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Effect of integration of NPK levels and organic sources on growth, yield and economics of rice

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ABSTRACT : A study was undertaken to evaluate the effect of integration of nitrogen, phosphorus and potassium (NPK) levels with green manuring and farmyard manure (FYM) on the growth and productivity of rice (*Oryza sativa* L.). The treatments consisted of combination of three levels of NPK (50% RFD, 75% RFD and 100% RFD) and two levels of nitrogen (30 and 60 kg N/ha) through two organic sources (FYM and dhaincha). The results revealed that an application of 100 per cent recommended dose of fertilizer (120, 26.2, 49.8 kg NPK/ha) increased plant height by 10.3 per cent, and also enhanced dry matter accumulation (16.4%), chlorophyll SPAD value (23.9%), effective tillers/ m^2 (12.9%), filled grains/ panicle (11.8%), test weight (8.5%), grain yield (27.6%) and straw yield (28%) over the 50% RDF. As regards the two levels of N through organic sources, application of 60 kg N through FYM gave higher values of growth parameters, yield attributes and grain yield as compared to 30 kg N/ha either through FYM or dhaincha. The integration of moderate NPK level (75% RFD) with 60 kg N/ha through FYM was found to be most productive, remunerative and cost-effective dose for rice (cv. NDR-359).

Key Words : Rice, NPK levels, FYM, *Sesbania*, Yield attributes, NPK removal, Economics

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Rice (*Oryza sativa* L.) is the main source of food for more than half the world's population and its cultivation secures a livelihood for more than two billion people. Rice in India has attained great significance in terms of area, production and productivity so as to feed the large masses. In fact, rice cultivation is in crisis the world over and India is no exception, with a shrinking area, fluctuating annual production, stagnating yields and escalating input costs in general and fertilizer in particular. The continuous use of high levels of chemical fertilizers is adversely affects its sustainability (Singh *et al*., 1999) and causing environmental pollution. However, most of the Indian farmers are unable to afford the heavy expenditure on fertilizers. With one tonne harvest of rice grain, about 10-31 kg N, 1-5 kg P and 8-35 kg K and 1-3 kg S/ha are removed from the soil (Dobermann *et al*., 1998). Unbalanced fertilizer use has resulted in micronutrient deficiencies. Therefore, there is an urgent need to exploit other options of plant nutrient supply besides the exclusive use of chemical fertilizer, it is high time to develop a sustainable production system with maximum productivity and minimum environmental pollution and health hazards.

Farmyard manure (FYM) and green manure are important sources of organic matter. Integrated nutrient management constituting both organic sources of nutrients and inorganic fertilizers may help the plant to maintain sufficient biomass production (Ghosh and Sharma, 1999). In this context, integrated use of chemical fertilizers and organics like FYM and dhaincha [*Sesbania aculeate* (Willd) Pers.] as green manure assumes greater significance. Keeping this is view, an experiment was conducted to evaluate the productivity and economics of rice and fertility and pore space of soil under integrated nutrient supply system.

RESEARCH PROCEDURE

The field experiment was conducted during rainy season of 2008 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India (25^0 18' N

latitude and 83^0 03' E longitudes at 113 m above mean sea level) under typical sub-tropical climate. The soil was low in available nitrogen and medium in available phosphorus and potassium. Some characteristics of surface (0–15 cm) soil samples at the experimental plot are described in Table A. The experiment was laid out in Randomized Block Design assigning three NPK levels [50%, 75% and 100% recommended fertilizer dose (RFD)] and two levels of organic sources [30 kg nitrogen (N) through farmyard manure (FYM), 30 kg N through dhaincha [*Sesbania aculeate* (Willd) Pers.], 60 kg N through FYM, 30 kg N/ha through dhaincha] make 12 treatment combinations. The 100 per cent RFD was 120 kg N, 26.2 kg P and 49.8 kg K/ ha. The whole field was divided into three blocks each representing a replication and combinations of treatment were randomly allocated within each replication. The C, N, P, K, moisture contents and C: N ratio of FYM and 50-day old dhaincha used were 17.7, 0.52, 0.20, 0.48, 34.0 per cent and 24 and 39.6, 2.0, 0.56, 0.78, 72per cent and 19.8, respectively. FYM and dhaincha were applied three days before transplanting of rice and incorporated into soil as per treatment. Four-week-old seedlings of rice 'NDR – 359' were transplanted on July 20th at 20 cm x 10 cm spacing. Available N, P and K content in soil at 0-30 cm depth from each plot after harvest of the crop were estimated. The plant samples were collected at harvest and analysed for N, P and K content in grain and straw. The total nutrient removal by crop was worked out by multiplying nutrient content in grain and straw with their respective biomass and summing removal values of grain and straw. The net return from individual crop was calculated by deducting the cost of cultivation from gross return and expressed as US dollar ($)/ ha on the basis of inputs and prices of outputs in experimentation years.

Table A : Some characteristics of the surface soil (0–15 cm) of the experimental plot

Parameters	Soil particular value
Physical properties	
Course sand (%)	8.13
Sand (%)	53.64
Silt (%)	19.38
Clay (%)	18.85
Texture	Sandy clay loam
	Typic Ustochrepts
Bulk density (kg/ m^3)	1460
Particle density (kg/ m^3)	2633
Pore space (%)	44.5
Chemical properties	
pH (1:2.5 soil to solution)	7.51
EC (dS/ m) (1:2.5 soil to solution)	0.14
CEC [C mol (p+)/ kg soil]	57
Organic C (%)	0.34
Available N (kg/ ha) (Alakaline permanganate)	219
Available P (kg/ ha) (0.5 M $NaHCO_3$)	14.1
Available K (kg/ ha) (in NH_4OAc extractable)	149.2

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under following heads :

Fertility levels :

Crop exhibited differential responses to various levels of NPK and organic sources (Table 1). The levels of NPK

Table 1: Effect of NPK levels and organic sources of N on growth, yield attributes, nutrient removal and economics of rice

Treatments	Plant height (cm)	Chlorophyll (SPAD values) at 60 DAT	Effective tillers/ m^2	Filled grains/ panicle	Test weight (g)	Grain yield (tonnes/ ha)	Straw yield (tonnes/ ha)	Harvest index (%)	Net return ($/ ha)	Benefit: Cost ratio
NPK levels										
50% RFD	91.4 b	29.42 b	207.3 c	99.5 b	27.55 c	4.41 c	5.09 b	46.58 a	454.08 b	1.09 b
75% RFD	96.4 ab	33.24 a	225.2 b	107.9 a	28.60 b	5.33 b	6.14 a	46.60 a	622.46 a	1.44 a
100% RFD*	100.8 a	34.81 a	234.0 a	111.2 a	29.89 a	5.73 a	6.51 a	46.20 a	658.13 a	1.46 a
SEm±	1.59	0.61	2.25	2.06	0.29	0.09	0.13	0.43	21.56	0.04
C.D. (P=0.05)	5.08	1.93	7.1	6.53	0.94	0.37	0.42	NS	67.72	0.13
Organic sources										
30 kg N/ ha through FYM	92.8 b	31.17 b	211.4 b	102.2 a	27.66 b	4.64 b	5.37 b	46.15 a	479.80 c	1.12 c
30 kg N/ ha through dhaincha**	93.7 b	31.51 b	216.0 b	104.3 a	28.20 b	4.86 b	5.44 b	47.39 a	544.29 b	1.32 b
60 kg N/ ha through FYM	99.8 a	33.76 a	232.4 a	110.4 a	29.71 a	5.66 a	6.53 a	46.63 a	657.71 a	1.22 c
60 kg N/ ha through dhaincha	98.6 ab	33.26 a	228.7 a	107.8 a	29.16 a	5.39 a	6.32 a	45.95 a	631.04 a	1.47 a
SEm±	1.61	0.57	2.2	2.18	0.29	0.11	0.15	0.40	20.55	0.03
C.D.(P=0.05)	4.72	1.68	6.3	NS	0.86	0.31	0.40	NS	60.24	0.10

*RFD : Recomended Fertilizer Dose of 120-26.2-49.8 kg N-P-K/ ha; ***Sesbania aculeate* (Willd) Pers.
Same letter(s) in a column did not differ significantly; NS = Not significant

significantly affected plant height, dry matter accumulation and chlorophyll (SPAD value). Application of 100 per cent RFD significantly increased plant height, dry matter accumulation and SPAD value over 50 per cent RFD, but was at par with 75 per cent RFD. Yield attributes of rice were significantly influenced by different levels of NPK. Among the levels of NPK, 100 per cent RFD recorded the highest effective tillers / m^2, filled grains/panicle and test weight but being at par with 75 per cent RFD in respect of filled grains /panicle, the magnitude of increase over 50 per cent RFD was 12.9, 11.8 and 8.5 per cent, respectively. Fertility level significantly affected grain and straw yields. The highest grain and straw was obtained with the application of 100 per cent RFD (5.73 and 6.51 t/ha), followed by 75 per cent RFD (5.33 and 6.14 t/ha) which was 27.7 and 27.9 per cent higher over the 50 per cent RFD, respectively. The increase in grain and straw yields of rice on application of nitrogen, phosphorus and potassium was largely a function of improved growth, translocation of more photosynthates towards sink and consequent development of yield attributes. These results are in conformity with those of Sudhakar *et al*. (2006). However, the harvest index remained unaffected by the fertility levels. This shows that translocation of photosynthates to the sink did not differ markedly.

Fertility levels markedly affected the removal of N, P and K by rice. Increasing fertility levels from 50 to 100 per cent RFD significantly enhanced the removal of N, P and K. This could be attributed to the fact that added nitrogen, phosphorus and potassium increased the N, P and K content in the grain and straw by providing balanced nutritional environment inside the plant and higher photosynthetic activity, which in turn resulted in profuse shoot and root growth, finally leading to improved grain and straw yields. Since the removal of nutrient is a function of dry matter and nutrient concentration, the increased grain and straw yields together with higher N, P and K content resulted in greater removal of these elements. The increased nutrient removals with application of graded fertility levels support the findings of Mankotia (2007). The application of 100 per cent RFD though remained at par with 75 per cent RFD both recorded significantly higher net return and benefit: cost ratio. Nevertheless, 100 per cent RFD proved most remunerative.

Organic sources of nitrogen :

The plant height, dry matter accumulation and SPAD value markedly influenced by organic sources at two levels and were maximum with 60 kg N applied through FYM though which remained at par with 60 kg N/ha through dhaincha but proved significantly higher than other combinations. The application of 60 kg N through FYM being comparable to 60 kg N through dhaincha produced significantly higher effective tillers/m^2 and test weight than 30 kg N/ha applied either through FYM or dhaincha. The increase over 30 kg N either through FYM or dhaincha were 9.9, 7.6 and 7.4, 5.4 per cent, respectively. This could be due to sufficient amount of N supplied through FYM having narrow C: N ratio that might have helped in mineralization and release of nutrients in adequate amount and the reduction of N loss by the formation of organic complexes as compared to dhaincha. However, the organic sources could not show any significant effect on filled grains/ panicle. Application of 60 kg N through FYM recorded the maximum grain and straw yields (5.66 and 6.53 t/ ha) but remained statistically at par with 60 kg N/ ha through dhaincha, registering an increase of 22.0 and 21.6 per cent compared with those of 30 kg N/ ha through FYM, respectively. Higher grain yield at 60 kg N through organic

Table 2: Effect of NPK levels and organic sources of N on total removal of NPK, organic carbon, available NPK of soil at harvest of crop

Treatments	Total removal (kg/ ha)			Organic carbon (%)	Available nitrogen (kg/ ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
	N	P	K				
NPK levels							
50% RFD	70.81c	9.40 c	72.00 c	0.327 a	214.3 a	13.9 a	140.5 a
75% RFD	88.32 b	11.72 b	94.99 b	0.351 a	218.6 a	14.4 a	143.9 a
100% RFD*	94.45 a	12.52 a	105.5 a	0.388 a	225.0 a	15.0 a	176.9 a
SEm±	1.82	0.27	2.49	0.019	3.42	0.29	1.74
C.D. (P=0.05)	5.35	0.79	7.30	NS	NS	NS	NS
Organic sources							
30 kg N/ ha through FYM	74.45 b	9.90 b	79.11 b	0.340 b	212.0 c	14.1 b	141.9 a
30 kg N/ ha through dhaincha**	78.99 b	10.46 b	82.79 b	0.341 b	214.3 bc	14.3 b	142.8 a
60 kg N/ ha through FYM	95.30 a	12.62 a	103.25 a	0.420 a	228.7 a	15.6 a	145.0 a
60 kg N/ ha through dhaincha	89.35 a	11.88 a	98.18 a	0.405 a	225.2 ab	15.4 a	144.4 a
SEm±	2.11	0.31	2.87	0.025	3.95	0.34	2.01
C.D. (P=0.05)	6.18	0.91	8.43	0.06	11.59	1.03	NS

*RFD : Recomended Fertilizer Dose of 120-26.2-49.8 kg N-P-K/ ha; ***Sesbania aculeate* (Willd) Pers.
Same letter(s) in a column did not differ significantly; NS = Not significant

Table 3 : Effect of different levels of NPK and organic sources on yields and relative economics

Treatments	Grain yield (tones/ ha)	Net return ($/ ha)	Benefit : Cost ratio
50% RFD + 30 kg N/ ha through FYM	3.79 c	338.64	0.83
50% RFD + 30 kg N/ ha through dhaincha*	3.74 c	337.60	0.86
50% RFD + 60 kg N/ ha through FYM	5.15 b	573.46	1.31
50% RFD + 60 kg N/ ha through dhaincha	5.00 b	566.49	1.37
75% RFD + 30 kg N/ ha through FYM	4.80 b	516.23	1.21
75% RFD + 30 kg N/ ha through dhaincha	5.23 b	613.13	1.48
75% RFD + 60 kg N/ ha through FYM	5.90 a	702.69	1.54
75% RFD + 60 kg N/ ha through dhaincha	5.54 ab	657.00	1.52
100% RFD** + 30 kg N/ ha through FYM	5.24 b	584.03	1.31
100% RFD + 30 kg N/ ha through dhaincha	5.67 ab	682.02	1.58
100% RFD + 60 kg N/ ha through FYM	5.95 a	696.64	1.47
100% RFD + 60 kg N/ ha through dhaincha	5.69 ab	669.79	1.49
SEm±	0.18	–	–
C.D. (P=0.05)	0.54	–	–

*_Sesbania aculeate_ (Willd) Pers.; **RFD : Recomended Fertilizer Dose of 120-26.2-49.8 kg N-P-K /ha
Same letter(s) in a column did not differ significantly

Production Cost ($/ tone)		Nutrient cost ($/ kg)	Seed cost ($/ kg)
Grain	185.25	Urea @ 0.1284	Dhaincha @ 0.5582 N through dhaincha
Straw	9.88	DAP @ 0.2346	
		MOP @ 0.1225	
		FYM @ 0.90/ kg N through FYM	

sources was supported by significantly higher values of yield attributes *viz*. effective tillers/ m^2 and test weight. An increase in rice yield with green manuring and FYM application has also been reported by Yaduvanshi (2003). The maximum net return ($ 657.71/ ha) was obtained at 60 kg N/ ha applied through FYM closely followed by 60 kg N through dhaincha and both proved remunerative over 30 kg N either through FYM of dhaincha. However, due to its per unit, lower cost dhaincha recorded significantly higher B: C ratio than FYM at both the levels of N application.

Removal of nitrogen, phosphorus and potassium by rice was positively influenced by N levels applied through organic sources (Table 2). Application of 60 kg N through FYM recorded the maximum removal of NPK by grain and straw and being at par with 60 kg N/ha through dhaincha both removed significantly higher N, P and K than 30 kg N/ha applied either through FYM or dhaincha. This could be ascribed to the higher grain and straw yield at 60 kg N/ ha applied through organic sources. Application of 60 kg N either through FYM of dhaincha observed higher content of organic carbon, available nitrogen and phosphorus in the soil at harvest as compare to 30 kg N/ ha applied either through FYM or dhaincha.

Interaction effect :

NPK levels and organic sources of N in respect of interaction effect on grain yield were found significant (Table 3). Application of 100 per cent RFD accompanied with 60 kg N/ ha through FYM recorded maximum grain yield of rice. However, this remained on par with 100 per cent RFD and 30 or 60 kg N application through dhaincha as well as 75 per cent RFD and 60 kg N/ ha application through FYM or dhaincha. However, the lowest grain yield was obtained with the application of 50 per cent RFD and 30 kg N/ ha through dhaincha. Therefore, it appears that addition of 60 kg N/ha either though FYM or dhaincha could substitute 25 per cent of the RFD which might be due to greater amounts of N and P supply to the soil. Subbaiah *et al*. (2006) also reported the responses of rice in terms of improved yield and nutrient uptake due to addition of green manure or FYM along with NPK levels. The highest net return was observed under integration of moderate NPK levels of 75 per cent RFD with 60 kg N through FYM ($ 702.69/ ha) followed by highest NPK level of 100 per cent RFD accompanied with 60 kg N/ha through FYM ($ 696.64/ ha) (Table 3). Nevertheless, with respect to benefit: cost ratio 100 per cent RFD with 30 kg N/ ha through dhaincha was most remunerative (1.58) than rest of the treatment combination.

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