1.46, 7.96, 9.67 and 0.89 mg/kg, respectively). Tilak (2004) found that microbial counts, namely bacteria, actinomycetes, fungi, *Azotobacter*, *Azospirillum*, phosphate solubilizing bacteria, the microbial biomass in the soil and nitrogenase activity in the roots were markedly high in soil where green manuring with *S. rostrata*, *S. aculeata* and mung bean was incorporated than in fallow soil.

MATERIALS AND METHODS

Experimental details and soil description

A four replicated field experiment was conducted during *kharif* season 2012 at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), located at a latitude of 29^{o} 40’ North and longitude of 77^{o} 42’ East with an elevation of 237 metres above mean sea level. The mean weekly maximum temperature was 35.8^{0}C which was recorded in the last week of June. It decline gradually and reached to its minimum at the time of harvest. Minimum temperature follows the same trend as of maximum temperature, though the lowest temperature was 16.6^{0}C during the third week of October. The mean weekly relative humidity at 7.00 and 14.00 hrs varied from 84.8 to 58.0 and 71.7 to 22.9 per cent, respectively. The total rainfall received during crop period was 609.6 mm. The soil of experimental field was Clay loam in texture (47.8% sand, 16.6% silt and 35.86 % clay), alkaline pH 8.2, EC 0.21 dS m^{-1}, OC 0.58 %, Available Nitrogen 228.30 kg ha^{-1}, Available Phosphors 17.60 kg ha^{-1}, Available Potassium 252.70 kg ha^{-1}, DTPA extractable Zinc (0.91 ppm) and Boron (37.4 ppm). All the physic-chemical properties were analyzed as per the slandered procedures (Jackson, 1973). The experiment comprises six treatment *viz.*, Control without N P K (T_1), 100 % RDF of N, P, K ,Zn & B @ 90; 40; 30; 05; 1.5 $kgha^{-1}$ respectively (T_2), 66 % of RDN +RDPK + 34% N by vermicompost - 1.25 t ha^{-1} (T_3), 66 % of RDN + RDPK + 34% N by *Sesbania Rostreta* - 0.9 t ha^{-1} (T_4), TATA PARAS-11;32;13;0.9;0.24 % N, P, K, Zn, B respectively (T_5) and Farmer Practices 100:50 $kgha^{-1}$ N P, respectively (T_6) were tested in RBD with a plot size of 12 m^2 and its nutrient application are varied to different treatments. Rice (Pusa Basmati-1121) was grown as per recommended package of practices with 20 cm x 15 cm (R x P) apart on with a transplanting data of 19 July 2012 and harvested on 9 November 2012. A thin layer of water (approximately 3.0 cm) was maintained during the initial stage of crop growth for better establishment of seedlings and maximum 5.0 cm at tillering stage and later an intermittent irrigation at the time of panicle initiation, flowering and grain formation stage were applied by using 1.5 m wide irrigation channel. In order to control insect, the recommended insecticide as Cartap hydro chloride 4G and to control the disease recommended fungicide as Carbendazim @ 0.1% etc were applied on the basis of economic threshold level (ETL).

Basic parameters

Observations on various growth parameters viz. plant height (cm); number of tillers m^2 and dry matter accumulation/plant were recorded at 30 DAT and at harvest of the crop. Yield attribute was recorded by selecting 10 plants from 12 m^2 and biological yield was estimated by the produce obtained from net plot area, treatment wise and finally expressed at 14 % moisture. The harvest index of rice was obtained by dividing the economical yield (grains yield) with the biological yield (grains + straw) and represented in percentage.

Plant sampling and analysis

The plants measured for growth and yield were used for analyzing the N, P and K content in plant (at 30 and 60 DAT, grains and straw). The samples were dried at 70 °C in a hot air oven. The dried samples were ground in a stainless steel Thomas Model 4 Wiley ® Mill. The N content in plant was determined by digesting the samples in sulfuric acid (H2SO4), followed by analysis of total N by the Kjeldahl method (Page, 1982) using a Kjeltec™ 8000 auto analyzer (FOSS Company, Denmark). The P content in plant was determined by the vanadomolybdo-phosphoric yellow colour method and the K content was analyzed in di-acid (HNO3 and HClO4) digests by the flame photometeric method (Page, 1982). Zinc (ppm) was determined DTPA extractant and estimated on atomic absorption spectrophotometer (GBC Avanta PM Modal) and Boron (ppm) was determined by Azomethine-H Colour Method (Lindsay and Norvell, 1978). The uptake of the nutrients was calculated by multiplying the nutrient content (%) by respective yield (kg/hm^2) and was divided by 100 to get the uptake values in kg/hm^2.

Soil sampling and analysis

Soil samples were collected at the start of the experiment from 0 to 15 cm soil depth using an auger of 5-cm diameter. Each sample was a composite from three locations within a plot. The freshly collected soil samples were mixed thoroughly, air-dried, crushed to pass through a 2-mm sieve and stored in sealed plastic jars before analysis. Available N (Alkaline permanganate method), Olsen P (0.5 mol/L NaHCO3 extractable), NH4OAc–extractable K were analyzed using the methods described by Page (1982). Zinc (ppm) was determined DTPA extractant and estimated on atomic absorption spectrophotometer (GBC Avanta PM Modal) and Boron (ppm) was determined by Azomethine-H Colour Method (Lindsay and Norvell, 1978).. The samples for determination of soil physical properties like pH was determined with the help of glass electrode on a pH meter in 1:2.5 soil: water suspension at 25^0 C (Jackson, 1973). The electrical conductivity was estimated with the help of EC meter in 1:2.5 soils: water suspension at 25^0 C and expressed as d sm^{-1} (Bower & Wilcox, 1965). Bulk density was measured to a depth of 20-cm at intervals of 5-cm soil depth using the core-ring method and one core per layer of each plot was collected and the samples were oven-dried for 48 h at 105 °C, weighed and bulk density calculated according to the method of Blake and Hartge (1986). The soil organic carbon was estimated by the procedure given by (Walkley and Black, method) rapid titration method (Jackson, 1973). All physico-chemical properties were measured at the onset of the experiment and after the harvesting of crop. While the numbers of soil culturable bacteria, fungi and actinomycetes were counted at the maturity stage. Soil cores near the rice roots were collected with an auger. The top 1 cm soil layer was removed and the remaining soil core (as deep as 0.2 m) was sampled. After air-drying, samples were sieved through a 1-mm sieve. Ten grams of each fresh soil sample was added to 95 mL of sterile distilled water. After homogenization for 30 min, each soil suspension was sequentially diluted and 50 ìL of the resulting solutions were plated on appropriate isolation cul¬ture media. After incubation at 28°C for 4–5 daysfor bacteria, 3–4 days for fungi and 6–8 days for ac-tinomycetes or 6–9 days, the colony forming units (CFU) were counted. Soil bacteria, fungi and actinomycetes were cul¬tured on beef extract + peptone + agar medium, Martin medium, improved Gauss No. 1 medium, and Waksman No. 77 medium (Vieira and Nahas 2005), respectively. The data obtained were subjected to statistical analysis as outlined by Gomez and Gomez (1984). The treatment differences were tested by using “F” test and critical differences (at 5 per cent probability).

RESULT AND DISCUSSION

Performances of Urdbean

The plant height increased progressively with the growth of crop (Table 1). Treatment T_2 at 30 DAT recorded the maximum plant height (63.40 cm). It was *on par* with the treatments T_5, T_4, T_3 and T_6, while it was significantly superior over the treatments T_1 (Control). However, at harvest stage, maximum plant height was observed in T_4 and was *on par* with treatments T_3, T_5 and T_2. All other treatments differ significantly from T_1 and T_6. T_1 recorded the lowest height at all the growth stages.

Treatment T_5 recorded the maximum number of tillers per m^{-2} (293.80) at 30 DAT, which was closely followed by T_2, T_4, T_3 and T_6 but at harvest the maximum no of tillers were recorded in treatment T_4 and was followed by T_3, T_5 and T_2, which was *on par* with T_3, T_5, T_2 and significantly superior over the treatments T_1, and T_6. At all the growth stages, treatment T_1 recorded the lowest number of tillers (196.80 and 207.50 at 30 DAT and at harvest, respectively) and T_1 was followed by T_6, T_3, T_2, T_4 and T_5.

The dry matter production increased rapidly in all the treatments from early stage to harvest. At 30 DAT dry matter production varied narrowly among the treatments. Treatment T_5 recorded the highest value of 1414.59kg ha^{-1} and was significantly *on par* with $T_{2,}$ T_3 and T_4 whereas it was superior over T_6 and T_1. All other treatments were significantly higher than $T_{1.}$ Treatment T_1 recorded the lowest value of 999.99kg ha^{-1}. At harvest stage, highest total dry matter accumulation was recorded in T_4 (10244.65 kg ha^{-1}) and minimum was recorded in T_1(6812.27 kg ha^{-1}). Next to T_4, T_3 gave the higher dry matter accumulation and was followed by T_5 and T_2. Similar trend was observed in grain and straw. Maximum dry matter in grain was accumulated in T_4 (3999.33 kg ha^{-1}) and was followed by T_3, T_5, T_2, T_6 and T_1. T_1 accumulated lowest (2060.13 kg ha^{-1}) dry matter. T_4 was found statistically *on par* with T_3, T_5 and T_2, but was significantly superior over T_6 and T_1. Similarly in straw, dry matter accumulation was found maximum in T_4 and was followed by T_3, T_5, T_2, T_6 and T_1. Minimum dry matter in straw was obtained from T_1 (4752.14 kg ha^{-1}). The results so obtained in performances probably due to nutrients were responsible for increased cell division, cell enlargement, growth, photosynthesis, and protein synthesis which are responsible for quantitative increase in plant growth. The results of present study are in agreement with the findings of several other investigators Tomar and Das (2011) and Tharmaraj *et al.,* (2011).

Panicle length

The variation in panicle length with various treatments varied from 23.03 cm to 28.08 cm (Table 1). Treatment T_5 recorded the highest panicle length (28.08 cm) and T_1 recorded the lowest number (21.03 cm).T_5 was significantly *on par* with T_2 but significantly higher than T_4 and T_3. T_5 was followed by T_2, T_4, T_3, $T_6$and T_1. T_4, T_3 and T_3, T_4 were *on par* with each other. All the treatments were significantly higher than T_1. This might be due to short supply of nutrients at the time of panicle initiation in combine use of treated plots. Several studies have reported such results Pooniya *et al.,* (2012).

Yield

The highest biological yield 103.72 qha^{-1} was recorded in T_5 and the lowest 68.12 qha^{-1} in T_1. T_5 was *on par* with T_2, T_3 and T_4 and was significantly superior over all other treatments (Table 1). T_6 was significantly superior over T_1. Harvest index of rice in the experiment ranged from 30.2 to 39.1. Treatment T_5 recorded the maximum harvest index (39.1) followed by T_2, T_4, T_3, T_6 and T_1. Yang *et al.,* 2004 observed that incorporation of organic residues significantly increased uptake of N, P and K by rice plants and facilitated the allocation and transfer of nutrient elements to the rice grains and straw.

Nutrient uptake (N. P, K $kgha^{-1}$) and (Zn and B gha^{-1}) of rice at different growth stages

The N uptake increased steadily form 30

Table 1. Effect of SSIPNM on growth, Length of panicle, plant biomass and harvest index

Treatment	Plant height (cm)		Tillers m^{-2}		Dry matter accumulation (kg ha^{-1})			Length of panicle (cm)	Biological yield (q ha^{-1})	Harvest index
	30 DAT	at harvest	30 DAT	at harvest	30 DAT	at harvest				
						grain	straw			
T_1	48.05	83.40	196.8	207.50	999.99	2060.13	4752.14	23.03	68.12	30.2
T_2	63.40	132.35	290.00	291.30	1409.99	3915.07	6100.33	27.06	102.02	39.0
T_3	61.70	133.37	283.30	304.30	1380.99	3957.38	6238.43	24.74	101.51	38.8
T_4	62.70	137.52	285.50	304.50	1399.99	3999.33	6245.32	26.21	101.95	38.8
T_5	63.20	132.62	293.80	298.50	1414.59	3957.22	6193.33	28.08	103.72	39.1
T_6	61.55	130.05	270.30	281.80	1119.99	2820.32	5985.00	24.11	88.05	30.2
SEm ±	2.13	2.42	3.70	4.71	60.81	104.61	92.21	0.52	0.88	-
CD	4.59	5.20	11.4	14.2	184.99	219.15	237.31	1.58	2.63	-

Table 2: Effect of SSIPNM on N, P and K uptake (kg ha^{-1}) in plant, grains and straw of rice

Treatment	Nitrogen uptake (kg ha^{-1})				Phosphorus uptake (kg ha^{-1})				Potassium uptake (kg ha^{-1})			
	Plant		Grains	Straw	Plant		Grains	Straw	Plant		Grains	Straw
	30 DAT	60 DAT			30 DAT	60 DAT			30 DAT	60 DAT		
T_1	9.10	22.59	22.04	15.40	1.10	2.42	1.87	2.47	11.40	28.23	2.31	44.67
T_2	14.95	54.81	47.18	25.50	2.25	6.70	6.30	4.33	28.76	56.02	12.14	78.69
T_3	14.22	39.86	50.54	25.45	2.62	8.33	7.28	5.37	24.58	85.08	14.48	87.34
T_4	14.56	45.55	51.31	29.67	2.80	9.11	7.56	5.87	22.54	70.45	16.32	88.68
T_5	14.85	48.80	47.88	25.02	2.40	7.32	6.69	4.52	24.90	64.66	13.22	84.85
T_6	10.42	32.72	32.43	21.73	1.45	5.03	3.64	3.77	13.10	38.25	4.82	61.05
SEm ±	0.01	0.01	0.01	0.01	0.01	0.003	0.003	0.006	0.01	0.01	0.01	0.02
CD	0.03	0.04	0.04	0.03	0.02	0.01	0.02	0.019	0.04	0.03	0.02	0.05

DAT to harvest stage (Table 2). At 30 and 60 DAT, treatment T_2 recorded the maximum uptake (14.95 kgha^{-1} and 54.81 kgha^{-1}), while at harvest T_4 recorded the maximum uptake (51.31 in grain and 29.67 in straw), respectively. The treatment T_1 accounted for the lowest uptake (9.10, 22.59 and 37.44 kg ha^{-1}) at 30, 60 DAT and at harvest, respectively). At 30 DAT, T_2 was found *on par* with T_5, T_4 and T_3. All the treatments were significantly superior over T_1. At 60 DAT and harvest, all the treatments were significantly superior over T_1. At 60 DAT, treatment T_2 recorded the highest N uptake (54.66 kg ha^{-1}) and lowest was recorded in T_1 while at harvest highest N uptake in grain (51.31kg ha^{-1}) was observed in T_4 which was *on par* with $T_{3.}$ Treatment T_4 was followed by T_3, T_5, T_2 and T_6. Treatment T_1 recorded the lowest uptake (22.04 kgha^{-1}) in grain. In straw, treatment T_4 recorded the highest uptake (29.67 kgha^{-1}) and it was significantly superior over all other treatments. T_1 recorded the lowest value of 15.40 and it was significantly lower than all other treatments followed by T_6, T_2, T_5, T_3 and T_4. It may be inferred that when organics manure are applied along with inorganic fertilizers to soil, complex nitrogenous compounds slowly breakdown and make steady N supply throughout the crop growth stages, which might have consequences in adequate availability of nitrogen and its subsequent uptake by the crop Kondapa Naidu *et al.*, (2009).

The phosphorus uptake increased steadily from 30 DAT to harvest stage. Treatment T_1 recorded the lowest uptake (1.1, 2.42 and 4.34 kgha^{-1}) at 30, 60DAT and at harvest stages, respectively). At 30 DAT, the highest P uptake (2.80) was recorded by T_4 followed by T_3, T_5, T_2 and T_6. T_1 was significantly lower than all other treatments, and it was followed by T_6, T_2, T_5, T_3 and T_4. At 60 DAT, T_4 recorded the highest P uptake (9.11) followed by T_3, T_5, T_2 and T_6. T_1 was significantly lower than all other treatments. Similarly at harvest, treatment T_4 recorded the highest P uptake (7.56 kgha^{-1}) by grain and it was significantly *on par* with T_3 and was superior over all other treatments. Treatments T_2 was *on par* with T_5. T_1 recorded the lowest value (1.87 kgha^{-1}) and it was significantly lower than all the treatments. Phosphorus uptake in straw varied from highest value of 5.87 kgha^{-1} (T_4) to lowest value of 2.47 kgha^{-1} (T_1). T_4 was followed by T_3, T_5, T_2 and T_6. The higher value might be due to increased organic matter content in soil and higher availability of nutrients to the crop. Addition of FYM and other liquid organic manures (Beejamruth, Jeevamruth and Panchagavya) along with chemical fertilizers increased the activity of micro organisms and hence P contribution to the available pool Maheswarapa *et al.*, (1999).

A steady increase was noticed in K uptake from 30 DAT to harvest stage. At 30 DAT, treatment T_2 recorded the maximum K uptake (28.76), whereas at 60 DAT and at harvest, maximum uptake was noticed in T_3 and T_4 (85.08 and 104.83), respectively. Treatment T_1 recorded the lowest uptake (11.40, 28.23 and 46.98 kgha^{-1}) at 30, 60 DAT and at harvest, respectively). At 30 DAT, T_2 was followed by T_5, T_3, T_4 and T_6. At 60 DAT, T_3 was followed by T_4, T_5, T_2 and T_6. At harvest stage, T_4 was followed by T_3, T_5, T_2 and T_6. T_1 was significantly lower than all other treatments, at all the growth stages. Potassium uptake by grain varied from highest value 16.32 kgha^{-1} (T_4) to lowest value of 2.31 kgha^{-1} (T_1). T_4 was significantly superior over all other treatments. T_1 was significantly lower than all other

Table 3. Effect of SSIPNM on Zn and B uptake (g ha^{-1}) in plant, grains and straw of rice

Treatment	Zn uptake (g ha^{-1})				B uptake (g ha^{-1})			
	At 30	At 60	Grain	Straw	At 30	At 60	Grain	Straw
T_1	79.42	197.77	156.57	35.55	16.65	33.33	11.56	31.47
T_2	136.19	421.55	349.22	91.32	35.48	90.85	34.06	60.70
T_3	130.43	380.17	369.62	93.88	29.16	81.33	32.45	57.52
T_4	133.55	415.85	378.74	94.62	27.95	81.08	31.19	56.20
T_5	140.67	429.56	366.43	93.21	32.11	89.66	33.64	59.46
T_6	101.52	286.42	229.57	74.37	20.89	52.84	20.22	47.88
SEm ±	5.7	6.41	3.98	1.2	1.81	1.73	4.06	2.80
CD	17.53	19.51	12.11	3.77	3.9	3.73	1.88	6.13

Table 4. Effect of SSIPNM on soil pH, EC and Organic carbon (%)

Treatments	Soil pH			EC			OC (%)		
	At 30 DAT	At 60 DAT	At Harvest	At 30 DAT	At 60 DAT	At Harvest	At 30 DAT	At 60 DAT	At Harvest
T 1	8.19	8.17	8.07	0.18	0.19	0.19	0.56	0.57	0.58
T 2	7.96	7.98	7.91	0.20	0.19	0.20	0.58	0.59	0.60
T 3	7.99	7.79	7.85	0.19	0.18	0.19	0.61	0.62	0.63
T 4	7.81	7.91	7.79	0.18	0.19	0.17	0.60	0.61	0.63
T 5	7.96	7.86	7.98	0.20	0.19	0.19	0.57	0.59	0.60
T 6	8.0	7.79	7.98	0.20	0.20	0.19	0.58	0.58	0.59
SEm ±	0.01‘	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
CD	0.15	0.13	0.16	NS	NS	NS	NS	NS	NS

Table 5. Effect of SSIPNM on available N, P and K ($kgha^{-1}$)

Treatments	Available N ($kgha^{-1}$)			Available P ($kgha^{-1}$)			Available K ($kgha^{-1}$)		
	At 30	At 60	At harvest	At 30	At 60	At harvest	At 30	At 60	At harvest
T 1	215.16	202.73	185.44	16.72	15.10	14.60	236.61	228.92	217.95
T 2	243.33	216.93	190.07	19.62	17.12	15.57	276.57	244.49	227.22
T 3	237.07	214.08	194.21	21.55	19.12	17.25	271.92	260.17	233.92
T 4	231.88	213.19	194.5	22.02	19.35	17.42	267.15	262.20	237.11
T 5	242.09	215.84	190.26	20.07	18.75	16.30	274.07	256.47	225.11
T 6	231.48	211.34	183.6	19.05	16.42	15.42	240.8	232.89	219.72
SEm ±	1.91	2.43	2.6	0.23	0.25	0.34	2.62	3.15	2.41
CD	4.12	5.24	5.61	0.69	0.75	1.02	5.64	6.79	5.19
Initial		228.3			17.6			252.7	

treatments. T_4 was followed by T_3, T_5, T_2 and T_6. In straw, highest potassium uptake (88.68 kg ha^{-1}) was recorded in T_4 and T_1 recorded the lowest value of 44.67 $kgha^{-1}$. T_4 was significantly superior over all other treatments except T_3, which was *on par* with T_4. All other treatments were significantly superior over T_1. This might be due to continuous and steady supply of K from organic and inorganic treated plots

The uptake of zinc was increased from 30 DAT to harvest stages (Table 3). The maximum uptake was recorded in T_5 at 30, 60 DAT whereas at harvest maximum uptake was noticed in T_4. The minimum uptake was recorded in T_1 at all the stages. T_3, T_4, and T_2 were *on par* with T_5, while significantly superior over T_1 and T_6. At 30 DAT, maximum uptake (140.67gm ha^{-1}) was recorded in T_5, whereas lowest value (79.42 gm ha^{-1}) was noticed in T_1. T_5 was followed by T_2, T_4, T_3, T_6 and T_1. At 60 DAT lowest uptake of Zn (197.77 gm ha^{-1}) by plant was observed in T_1 and maximum (429.56 gm ha^{-1}) was recorded in T_5 which was followed byT_2, T_4, T_3, T_6 and T_1. Uptake of Zn at harvest varied from 470.29 gm ha^{-1} in T_4 to 192.12 gm ha^{-1} in T_1. In grain maximum uptake (378.74gm ha^{-1}) was observed in T_4 and minimum (156.57 gm ha^{-1}) in T_1. Similarly in straw, T_4 and T_1 recorded the maximum (94.62 gm ha^{-1}) and minimum (35.55 gm ha^{-1}), respectively. The beneficial effect of organic manure when it applied in conjunction with chemical fertilizer helped in increasing the nutrient availability and sustains it over a long period. The results were in conformity with the findings of Dikshit and Khatik (2002).

The uptake of boron was increased from 30 DAT, 60 DAT to harvest stages. The maximum uptake was recorded in T_2 at all the growth stages followed by T_5, T_3, T_4, T_6 and T_1. The maximum uptake was in T_2(35.48, 90.85, 94.76 g ha^{-1}, respectively) at all the stages. The minimum uptake was recorded in T_1 at all the stages. T_2 was *on par* with T_5 and T_3 was *on par* with T_4, while was significantly higher than T_1 and T_6. Microbial decomposition of organic manures with simultaneous release of organic acids which acts as chelating agents might have favored the

Table 6. Effect of SSIPNM on available Zn and B (mg kg^{-1})

Treatments	Available Zn (mg kg^{-1})			Available B (mg kg^{-1})		
	At 30 DAT	At 60 DAT	At harvest	At 30 DAT	At 60 DAT	At harvest
T_1	0.90	0.89	0.86	33.00	30.47	27.35
T_2	1.00	0.97	0.94	47.25	45.17	41.20
T_3	0.96	0.96	0.95	42.10	39.80	37.70
T_4	0.94	0.95	0.94	43.92	40.62	38.32
T_5	1.03	1.01	0.92	48.30	45.92	41.85
T_6	0.92	0.92	0.89	38.97	35.75	33.80
SEm ±	0.002	0.001	0..002	0.23	0.25	0.24
CD	0.004	0.004	0.005	0.60	0.73	0.71
Initial		0.93			37.32	

Table 7. Effect of SSIPNM on microbial population in soil

Treatment	Bacteria (cfu)	Fungus (cfu)	Actinomycetes (cfu)
T_1	37.97×10^5	15.60×10^2	19.57×10^4
T_2	58.80×10^5	27.02×10^2	17.5×10^4
T_3	75.15×10^5	29.77×10^2	14.72×10^4
T_4	76.55×10^5	30.42×10^2	10.97×10^4
T_5	57.47×10^5	25.87×10^2	19.25×10^4
T_6	51.57×10^5	23.77×10^2	19.11×10^4
SEm ±	0.93	0.78	0.35
CD	2.84	2.38	1.08

availability of micronutrients in soil and their uptake by rice. The results were in consonance with the findings of Kondapa Naidu *et al.*, (2009).

Response to Soil pH, EC and OC (%)

In general a decreasing trend in soil pH 8.19 to 7.80, 8.17 to 7.86 and 8.07 to 7.79 from initial to harvesting at 30, 60 DAT and harvest stage of rice was noticed (Table 4). At 30 DAT, T_1 and T_4 recorded the maximum (8.19) and minimum (7.8) soil pH, respectively. T_2 and T_5 were non significant while T_6 and T_3 were *on par* with each other. At 60 DAT, T_1 (8.17) and T_4 (7.79) recorded the maximum and minimum soil pH, respectively. T_3 and T_6 were non significant. At harvest T_1 (8.07) and T_4 (7.79) recorded the maximum and minimum soil pH, respectively. T_5 and T_6 were non significant. The results agree with the findings of Diwakar *et al.*, (2004).

There was no significant change was noticed in electrical conductivity in soil at all the stages due to different treatments. However a slightly decreasing trend of soil EC from initial level to harvesting stage of the rice was observed. This might be due to no improvement in ionic concentration of soil solution due to ionization of NPK fertilizers & mineralization of organic matter .Since it was short (one season) study, the significant changes due to addition of organics could not be expected Yadav and Lourduraj (2007).

There was no significant change in organic carbon percent in all the treatments was observed. However the organic carbon percent was increased in all the treatments at all the stages from initial level (0.58%) to harvesting stage (0.603%). T_3 recorded the maximum organic carbon percent at 30, 60 DAT and harvest while the minimum organic carbon percent was recorded in T_1. T_3 was followed by T_4, T_2, T_5 and T_6. The increased carbon due to addition of organic manures has been also reported by Singh *et al.*, (2005).

Response to Available N, P, K (kg ha^{-1}) and Zn and B (mg kg^{-1}) at different growth stages

Treatment T_2 recorded the highest available nitrogen 243.33 kg ha^{-1} and treatment T_1 recorded the lowest available nitrogen, 215.16 kg ha^{-1}. T_2 was followed by T_5, T_3, T_4 and T_6. T_2 was *on par* with T_5 and T_4 was *on par* with T_6 and all other treatments were significantly superior over T_1 (Table 5). The soil N at 30 DAT was greater than the initial status (228.30 kg ha^{-1}) in all the treatments except in T_1 which registered the lowest value. At 60 DAT, Treatment T_2 recorded the highest available nitrogen of 216.93 kg ha^{-1} and treatment T_1 recorded the lowest available nitrogen 202.73 kg ha^{-1}. T_2 was followed by T_5, T_3, T_4 and T_6. T_2 was *on par* with T_3, T_4, T_5 and was significantly higher than T_6 and all other treatments were significantly superior over T_1. The soil N at 60 DAT was slightly less than the initial status (228.30 kg ha^{-1}) in all the treatments. At harvest, Treatment T_4 recorded the highest available nitrogen 194.50 kg ha^{-1} and treatment T_1 recorded the lowest available nitrogen, 185.44 kg ha^{-1}. T_4 was followed by T_3, T_5, T_2 and T_6. T_4 was *on par* with T_2, T_3 and T_5 and was significantly higher than T_6 and all other treatments were significantly superior over T_1. The soil N at harvest was less than the initial status (228.30 kg ha^{-1}) in all the treatments. This might be the reason that treatments receiving even higher doses of inorganic fertilizers (T2) and (T5) did not shows higher available N in the soil at harvest. However, the present study clearly shows that Organic manure increases the organic carbon, available nitrogen of the soil at harvest. Present findings are in conformity with the reports of other investigators Singh *et al.*, (2005).

At 30 DAT, the available phosphorus content in soil increased from its initial status in all the treatments except T_1 which accounted for slightly lower phosphorus content than initial status (17.60 kg ha^{-1}). The available phosphorus content varied from 22.02 kg ha^{-1} in T4 to 16.72 kg ha^{-1} in T_1. T_4 was followed by T_3, T_5, T_2 and T_6. T_4 was *on par* with T_3, andT_2 was *on par* with T_5 and rest all other treatments were significantly over control. At 60 DAT, the available phosphorus content in soil slightly increased from its initial status (17.60 kg ha^{-1}) in T_3, T_4 and T_5 treatments, However T_2 and T_5 accounted for a slightly lower phosphorus content than initial status (17,60 kg ha^{-1}). The available phosphorus content varied from 19.35 kg ha^{-1}in T_4 to 15.10 kg ha^{-1} in T_1. $T4_6$ was followed by T_3, T_5, T_2 and T_6. T_4 was *on par* with T_3 and all treatmentswere significantly over control. At harvest, the available phosphorus content in soil decreased from its initial status (17.60 kg ha^{-1}) in all the treatments. The available phosphorus content varied from 17.42 kg ha^{-1} in T_4 to 14.60 kg ha^{-1} in T_1. T_4 was followed by T_3, T_5, T_2

and T_6. T_4 was *on par* with T_3 and T_2 was *on par* with T_5 and all treatments were significantly over control. The higher value might be due to increased organic matter content in soil and higher availability of nutrients to the crop.

At 30 DAT, the available potassium content in soil increased from its initial status (252.70 kg ha^{-1}) in all the treatments except T_1. The available potassium content varied from 276.57 kg ha^{-1} (T_2) to 236.61 kg ha^{-1} (T_1). All the treatments were significantly over on treatment T_1. T_2 was followed by T_5, T_3, T_4 and T_6. T_2 was *on par* with T_5 and T_3 whereas differ non significantly with T_6 and T_1. At 60 DAT, the available potassium content in soil increased from its initial status in all the treatments except T_1, T_2 and T_6. The available potassium content varied from 262.20 kg ha^{-1} (T_4) to 228.92 kg ha^{-1} (T_1). All the treatments were significantly over on treatment T_1.T_4 was *on par* with T_3 & T_5 while differ significantly from T_2, T_6 and T_1. At harvest, the available potassium content in soil decreased from its initial status in all the treatments. The available potassium content varied from 237.11 kg ha^{-1} (T_4) to 217.95 kg ha^{-1} (T_1). All the other treatments were significantly over on treatment T_1.T_4 was *on par* with T_3 and T_5 with T_2 and T_1 was *on par* with T_6.

Available Zinc was slightly increased from initial level to harvest stage except T_1 and T_6. At 30 DAT the maximum (1.03 mg kg^{-1}) and minimum (0.90 mg kg^{-1}) available zinc was recorded in T_5 and T_1, respectively (Table 6). T_5 was significantly over on all the treatments. T_5 was followed by T_2, T_3, T_4, T_6 and T_1. At 60 DAT the maximum (1.01 mg kg^{-1}) and minimum (0.89 mg kg^{-1}) available zinc was recorded in T_5 and T_1, respectively. T_5 was followed by T_2, T_3, T_4, T_6 and T_1. At harvest stage the maximum (0.95 mg kg^{-1}) and minimum (0.86 mg kg^{-1}) available zinc was recorded in T_3 and T_1, respectively. T_3 was followed by T_4, T_2, T_5, T_6 and T_1. T_2 and T_4 were *on par* with each other. This might be due to more chelating effects of Zn with organic compound resulting low availability of Zn in early stage, however the availability of Zn in combine use of organic and inorganic fertilizers treated plots improved at harvest because of more release of Zn from chelating agents.

Available boron was slightly increased from initial level to harvest stage except T_1 and T_6. At 30 DAT the maximum (48.30 mg kg^{-1}) and minimum (33.0 mg kg^{-1}) available boron was recorded in T_5 and T_1, respectively. T_5 was significantly over on all the treatments. T_5 was followed by T_2, T_4, T_3, T_6 and T_1. At 60 DAT the maximum (45.92 mg kg^{-1}) and minimum (30.47 mg kg^{-1}) available boron was recorded in T_5 and T_1 respectively. T_5 was followed by T_2, T_4, T_3, T_{-6} and T_1. At harvest stage the maximum (41.85 mg kg^{-1}) and minimum (27.35 mg kg^{-1}) available boron was recorded in T_5 and T_1,respectively. T_5 was followed by T_2, T_4, T_3, T_6 and T_1. At all the stages T_5 was significantly over all the treatments. This may be due to supplementation of Boron through inorganic fertilizers either through Borax or customized fertilizers. However, organic manure (Vermicompost or Sesbania) also supply the Boron but not to the extent of inorganic fertilizers.

Response to microbial population

After harvest the microbial population was counted (Table 7) and highest bacterial and fungal population was found in treatment T_4 (76.55x10^{5}cfu, 30.42x10^{2}cfu, respectively). This may be due to availability of more organic matter or plant biomass for their food and energy in inorganic or combine use of fertilizers treated plots, while the highest actinomycetes population was found in treatment T_1 (19.57x10^{4}cfu). The lowest population of bacteria and fungus were found in treatment T_1 (37.97x10^{5}cfu, 15.60x10^{2}cfu, respectively), while the lowest actinomycetes population was found in treatment T_4 (10.97x10^{4}cfu). This may be due to poor availability of lignin like compound for the food and energy for actinomycetes sunder other treatments as compare to control. Bacteria population was significantly higher in T_4 over T_1 followed by T_3, T_2, T_5 and T_6. Fungus population was significantly higher in T_4 over T_1 followed by T_3, T_2, T_5 and T_6. Actinomycetes population was significantly higher in T_1 over all the treatments followed by T_5, T_6, T_2, T_3 and T_4.T_5 was *on par* with T_6. The results were in consonance with the findings of Tilak (2004).

CONCLUSION

On the basis of present study, it can be suggested that inclusion of 34% N through vermicompost/green manuring along with recommended P and K maintains the microbiological population, besides improving physico-chemical properties. Though, application of customized fertilizer produces highest biomass with improvement in available N and B in soil. It means there is an urgent need to replenish farmer practices on community basis by SSIPNM.

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