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Original Article

Determination of Replacement Value of Chemical Fertilizers with Organics in Rice Crop

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Abstract

A field experiment was carried out during kharif season of 2002 and 2003 to assess the extent of reductions in yield due to application of inorganic fertilizers below the recommended level. The NPK levels applied were @ 100%, 75% and 50% of recommended fertilizers through inorganic fertilizers. The higher values of NPK elements are required for identical increase in yield if the sources are organics. Among organics, higher amounts for Bagasse NPK are required for same increase in the yield. The NPK was twice as effective as FYM, NPK and about 4 times as effective as Bagasse NPK in terms of increasing the yield of rice. The fertilizer P was about 4 times as efficient in increasing P uptake by rice as FYM P and more than 10 times higher as compared to Bagasse P. The fertilizer K was about 6 times and 10 times more effective than FYM and Bagasse K, respectively in enhancing the K uptake by rice.

Keywords

Replacement value of inorganic; Organic; Rice.

Introduction

Continuous use of high levels of chemical fertilizers had led to soil degradation resulting in reduced crop productivity. Nambiar and Abrol[1] reported a declining trend in the productivity of rice even when grown under adequate application of N, P and K. Depletion of organic carbon, lower moisture retention and reduction in water stable aggregates were reported to be the prime reason for unsustainability of rice production in rice-wheat system.[2] Hence, positive impact of organic manures/residue additions in such fields is expected. Incorporation of crop residue preserves plant nutrients as well as improves the physico-chemical and biological properties of soil improving the ecological balance of rhizosphere. The long-term sustainable production needs balanced supply of essential plant nutrients in available form along with suitable physical, chemical and biological properties of soil to attain a better growth and development of crop and efficient utilization of nutrients from the rhizosphere. The balanced nutrition involves systematic exploitation and replenishment of potential of soil resources, chemical fertilizers, bio-fertilizers and organic manures.

Materials and Methods

The experiment was conducted at the Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The soil of experimental site was loam in texture (0-15 cm) high in Organic carbon (9.0 g kg^{-1}) and available N, P

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and K were 210 kg, 22.6 kg and 240.7 kg ha^{-1} while S, Zn and B were 10 mg kg^{-1} , 0.45 mg kg^{-1} and 0.66 mg kg^{-1} soil, respectively. The soil was neutral in reaction (pH 7.46) with 0.2l dSm^{-1} EC. During kharif season in both the years, rice variety *Govind* was taken with recommended practices. The experiment with eighteen treatment combinations, replicated thrice was planted in R.B.D. in 20 x 10 cm spacing. The full dose of P and K along with 1/3 of N as per treatment was applied at the time of planting and remaining N was top dressed in two equal doses. The grain and stover samples were analyzed for N, P& K contents with standard chemical procedures during both the years. The uptake was calculated from the yield data in conjunction with their respective contents. The apparent nutrient recovery (REN) and Agronomic efficiency of applied nutrient (AEN) were calculated by using following formulae:

$$\text{REN} \ (\%) = \frac{\text{A - B}}{\text{C}} \times 100$$

$$\text{AEN (kg grain kg}^{-1} \text{ nutrient)} = \frac{\text{D - E}}{\text{C}}$$

Where,

A = Nutrient uptake in treated plot (kg ha^{-1})

B = Nutrient uptake in corresponding control plot (kg ha^{-1})

C = Amount of nutrient applied through a particular source (kg ha^{-1})

D = Grain yield in treated plot (kg ha^{-1})

E = Grain yield in corresponding control plot (kg ha^{-1})

Results and Discussion

Agronomic Efficiency of Nutriments

In terms of the increase in yield of rice with unit increase in the fertilizer NPK or FYM and Bagasse NPK, (Table 1) it was found that for one kg increase in yield (fertilizer NPK/yield increased) 0.12 and 0.13 kg of fertilizer NPK was required during 2002 and 2003, respectively. For the similar yield (FYM NPK/yield increased) increase, the FYM NPK required had an average values (5 and 10 t ha^{-1} FYM) of 0.22 and 0.52 and the Bagasse NPK (Bagasse NPK/yield increased) required was (average values of 5 and 10 t ha^{-1} Bagasse) 0.89 and 1.72 kg during 2002 and 2003, respectively. This clearly shows that higher values of NPK elements are required for identical increase in yield if the sources are organics. Among organics, higher amounts for Bagasse NPK are required for same increase in the yield. In terms of increase in yield for fertilizer NPK required (yield increased/ fertilizer NPK) the average values were 9.45 and 10.58 kg during the year 2002 and 2003, respectively (Table 2). Similar average values (5 and 10 t ha^{-1}) of FYM NPK (yield increased/FYM NPK) were 4.82 and 2.78 kg and the average (5 and 10 t ha^{-1} Bagasse) values for Bagasse NPK were 1.59 and 2.17 kg, respectively. It seems, therefore, that fertilizer NPK was twice as effective as FYM NPK and about 4 times as effective as Bagasse NPK in terms of increasing the yield of rice.

In terms of increase in N uptake of rice, kg^{-1} of fertilizer N applied, the average values for the year 2002 and 2003 were (increase in N uptake/

Table 1: Agronomic efficiency of added NPK nutrients in Rice, Kg^{-1} of yield increase (Applied NPK/Yield Increase)

Nutrients and sources	2002				2003			
	RF	75% of RF	50% of RF	Mean	RF	75% of RF	50% of RF	Mean
Fertilizer NPK	0.08		0.15	0.12	0.19		0.06	0.13
FYM (@ 5 t ha^{-1}) NPK	0.22	0.23	0.17	0.21	1.29	0.60	0.22	0.70
FYM (@ 10 t ha^{-1}) NPK	0.25	0.20	0.20	0.22	0.35	0.39	0.24	0.33
Bagasse (@ 5 t ha^{-1}) NPK	1.83	0.36	0.37	0.85	6.58	0.33	0.15	2.35
Bagasse (@ 10 t ha^{-1}) NPK	1.24	0.88	0.64	0.92	1.58	0.75	0.91	1.08

Average of FYM (@5 and 10 t ha^{-1}), NPK = 0.22 (2002) and 0.52 (2003)
Average of Bagasse (@5 and 10 t ha^{-1}), NPK = 0.89 (2002) and 1.72 (2003)

fertilizer N) 0.39 and 0.44 kg, respectively (Table 3). Corresponding values for each kg increase in N uptake (increase in N uptake/FYM N) were 0.39 and 0.32 kg for (5 and 10 t ha^{-1}) FYM N and (increase in N uptake/Bagasse N) 0.20 and 0.27 kg for Bagasse N during 2002 and 2003, respectively.

In terms of increase in P uptake by rice, kg ha^{-1} of fertilizer P added the average values for the year 2002 and 2003 (increase in P uptake/ fertilizer P) were 0.36 and 0.48 kg, respectively. Corresponding values for each kg increase in P uptake (increase in P uptake/FYM P) averaged at (5 and 10 t ha^{-1} FYM) 0.08 and 0.07 kg FYM P and (increase in P uptake/Bagasse P) 0.03 and 0.03 Bagasse P during 2002 and 2003,

Table 2: Agronomic efficiency of added NPK nutrients in Rice, Kg^{-1} of Nutrient Applied (Yield Increased/Applied NPK)

Nutrients and sources	2002				2003			
	RF	75% of RF	50% of RF	Mean	RF	75% of RF	50% of RF	Mean
Fertilizer NPK	12.05		6.84	9.45	5.26		15.91	10.58
FYM (@ 5 t ha^{-1}) NPK	4.64	4.28	6.04	4.99	0.77	1.66	4.61	2.35
FYM (@ 10 t ha^{-1}) NPK	3.99	5.01	4.96	4.65	2.83	2.55	4.24	3.21
Bagasse (@ 5 t ha^{-1}) NPK	0.55	2.81	2.68	2.01	0.15	3.04	6.76	3.32
Bagasse (@ 10 t ha^{-1}) NPK	0.81	1.14	1.57	1.17	0.63	1.34	1.10	1.02

Average of FYM (@5 and 10 t ha^{-1}), NPK = 4.82 (2002) and 2.78 (2003)
Average of Bagasse (@5 and 10 t ha^{-1}) , NPK = 1.59 (2002) and 2.17 (2003)

Table 3: Uptake of Nutrients per Kg of nutrient applied in Rice (Nutrient Uptake increased/Applied Nutrient)

Nutrients and sources	2002				2003			
	RF	75% of RF	50% of RF	Mean	RF	75% of RF	50% of RF	Mean
Fertilizer								
N	0.55	0.22		0.39	0.32	0.56		0.44
P	0.34	0.37		0.36	0.39	0.57		0.48
K	1.85	1.13		1.49	0.87	2.79		1.83
FYM (@ 5 t ha^{-1})								
N	0.41	0.40	0.23	0.35	0.14	0.24	0.20	0.19
P	0.09	0.07	0.07	0.08	0.03	0.05	0.06	0.05
K	0.30	0.15	0.22	0.22	0.13	0.14	0.13	0.13
FYM (@10 t ha^{-1})								
N	0.60	0.46	0.22	0.43	0.55	0.44	0.32	0.44
P	0.09	0.09	0.07	0.08	0.08	0.08	0.08	0.08
K	0.35	0.30	0.30	0.32	0.27	0.15	0.29	0.24
Bagasse (@5 t ha^{-1})								
N	0.50	0.48	-0.43	0.18	0.04	0.27	0.64	0.32
P	0.02	0.05	0.03	0.03	-0.004	0.05	0.08	0.04
K	0.26	0.15	0.23	0.21	0.12	0.14	0.33	0.20
Bagasse (@10 t ha^{-1})								
N	0.30	0.31	0.06	0.22	0.26	0.17	0.19	0.21
P	0.03	0.03	0.02	0.03	0.02	0.02	-0.001	0.01
K	0.07	0.06	0.09	0.07	0.20	0.07	-0.09	0.06

Average of FYM (@ 5 and 10 t ha^{-1})				Average of Bagasse (@5 and 10 t ha^{-1})			
N	=	0.39 (2002)	0.32 (2003)	N	=	0.20 (2002)	0.27 (2003)
P	=	0.08 (2002)	0.07 (2003)	P	=	0.03 (2002)	0.03 (2003)
K	=	0.27 (2002)	0.19 (2003)	K	=	0.14 (2002)	0.13 (2003)

Table 4: Recovery efficiency (%) of added nutrients in Rice crop

Nutrients and sources	2002 RF	2002 75% of RF	2002 50% of RF	2002 Mean	2003 RF	2003 75% of RF	2003 50% of RF	2003 Mean
Fertilizer								
N	55.00		22.10	38.55	32.33		56.07	41.15
P	33.74		37.25	35.50	38.63		57.25	47.94
K	184.99		113.33	149.16	87.27		278.51	182.89
FYM (@ 5 t ha^{-1})								
N	40.75	39.73	23.10	34.53	14.04	23.58	20.15	19.26
P	9.25	6.63	7.38	7.75	2.97	4.80	5.77	4.51
K	30.33	14.91	22.07	22.44	13.23	13.82	13.33	13.46
FYM (@10 t ha^{-1})								
N	59.55	46.27	22.37	42.73	54.55	43.60	31.55	43.23
P	9.25	8.81	6.94	8.33	8.23	8.06	8.09	8.13
K	35.07	30.40	29.82	31.76	27.11	14.82	28.95	23.63
Bagasse (@5 t ha^{-1})								
N	50.16	48.40	-41.20	19.12	3.50	27.42	64.42	31.78
P	2.40	4.90	3.40	3.57	-0.36	4.55	8.36	4.18
K	25.69	15.19	22.69	21.19	11.64	14.12	33.21	19.66
Bagasse (@10 t ha^{-1})								
N	29.24	29.92	5.84	21.67	26.38	16.88	18.67	20.64
P	2.65	2.60	2.35	2.53	2.32	2.27	-0.14	1.48
K	7.03	6.25	8.88	7.39	19.91	7.27	-9.45	5.91

Average of FYM (@ 5 and 10 t ha-1)				Average of Bagasse (@ 5 and 10 t ha-1)			
N	=	38.63 (2002)	31.25 (2003)	N	=	20.40 (2002)	26.21 (2003)
P	=	8.04 (2002)	6.32 (2003)	P	=	3.05 (2002)	2.83(2003)
K	=	27.10 (2002)	18.55 (2003)	K	=	14.29 (2002)	12.79 (2003)

respectively.

Thus fertilizer P was about 4 times as efficient in increasing P uptake by rice as FYM P and more than 10 times higher as compared to Bagasse P.

In terms of increase in K uptake by rice, kg ha^{-1} of fertilizer K applied, the average values for the year 2002 and 2003 (increase in K uptake/fertilizer K) were 1.49 and 1.83 kg, respectively. Corresponding values for each kg increase in K uptake (increase in K uptake/FYM K) (5 and 10 t FYM) for FYM K were 0.27 and 0.19 kg and (increase in K uptake/Bagasse K) for Bagasse K were 0.14 and 0.13 kg during 2002 and 2003, respectively. Thus the fertilizer K was about 6 times and 10 times more effective than FYM and Bagasse K, respectively in enhancing the K uptake by rice.

Apparent Recovery Efficiency of Nutrients

The apparent recovery percentage of applied nutrients from various organic and inorganic sources in rice crop were worked out from the uptake values of concerned nutrients and the doses applied from different sources (Table 4). It was observed that the applied nutrients in crop showed an average apparent recovery of 38.55 and 41.15 per cent for N, 35.50 and 47.94 per cent for P and 149.16 and 182.89 per cent for K during 2002 and 2003, respectively. Similarly, the corresponding average values of organic sources (average of 5 and 10 t ha^{-1}) like FYM N were 38.63 and 31.25 per cent, FYM P 8.04 and 6.32 per cent and FYM K 27.10 and 18.55 per cent of added nutrients during 2002 and 2003, respectively. Likewise, Bagasse gave the values of 20.40 and 26.21 per cent for N, and 3.05 and 2.83 per cent for P and 14.29 and 12.79 per cent for K during the experimentation in the years 2002 and 2003, respectively.

Increasing cost of fertilizers enhancing incidence of multiple nutrient deficiency and deterioration of physical properties of soil are known to be responsible for lower yields in the areas having fertility of soils. It has been found that application of most of the nutrients through green manure or with other organic manure like FYM, Compost, Blue green algae and Bagasse etc enhancing the soil fertility .The productivity of system could be sustain through the application of organic sources of nutrients. Hedge and Dwivedi [3] explored possibilities to substitute 50 per cent N need of rice through FYM without any significant reduction in the productivity of rice-wheat system at Palampur, R.S. Pura and Kalyani. FYM has been found better than Bagasse as it produced more NPK contents as compared to Bagasse. It is could be due to high C:N ratio of Bagasse and also reported elsewhere.[4,5,6] As evident from the present study that high quantities of organics are required to achieve the adequate levels of NPK, integration of organics with chemical fertilizers seems to be the right approach not only in maintaining high productivity but also in providing maximum stability in crop production.[2,7]

References

1. Nambiar KKM and Abrol IP. Long term fertilizer experiment in India – An over view. *Fertil. News,* 1989; 34(4): 11.
2. Nambiar KKM. Soil fertility and crop productivity under long term fertilizer use in India. New Delhi: Publication and Information Division, ICAR; 1994, 144.
3. Hedge DM and Dwivedi BS. Nutrient management in rice-wheat cropping system in India. *Fertil. News.* 1992; 37(2) : 27-41.
4. Srinivasan A. Influence of nitrogen top dressing on the performance of blue green algae. *IRRN.* 1981; 6(2): 19.
5. Pandey NT and Tripathi RS. Effect of agronomic management practices for maximizing rice production under vertisol. *Indian J Agron.* 1993; 38(3): 470-471.
6. Rathi AS. Studies on integrated nutrient management in transplanted rice. Ph.D. thesis, G.B. Pant University of Agriculture and Technology, Pantnagar. 2003.
7. Ghosh A and Sharma AR. Effect of combined use of organic manure and nitrogen fertilizer on the performance of rice under flood prone lowland conditions. *J Agric Sci.* 1999; 132: 461-465.