J. Soils and Crops 28 (1) 31-36, June 2018 ISSN 0971-2836
NAAS Rating - 4.46
Scientific Journal Impact Factor (2017) 4.338

IMPACT OF ORGANIC AND INORGANIC SOURCES OF NUTRIENTS ON YIELD, NUTRIENT UPTAKE, SOIL FERTILITY AND ECONOMIC PERFORMANCE OF RICE IN A *TYPIC HAPLUSTERT*

M.K. Meshram[1], B.S. Dwivedi[2], K.R. Naik[3], Risikesh Thakur[4] and K.S. Keram[5]

ABSTRACT

The present investigation was conducted during 2011–12 under ongoing All India Coordinated Research Project on Cropping Systems with rice-wheat cropping sequence which was initiated during 1985 at the Research Farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, to assess the effect of combined and alone application of fertilizer and organic manures on yield, nutrient utilization along with soil fertility after thirty six crop cycles of rice and wheat. The results revealed that the substitution of 50% N through green manure (GM) with 50% NPK recorded significantly higher grain and straw yield (4121 and 7080 kg ha^{-1}, respectively) over the farmer's practice (2816 and 4922 kg ha^{-1}, respectively). Maximum nutrients uptake (N, P and K) by rice 87.5, 26.32 and 111.50 kg ha^{-1}, respectively were observed in the treatment receiving 50% NPK + 50% N through GM. The conjunctive use of organic manure and inorganic fertilizers gave highest microbial population and availability of N, P, K, S and Zn at post-harvest soil of rice as compared to other treatment combinations. The findings further, revealed that integration of 50% NPK and 50% N through green manuring of *Crotalaria juncea* to rice fetched the maximum NMR (Rs.18325 ha^{-1}) and B:C ratio (1.68). Thus, integrated use of 50% recommended dose of NPK fertilizer and 50% N through green manure with *Crotalaria juncea* sustains rice production, nutrient uptake by rice and also improved the soil fertility status of Vertisols.Whereas, the integration of FYM was next to green manuring in these regards. Both these IPNS were more economically viable nutrient management practices than application of plant nutrient through the fertilizers alone.

(Key words : IPNM, yield, uptake, economics, rice, Vertisols)

INTRODUCTION

Rice is the premier food grain crops of the India and in particular of Madhya Pradesh. There has been a phenomenal increase in their production after mid sixties with the introduction of high yielding varities. Due to inadequate and imbalanced fertilizer application, farmers are not able to harness the full yield potential of rice crop. The organic matters being the storehouses of nutrients, combined application of organic and inorganic fertilizer can increase the yield, improve the fertility status of soil, improve the input-use efficiency by the crop and can certainly cut down the expenditure on costly fertilizers (Laxminarayana and Patiram, 2006). The balance fertilization through integrated use of manure, fertilizer and biofertilizer along with micronutrients has been found useful in rice crop. Use of organic manure, green manuring, green leaf manuring, crop residues along with inorganic fertilizers not only reduces the demand for inorganic fertilizers, but also increases the efficiency of applied nutrients due to their favorable effect on physical, chemical and biological properties of soil. Hence, a field experiment was undertaken to study the effect of combined application of inorganic fertilizers and organic manures on yield of rice and its effect on soil properties.

MATERIALS AND METHODS

The present investigation undertaken during 2011–12 after twenty six crop cycle under ongoing AICRP on Cropping Systems with rice-wheat cropping sequence which was initiated during 1985 at the Research Farm of JNKVV, Jabalpur, Madhya Pradesh (23^{o}10" N latitude and 79^{o}57" E longitude). Jabalpur has a semi arid and sub tropical climate with a characteristic feature of dry summer and cold

1. P.G. Student, Deptt. of Soil Science & Agril. Chemistry, College of Agriculture, Jabalpur, J.N.K.V.V., Jabalpur (M.P.)
2. Scientist, Deptt. of Soil Science & Agril. Chemistry, College of Agriculture, Jabalpur, J.N.K.V.V., Jabalpur (M.P.)
3. Principal Scientist, Deptt. of Agronomy, College of Agriculture, Jabalpur, J.N.K.V.V., Jabalpur (M.P.)
4. Asstt. Professor, Deptt. of Soil Science & Agril. Chemistry, College of Agriculture, Waraseoni (Balaghat), J.N.K.V.V., Jabalpur (M.P.)
5. Ph.D. Scholar, Deptt. of Soil Science & Agril. Chemistry, College of Agriculture, Jabalpur, J.N.K.V.V., Jabalpur (M.P.)

winter. The average maximum temperatures during the month of May-June varies between 45.5 to 46.4 ^{0}C and are the hottest month of the year, while the average minimum temperature varies between 8.2 to 8.7 ^{0}C during December-January, which are the coldest month of the year. The average annual seasonal rainfall of this region is about 1200 mm which is mostly received between June to September and a little rainfall (75 to 175 mm) received in the month from October to May. The average humidity of the region is about 73 per cent. The soil of the experimental field is medium black (56.8% clay) belonging to Kheri series of fine montmorillonitic hyperthermic family of *Typic Haplustert* and had an initial pH of 7.62, electrical conductivity 0.55 dS m^{-1} (1:2.5 soil : water ratio) and organic carbon 6.5 g kg^{-1}. The soil available N, P and K were 240, 16 and 448 kg ha^{-1}, respectively. The experiment included eleven treatments viz., T_1 – Absolute control, T_2 – 50% NPK; T_3 – 75% NPK, T_4 – 100% NPK, T_5 – 50% NPK +12 t FYM, T_6 – 75% NPK + 6 t FYM, T_7 – 50% NPK + 25% N as wheat straw, T_8 – 75% NPK + 25% N as wheat straw, T_9 – 50% NPK + 50% N as green manure, T_{10} – 75% NPK + 25% N as green manure and T_{11} – N_{40} + P_{20} + 3 t FYM (Farmer's Practice) replicated four times in a randomized block design.

The recommended N, P and K dose, based on initial soil test, was 120 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} for rice and 120 kg N, 80 kg P_2O_5 and 40 kg K_2O ha^{-1} for wheat (should be confirming from dairy-IFS). As per treatment organic manures through different source viz., FYM, green leaf manures (*Crotalaria juncea*) and wheat straw were applied. As a basal dose, half of urea and the requisite quantity of SSP and MOP were applied at the time of sowing for different treatments in each plot. Basal placement of fertilizers was done at the soil depth of about 4 cm before sowing. Rest of nitrogen was top dressed after 30 days of transplanting.

Rice (MR-219) was transplanted in the third week of July and harvested in the second week of December. Insects and diseases were kept under check following suitable control measures. Five hills were randomly marked with wooden sticks and tagged with luggage labels for recording the various observations pertaining to yield attributes at maturity in rice crop. At maturity of rice crop was harvested manually and yield data were recorded after threshing. The soil samples were collected after harvest of rice crop from 0-15 cm depths in the 36th cropping year (2011-12) and were analysed for different parameters by standard laboratory procedures for organic carbon (Walkley and Black, 1934), available N (Subbiah and Asija, 1956), available P (Olsen *et al.,* 1954), and available K (Muhr *et al.,* 1965). The fresh soil samples collected during grand growth stage of wheat were immediately used for estimating biological properties of soil. Soil samples were analysed for viable count of *Azotobacter, Azospirillum*, PSB and total bacterial count by serial plate dilution method (Subba Rao, 1986).

RESULTS AND DISCUSSION

Crop yields

The highest grain and straw yield was recorded in 50% NPK + 50% through green manure treatment (4121 and 7080 kg ha^{-1}, respectively) which was significantly superior to all other treatments (Table 1). The lowest grain and straw yield was recorded in absolute control plot (1644 and 2874 kg ha^{-1}, respectively) which was significantly inferior to most of the treatments except 50% NPK + 50% through green manure treatments. Further, 100% NPK, 50% NPK+12 t FYM and 50% NPK+25% N as wheat straw treatments were at par in this respect. Further, the grain yield of rainy season rice was higher under 100% recommended dose of NPK applied through either inorganic source alone or 75% through inorganic and 25% through organic source. Application of NPK at sub-optimal dose i.e. 75 and 50% of recommended NPK dose reduced the grain yield significantly. The results are in line with the findings of Sharma *et al.* (2015) , who reported that the substitution of 25% NPK through farmyard manure (FYM) in recommended dose of NPK along with 5 kg Zn ha^{-1} and PSB+BGA recorded significantly higher grain yield of rice over the 100% NPK treatment. Improvement in yield due to combined application of inorganic fertilizer and organic manure might be attributed to controlled release of nutrients in the soil through mineralization of organic manure which might have facilitated better crop growth (Saha *et al.,* 2008). Among different INM (Integrated Nutrient Management) treatments, green manuring of *Crotalaria juncea* proved superior to FYM and wheat straw, which may be the probable reason for its marked superiority in growth and yields of crop (Gupta *et al.,* 2006). This indicates that sustainability in productivity of rice could be maintained by integrated use of organic and inorganic fertilizers. Similar findings on crop productivity were also noted by Dwivedi *et al.* (2012), who reported that the integrated use of inorganic fertilizers with organic manure and biofertilizers gave the highest grain yield of rice. However, use of only farm yard mannure during *kharif* was unable to increase crop yields to a sustainable level in the long run.

Nutrients uptake by rice

The data in table 1 indicates that N uptake by rice increased with the increasing levels of fertilizers and integration with organic manures. The highest N uptake 87.50 kg ha^{-1} by rice was observed in 75% NPK + 25% N through green manure treatment while, the lowest uptake 24.10 kg ha^{-1} was found in absolute control plot. The higher nutrient uptake with organic manure might be attributed to solubilization of native nutrients, chelation of complex intermediate organic molecules produced during decomposition of added organic manures, their mobilization and accumulation of different nutrients in different plant parts (Tiwari *et al.,* 2012). The results are in agreement with the findings of Sharma *et al.* (2015) . They also reported maximum N uptake by rice in the treatment receiving 75% NPK + 5 t FYM ha^{-1} + PSB + BGA + Zn in a Vertisol.

Phosphorus uptake by rice was also influenced by combined application of inorganic fertilizers and organic manure. Almost all the INM treatments except farmer's practice recorded significantly higher P uptake by rice compared to 50% NPK during both the years (Table 1). The solubilizing action of organic acids produced during decomposition of organic manures or green manure might have increased the release of native P, stimulated microbial growth in soil, and favoured root growth which had finally led to increased P uptake by rice. Thakur *et al.* (2011) also recorded higher P uptake due to combined application of inorganic fertilizers with organic manure (FYM) under soybean-wheat cropping sequence in a Vertisol. Different INM treatments removed 21.76 to 26.32 kg P ha^{-1}, were almost similar with each other, but higher over control. The farmer's practice of nutrient management also removed significantly higher P (10.45 kg ha^{-1}) by rice than control. Availability of more P to rice plants when supplied through varying rates of fertilizers alone or in combination with organic sources was more, which attributed to higher P uptake (Sharma *et al.*, 2011).

Potassium uptake was found significantly higher in almost all the INM treatments as compared to Farmer's practice. Rice exhausted significantly varying quantities of K uptake (Table 1). Like N and P, the uptake of K by rice was minimum (32.6 kg ha^{-1}) when no addition of manure or fertilizer was done. However, increasing rates of fertilizer application uptake correspondingly higher quantities of K upto 100% NPK levels of fertilizer application. The K uptake by rice was maximum under 75% NPK + 25% N through green manure treatment (111.5 kg ha^{-1}) among all treatments (Sahu *et al.*, 2009). Treatment consisting of farmer's choice of plant nutrition also uptake significantly higher quantity of K than control plots. The increased uptake of K by rice may be ascribed to the release of K from the K-bearing minerals by complexing agents and organic acids produced during decomposition of organic resources. Similar findings were also observed by Sawarkar *et al.* (2013) , who reported that the 100% NPK+FYM gave the highest uptake of K under soybean-wheat cropping system in a Vertisol.

Soil fertility

The organic C and available N contents of the experimental soil was found to increase over the initial value in all the INM treatments (Table 2). The maximum increase in the OC and available N were noted in integrated application of 50% NPK and 50% N through green manureing treatment (7.7 g kg^{-1} and 290 kg ha^{-1}) and it was significantly superior to 50% NPK + 12 t FYM treatment (7.5 g kg^{-1} and 285 kg ha^{-1}). The treatment 75% NPK + 6 t FYM treatment was at par with 50% NPK + 25% N as wheat straw and 75% NPK + 25% N as wheat straw treatment. The lowest value of OC was recorded in absolute control plot (6.0 g kg^{-1}). The available soil N was also found to increase in all the INM treatments (FYM and/or GM) at 50% NPK level. This increase may be attributed to higher microbial activity in the INM treatments which favoured the conversion of the organically bound nitrogen to inorganic form (Panwar, 2008 and Singh *et al.*, 2006). The soil available P (Table 2) was either maintained or significantly improved due to addition of different organic manure over absolute control plot (8.6 kg ha^{-1}). Organic manures, on decomposition, solubilise insoluble organic P fractions through release of various organic acids, thus resulting into a significant improvement in available P status of the soil (Mondal *et al.,* 2008). Maitra *et al.* (2008) also found similar improvement in soil available P status in a Typic Ustochrept of Uttar Pradesh due to integrated nutrient management in sunhemp. The status of K (Table 2) showed rising trend over its initial status under different INM treatments except farmer's practice but the values of available K reduced over its initial status under others fertilizer applied at varying rates or absolute control after completion of 26th crop cycle. The margin of reduction in K status over its parental status was relatively less, when 100% NPK was applied continuously for 26th years of rice crop (Yogananda *et al*., 2004).

Biological properties of soil

Rice field exhausted significantly varying in microbial population (Table 3). The population of *Azotobacter*, *Azospirillum*, PSB and TBC was minimum 9.25, 1.4, 5.4 and 30.32 cfu g^{-1} respectively, when no addition of manure or fertilizer was done. However, increasing rates of fertilizer application correspondingly higher population of microbial upto 100% NPK levels of fertilizer application. The higher microbial population (*Azotobacter*, *Azospirillum*, and PSB) was found in treatment T_9 (38.80, 8.74 and 26.4) comprises 50% NPK + 50% N as green manure, but TBC was found higher in treatment T_5 (60.54) comprises with 50% NPK+12 t FYM. It may be due to better rhizosphere and rhizosphere effect. Similar results were also reported by Sawarkar *et al.* (2015) , who observed that the highest microbial population was found in 100% NPK+15 t FYM ha^{-1} treatment and lowest in control plot under soybean-wheat cropping system in a Vertisol.

Economics

The cost of cultivation was marginally increased when the nutrients were applied through the combination of different sources, but due to higher grain and straw yields, the net income and B:C ratio were also higher under the integrated use of organic and inorganic source of nutrients (Table 4). The highest net income of Rs. 18,325 ha^{-1} and B:C ratio (1.68) was obtained with application of 50% NPK with 50% N through green manure. The second best treatment (100% NPK) gave net income (Rs. 15,512 ha^{-1}) and B:C ratio of (1.60). Whereas, the lowest B:C ratio of 0.89 was found in T_1 (Absolute control). Thus, rice cultivation proved more beneficial/profitable when grown with integrated nutrient management (inorganic, organic and biofertilizers). Pandey *et al.* (2006) also opined that the cost of production could be mitigated if all INM is adopted.

It may be concluded that the integrated use of 50% recommended dose of NPK fertilizer and 50% N through

Table 1. Effect of different nutrient management practices on grain and straw yield and its uptake by rice crop

Treatments	Yield ($kg\ ha^{-1}$)		Total nutrient uptake ($kg\ ha^{-1}$)		
	Grain	Straw	N	P	K
T_1 : Absolute Control	1644	2874	24.1	5.43	32.6
T_2 : 50% NPK	2917	5100	45.5	10.39	58.5
T_3 : 75% NPK	3164	5532	52.7	12.16	66.3
T_4 : 100% NPK	3739	6537	76.8	19.66	94.9
T_5 : 50% NPK +12 t FYM	3698	6465	77.0	21.76	97.2
T_6 : 75% NPK + 6 t FYM	3369	5891	59.6	13.73	72.0
T_7 : 50% NPK + 25% N as WS	3616	6323	72.1	17.63	83.7
T_8 : 75% NPK + 25% N as WS	3287	5748	56.9	13.72	71.1
T_9 : 50% NPK + 50% N as GM	4121	7080	87.5	26.32	111.5
T_{10} : 75% NPK + 25% N as GM	3398	5942	60.9	15.60	75.8
T_{11} : Farmer's Practice	2816	4922	45.3	10.35	56.6
SEm ±	**177**	**308**	**5.1**	**1.21**	**5.0**
CD (P=0.05)	**510**	**890**	**14.7**	**3.49**	**14.4**

Where :- FYM = Farmyard Manure, WS = Wheat Straw, GM = Green Manure

Table 2. Effect of different nutrient management practices on Soil fertility status

Treatments	pH	EC ($dS\ m^{-1}$)	OC ($g\ kg^{-1}$)	Available nutrients ($kg\ ha^{-1}$)		
				N	P	K
T_1 : Absolute Control	7.54	0.48	6.0	238	8.6	287
T_2 : 50% NPK	7.54	0.49	6.4	256	9.3	320
T_3 : 75% NPK	7.55	0.54	6.6	265	10.8	370
T_4 : 100% NPK	7.58	0.50	6.8	270	13.7	428
T_5 : 50% NPK +12 t FYM	7.55	0.51	7.5	285	15.0	455
T_6 : 75% NPK + 6 t FYM	7.55	0.48	7.3	279	15.8	450
T_7 : 50% NPK + 25% N as WS	7.56	0.51	7.4	282	15.6	475
T_8 : 75% NPK + 25% N as WS	7.54	0.44	7.3	278	16.4	462
T_9 : 50% NPK + 50% N as GM	7.54	0.53	7.7	290	17.7	480
T_{10} : 75% NPK + 25% N as GM	7.55	0.47	7.5	283	16.2	468
T_{11} : Farmer's Practice	7.57	0.46	6.8	272	14.6	429
Initial status (2007-08)	7.62	0.55	6.5	240	16.0	448
SEm ±	**0.04**	**0.03**	**0.10**	**8.69**	**0.56**	**7.94**
CD (P=0.05)	**–**	**–**	**0.28**	**25.08**	**1.62**	**22.94**

Where :- FYM = Farmyard Manure, WS = Wheat Straw, GM = Green Manure

Table 3. Effect of different nutrient management practices on microbial population in soil

Treatments	*Azotobacter* (10^3cfu g^{-1})	*Azospirillum*	PSB	TBC
		(10^6cfu g^{-1})		
T_1 : Absolute Control	9.25	1.40	5.4	30.32
T_2 : 50% NPK	15.23	1.72	9.7	37.00
T_3 : 75% NPK	16.54	2.28	12.0	40.54
T_4 : 100% NPK	19.36	3.14	13.2	45.05
T_5 : 50% NPK +12 t FYM	30.31	5.73	22.5	60.54
T_6 : 75% NPK + 6 t FYM	28.40	4.26	16.8	58.15
T_7 : 50% NPK + 25% N as WS	29.80	4.37	18.0	58.84
T_8 : 75% NPK + 25% N as WS	27.50	3.64	16.2	54.75
T_9 : 50% NPK + 50% N as GM	38.80	8.74	26.4	50.95
T_{10} : 75% NPK + 25% N as GM	35.40	5.23	22.0	45.95
T_{11} : Farmer's Practice	25.90	3.35	14.3	46.74
Initial status (2007-08)	8.90	1.20	4.70	28.80
SEm ±	**1.29**	**0.25**	**0.85**	**1.42**
CD (P=0.05)	**3.72**	**0.73**	**2.44**	**4.10**

Where :- FYM = Farmyard Manure, WS = Wheat Straw, GM = Green Manure

Table 4. Effect of different nutrient management practices on economic status

Treatments	Cost of cultivation	GMR	NMR	B:C ratio
	(Rs. ha^{-1})			
T_1 : Absolute Control	20488	18162	-2326	0.89
T_2 : 50% NPK	22088	32227	10139	1.46
T_3 : 75% NPK	22888	34959	12071	1.53
T_4 : 100% NPK	25800	41312	15512	1.60
T_5 : 50% NPK +12 t FYM	26288	40854	14566	1.55
T_6 : 75% NPK + 6 t FYM	25048	37227	12179	1.49
T_7 : 50% NPK + 25% N as WS	27488	39954	12466	1.45
T_8 : 75% NPK + 25% N as WS	25648	36321	10673	1.42
T_9 : 50% NPK + 50% N as GM	27128	45453	18325	1.68
T_{10} : 75% NPK + 25% N as GM	25468	37548	12080	1.47
T_{11} : Farmer's Practice	22868	31108	8240	1.36

Where :- FYM = Farmyard Manure, WS = Wheat Straw, GM = Green Manure green manure with *Crotalaria juncea* sustains rice production, nutrient uptake by rice and also improved the soil fertility status of Vertisols. The findings further, revealed that integration of 50% NPK and 50% N through green manuring of *Crotalaria juncea* to rice fetched the maximum NMR (Rs.18325 ha^{-1}) and B:C ratio (1.68). Whereas, the integration of FYM was next to green manuring in these regards. Both these IPNS were more economically viable nutrient management practices than application of plant nutrient through the fertilizers alone.

REFERENCES

Dwivedi B.S., A.K. Pandey, R.K. Tiwari, A.K. Jha and N.K. Khamparia, 2012. Performance of integrated nutrient management on yield and uptake direct seeded rice. Progressive Agriculture, **12** (2) : 381-385.

Gupta Vikas, R.S. Sharma and S.K. Vishwakarma, 2006. Long-term Effect of Integrated Nutrient Management on Yield Sustainability and Soil Fertility of Rice (*Oryza sativa*)–wheat (*Triticum aestivum*) Cropping System. Indian J. Agron, **51** : 3.

Laxminarayana, K. and S. Patiram, 2006. Effect of integrated use of inorganic, biological and organic manures on rice productivity and soil fertility in Ultisols of Mizoram. J. Indian Soc. Soil Sci., **54** (2): 213–20.

Maitra, D.N., S.K. Sarkar, S. Saha, M.K. Tripathy, B. Majumdar and A.R. Saha, 2008. Effect of phosphorus and farmyard manure applied to sunnhemp on yield and nutrient uptake of sunnhemp–wheat cropping system and fertility status in a Typic Ustochrept of Uttar Pradesh. Indian J. Agril. Sci., **78**: 70–74.

Mondal, S.S., Prasenjit Jana and Pradyut Chandra, 2008. Integrated nutrient management for sustaining productivity and soil fertility build-up in rice–lathyrus– sesame cropping system. Indian J. Agril. Sci., **78**: 534–536.

Muhr, G.R., N.P. Datta, H.S. Subramany, V.K. Leley and R.L. Donahue, 1965. Soil testing in India, Asian Press, New Delhi.

Olsen S.R., C.V. Cole, F.S. Watanabe and L.A. Dean, 1954. Estimation of available phosphorus in soils by extraction with $NaHCO_3$, U.S.D.A. Circular, **939** : 1 – 19.

Pandey, A.K., K.A. Gopinath, R. Bhattacharya, K.S. Hooda, S.N. Sushil, S. Kundu, G. Selvakumar and H.S. Gupta, 2006. Effect of source and rate of organic manures on yield attributes, pod yield and economics of garden pea grown under organic farming system. Indian J. Agril. Sci., **76**(4): 230–234.

Panwar, A.S. 2008. Effect of integrated nutrient management in maize–mustard cropping system in mid hills altitude. Indian J. Agril. Sci., **78**: 27–31.

Saha, A.R., D.N. Maitra, B. Majumdar, S. Saha and S. Mitra, 2008. Effect of integrated nutrient management of roselle (*Hibiscus sabdariffa*) productivity, its mineral nutrition and soil properties. Indian J. Agril Sci., **78**: 418–421.

Sahu, Rakesh, D.L. Kauraw and Risikesh Thakur, 2009. Impact of integrated resource management on production and nutrients uptake by rice Crop. J. Soils and Crops, **19** (2): 205 – 209.

Sawarkar, S.D., N.K. Khamparia, Risikesh Thakur, M.S. Dewda and Muneshwar Singh, 2013. Effect of long-term application of inorganic fertilizers and organic manure on yield, potassium uptake and profile distribution of potassium fractions in Vertisol under soybean-wheat cropping system. J. Indian Soc. Soil Sci., **61**(2): 94-98.

Sawarkar, S.D., Muneshwar Singh, N.K. Khamparia, R.H. Wanjari and Risikesh Thakur, 2015. Research Bulletin on Long Term Impact of Fertilizer and Manure on Soil Quality, Crop Productivity and Sustainability under Soybean-Wheat System in Vertisol. AICRP on LTFE, ICAR – Indian Institute of Soil Science, Bhopal; pp. 1 – 63.

Sharma, G.D., R.K. Thakur, N. Chouhan, B.L. Sharma and D.K. Tiwari, 2015. Effect of INM on yield, nutrient uptake, protein content & economics performance of rice. Green Farming, **6** (1): 50-54.

Sharma, S. N., Rajendra Prasad, Davari Mohammadreza, Ram Moola and Manoj Kumar Dwivedi, 2011. Effect of Phosphorus Management on Production and Phosphorus Balance in Rice-wheat Cropping System. Archives of Agron. & Soil Sci., **57**: 655-667.

Singh, Surendra, R.N. Singh, Janardan Prasad and B.P. Singh, 2006. Effect of integrated nutrient management on yield and uptake of nutrients by rice and soil fertility in rainfed uplands. J. Indian Soc. Soil Sci., **54**: 327–330.

Subba Rao, N.S. 1986. Soil microorganisms and plant growth. Second edition published by Oxford and IBH publishing Co. Pvt. Ltd., New Delhi, pp. - 206-297.

Subbiah, B.V. and G.L. Asija, 1956. A rapid method for the estimation of nitrogen in soils. Curr. Sci., **25**: 259-260.

Thakur, Risikesh, S.D. Sawarkar, U.K. Vaishya and Muneshwar Singh, 2011. Impact of continuous use of inorganic fertilizers and organic manure on soil properties and productivity under soybean-wheat intensive cropping of a Vertisol. J. Indian Soc. Soil Sci., **59**:74-81.

Tiwari R.K., B.S. Dwivedi, G. Deshmukh, A.K. Pandey and R.K. Thakur, 2012. Studies on variation in nodulation and nitrogen uptake in chickpea genotypes suitable for Madhya Pradesh. J. Soils and Crops, **22** (2): 277 – 279.

Walkley A. and C.A. Black, 1934. Estimation of soil organic carbon by the chromic acid titration method. Soil Sci., **47**: 29 – 38.

Yogananda, S.B., V.C. Reddy and K. Sudhir, 2004. Effect of Urban Compost and inorganic fertilizers on soil nutrient status and grain yield of hybrid rice. Mysore J. Agric. Sci., **38**(4): 454-458.

Rec. on 05.03.2017 & Acc. on 10.04.2017