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RESEARCH PAPER

Long term effect of NPK in rice-wheat cropping system under irrigated conditions of Madhya Pradesh

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Abstract : A long term experiment was conducted on effect NPK in rice-wheat system under all India co-ordinated research project on integrated farming system at college of Agriculture research farm, Kuthulia Rewa during 1977-78 to 2011-12, The study reveals that application of 120kg N/ha, 80kg P_2O_5-/ha and 40kg K_2O/ha gave maximum grain yield, net profit and benefit cost ratio. The wheat equivalent yield was also maximum. The response of nitrogen and phosphorus in rice crop was quadratic while in wheat crop it was linear. The yield of rice crop showed stagnation while wheat crop starts decline. The soil properties after completion of 35-years of rice –wheat crop cycle showed increase in organic carbon, available N and phosphorus while potash status in soil showed reduction in available potash as compared to initial soil status.

Key Words : Long-term effect, Rice-wheat cropping system, Soil health, Soil sickness, Quadratic and linear response

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INTRODUCTION

Rice (*Oryza sativa* L.) wheat (*Tritium aestivum* L.) rotation is the dominant cropping system in India. Approximately, 10.5 million hectare areas comes under this cropping system which countributes 25per cent of total food grain in India. About 33per cent of India's rice and 42per cent of wheat is grown in this rotation. Nearly 65per cent of total fertilizer used in the country is applied to rice and wheat crops alone (Yadav and Kumar, 2009). Rice and wheat are the important crops of Madhya Pradesh.

Both rice and wheat crops grown in a sequence require high quantity of nutrients to obtain real potential yield (Hegde and Pandey, 1989). Application of inadequate and unbalanced quantity of fertilizer to these crops not only results low crop yield but also deteriorates the soil properties (Sharma *et al.*, 2003). Degreadation in soil health has emerged as a major factor responsible for stagnation in agriculture production. The maintenance of good soil health needs balance fertilization which includes the application of NPK in proper amount and form. Shukla *et al.* (2005) discuss the status of plant nutrient use, nutrient removal, and nutrient balances for this system with the aim to enhance productivity and develop balanced and efficient fertilizer management strategies for the region.

Long–term studies reveals that crop productivity is declining even after applying recommended dose of N.P.K. fertilizers (Yadav and Kumar, 2009). Therefore, a long-term experiment on effect of N.P.K. in rice-wheat system is in progress since 1977-78 under all India co-ordinated Research project-on integrated farming system. Ahmad *et al.* (2001) reported that application of organic manures plus fertilizers increased growth parameters of rice crop.

MATERIAL AND METHODS

The present field experiment was taken under all India co-ordinated research project on farming system at Kuthalia farm of J.N.K.V.V., College of agriculture Rewa Madhya Predesh. The present experiment was started in the year 1977-

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78 and still continue. Treatment consisted of three levels of nitrogen *i.e.* 40, 80 and 120 kg N/ha, three levels of phosphorus *i.e.* 0, 40 and 80 kg P_2O_5/ha and two levels of potash *i.e.* 0 and 80 kg K_2O/ha in rice and wheat crop. Total 18 treatment combinations were arranged in Randomized Block Design with four replications. The cropping system was rice followed wheat. The same layout plan was used every year in the same field. The test variety was IR-36 in rice and WH-147 in wheat. The rice crop was transplanted in second to third weeks of July while wheat crop was sown in lines in second to third weeks of November during different year (1977 to 2012).

The soil of the experimental field was silty clay loam in texture, neutral in reaction (pH 7.25), medium in organic carbon (0.54%), low in available nitrogen 280 kg/ha, medium in available phosphorus (15 kg/ha) and high in available potash (500 kg K_2O/ha).

The normal rainfall of the tract is 1140mm. All the recommended package of practices were adopted in rice and wheat as recommended for irrigated condition. The nitrogen dose was given through urea, phosphorus through single super phosphate and potash through mutriate of potash.

Calculation of fertilizer response:

For calculating the nitrogen and phosphorus response the following regression equation were developed for rice and wheat crops on the basis of 35 years of pooled data.

$Y = a + bx + cx^2$ (quadratic in rice)

$Y = a + bx$ (linear in wheat)

where,

Y= yield, a, b, and c are constant to be calculated

X = Interval of fertilizer dose *i.e.*40 kg = 1.

X-Maxima :

The maximum level of nitrogen and phosphorus dose in rice were calculated by following :

$$X - maxima = \frac{-b}{2c} \times x$$

where,

x = It is the interval one unit is equal to 40kg.

Response of N and P :

The responce of nitrogen and phosphorus in rice crop calculated by following :

$$Response\ kg\ grain/kg\ of\ nutrient = \frac{bx - cx^2}{x}$$

(in quadratic equation)

where, x is the interval between two doses, b and c are the constant.

RESULTS AND DISCUSSION

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

Effect on rice :

The grain yield of rice in response to continuous application of N.P.K. in rice- wheat system has been given in Table 1. After perusal of results it is clear that grain yield of rice was affected significantly under the response of NPK. The grain yield rice was maximum 50.61q/ha at 120 kg N/ha

Table 1 : Average grain yield (q/ha) of rice under the effect of continuous application NPK in rice-wheat cropping system

Treatments	Average of 30 years	Grain yield (q/ha)				
		2008-09	2009-10	2010-11	2011-12	Mean
Nitrogen levels N (kg/ha)						
N-40	28.64	38.96	41.91	47.00	34.66	38.20(0.00)
N-80	34.32	43.91	49.61	56.00	37.04	44.17(115.70%)
N-120	40.55	51.09	56.75	63.56	41.14	50.61(132.46%)
SEM±	--	0.60	0.73	0.71	0.91	--
C.D. (P=0.05)	--	1.69	2.06	2.00	2.57	--
Phosphorus levels P_2O_5 (kg/ha)						
P-0	29.18	39.08	45.28	50.80	33.99	39.66(0.00%)
P-40	34.74	45.55	49.97	55.56	39.06	44.97(113.35%)
P-80	39.59	49.17	53.00	60.22	39.73	48.34(121.6%)
SEM±	--	0.60	0.73	0.71	0.91	--
C.D. (P=0.05)	--	1.69	2.06	2.00	2.57	--
Potas levels K_2O (kg/ha)						
K-0	33.31	43.41	47.64	54.10	36.52	42.99
K-40	35.69	45.77	51.19	56.95	38.67	45.66(106.27%)
SEM±	--	0.51	0.62	0.50	0.71	--
C.D. (P=0.05)	--	1.44	1.75	1.41	2.02	--

Figures in parentheses are per cent increase over lower dose

which was 32.46per cent yield higher than lower doses of nitrogen. The grain yield of rice was maximum 48.34 q/ha at 80 kg P_2O_5 which was 21.6 per cent higher than no phosphorus application. The response of potash was maximum at 40 kg K_2O/ha which was 6.27 per cent higher than no potash application (Anonymous, 2012). The yield of rice was stagnated after completion of 35 years of continuous cropping. The similar findings were also reported by Yadav and Kumar (2009).

Effect on wheat :

The grain yield data of wheat WH-147 is given in Table 2 which reveal that grain yield of wheat crop was affected significantly under the effect of NPK. On the basis of 34 years of pooled data given in Table 2, it is clear that grain yield was maximum. 35.27 q/ha at 120 kgN/ha which was 59.4 per cent higher than lower dose of N. The maximum grain yield of wheat was obtained at highest tested dose of phosphorus *i.e.* 80 kg P_2O_5/ha which gave 36.4 per cent higher grain yield over no phosphorus application. Similarly response of potash was also maximum at 40 kg K_2O/ha which gave 10.2 per cent higher grain yield over no potash application (Gupta *et al.*, 2006). The yield of wheat crop showed decline trends due to development of soil sickness (Yadav and Kumar, 2009 and Gupta *et al.*, 2006).

Nitrogen and phosphorus requirement of rice and wheat :

In view of the hand of response of nitrogen and phosphorus single degree freedom analysis was done which was found quadratic for rice and linear for wheat which are given in Table 3. It is clear on the basis of equation that N-maxima for rice was 114.5kg/ha which gave the response @ 44.09 kg grain/kg of nitrogen. The P-maxima was 67.9 kg/ha for rice which gave the response @ 71.5 kg grain/kg of P_2O_5. The nitrogen and phosporus response in wheat crop was linear which gave the response @ 16.1 kg grain/kg of nitrogen and 10.1 kg grain/kg of P_2O_5. Tiwari *et al.* (1992) reported that response to potassium application in rice increased with increasing rate of nitrogen application.

Table 2 : Average grain yield of wheat WH-147 (q/ha) under the influence of long-term application NPK in rice-wheat system

Treatments	Average of 30 years	Grain yield (q/ha)				
		2008-09	2009-10	2010-11	2011-12	Mean
Nitrogen levels N (kg/ha)						
N-40	14.94	16.46	22.03	28.07	29.12	22.12
N-80	21.84	22.72	28.63	32.63	33.26	27.81(125.72%)
N-120	30.39	34.61	35.77	40.27	35.32	35.27(159.4%)
SEM±	--	0.50	0.78	0.67	0.68	–
C.D. (P=0.05)	--	1.42	2.21	1.91	1.92	–
Phosphorus levels P_2O_5 (kg/ha)						
P-0	16.16	19.02	26.20	30.02	29.10	24.1
P-40	21.12	25.02	28.12	34.10	32.50	28.17(116.8%)
P-80	29.81	29.74	32.11	36.85	35.93	32.88(136.4%)
SEM±	--	0.50	0.78	0.67	0.68	–
C.D. (P=0.05)	--	1.42	2.21	1.91	1.92	–
Potash levels K_2O (kg/ha)						
K-0	20.83	23.02	27.62	32.09	31.52	27.01
K-40	23.96	26.17	30.00	35.22	33.50	29.77(110.2%)
SEM±	--	0.42	0.49	0.53	0.57	–
C.D. (P=0.05)	--	1.21	1.40	1.50	1.61	–

Figures in parentheses are per cent increase over lower dose

Table 3 : Regression equation and response of nitrogen and phosphorus in rice and wheat crops

Crop	Types of regression	Regression equation	X-maxima (kg/ha)	Response kg grain/kg of nutrient
Rice				
Nitrogen response	Quadratic	$Y=20.66+20.61x-3.5x^2$	114.5	44.09
Phosphorus response	Quadratic	$Y=39.63+10.52x-3.1x^2$	67.90	71.50
Wheat				
Nitrogen response	Linear	$Y=16.24+0.16x$	-–	16.10
Phosphorus response	Linear	$Y=25.05+0.10x$	-–	10.10

Wheat equivalent yield and economics :

The wheat equivalent yield was maximum 80.77 q/ha at 120 kg N/ha which gave maximum net profit Rs. 66014/ha with benifit cost ratio 2.7. The equivalent wheat yield was 42.9per cent higher than 40 kg N/ha while net profit was 76.5per cent higher at 120 kg N/ha (Table 4).

The response of phosphorus in terms of wheat equivalent yield was maximum 76.4 q/ha at 80 kg P_2O_5 /ha which was 27.7per cent higher than no phosphorus application. The net profit of Rs. 60730/ha with B:C ratio 2.6 were maximum at 80 kg P_2O_5/ha which was 43.6per cent higher than no phosphorus application. The wheat equivalent yield at 40 kg K_2O/ha was 70.9 q/ha which was 7.9per cent higher than no K_2O application while the net profit was 11.3per cent higher than control (Table 4). The chemical fertilizer sustained the yield through increased nutrients availability and nutrient use efficiency in rice-wheat system if applied in balance form was also reported by Yadav and Kumar (2009).

Effect on chemical properties of soil :

Data pertaining to chemical properties of soil after completion of 35 rice -wheat crop cycle have been given in Table 5. It is clear from the data that soil pH and electrictical conductivity of soil was unaffected as compared to initial status in response to NPK. The organic carbon status was increased by 7.9 per cent to 15.9 per cent under the response of nitrogen, 3.2 per cent to 17.5 per cent under the response of phosphorus and 14.3 per cent in response to potash. The available nitrogen status increased by 8.1 per cent at 120kg N/ ha, 8.5per cent at 80 kg P_2O_5/ha and 6.6 per cent at 40 kg K_2O/ ha. Similarly phosphorus status was also found to increase by 5-14.4 per cent at 120kg N/ha, 19.2 per cent at application of 80 kg P_2O_5/ha and 11.2 per cent at 40kg K_2O/ha. The available potassium status was decreased by 10.6 to 13.4 per

Table 4 : Long term effect of NPK on wheat equivalent yield (q/ha), GMR, NMR and benefit cost ratio in continuous cropping of rice-wheat

Treatments	Wheat equivalent yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
Nitrogen levels (kg/ha)					
N-40	56.52	36510	73904	37394	2.02
N-80	67.61(119.6%)	37630	88952	51322(137.2%)	2.36
N-120	80.77(142.9%)	38750	104764	66014(176.5%)	2.7
Phosphorus levels P_2O_5 (kg/ha)					
P-0	59.8	35870	78140	42270	2.2
P-40	68.7(114.8%)	37470	89750	52280(123.6%)	2.4
P-80	76.4(127.7%)	39070	99800	60730(143.6%)	2.6
Potash levels K_2O (kg/ha)					
K-0	65.7	36470	85840	49370	2.4
K-40	70.9(107.9%)	37670	92630	54960(111.3%)	2.5

Figures in parentheses are per cent increase over control.
Rice Rs. 1080/q Wheat Rs. 1200/q Wheat and paddy straw Rs. 100/q

Table 5 : Change in soil properties over initial status (1977-78) under the influence of continuous application of NPK in rice-wheat cropping system (after 35 years)

Treatments	Soil pH	E.C. (ds/m)	O.C. (g/kg)	Available nutrients (kg/ha) N	P	K
Nitrogen levels (kg/ha)						
N-40	7.51	0.51	6.8(107.9)	271(105.0)	11.9(95.2)	436(87.2)
N-80	7.58	0.49	7.0(111.1)	273(105.8)	13.2(105.6)	447(89.4)
N-120	7.49	0.50	7.3(115.9)	279(108.1)	14.3(114.4)	433(86.6)
Phosphorus levels P_2O_5 (kg/ha)						
P-0	7.61	0.49	6.5(103.2)	268(103.9)	11.2(89.6)	405
P-40	7.54	0.50	7.1(112.7)	278(107.8)	13.6(108.8)	451(90.2)
P-80	7.55	0.52	7.4(117.5)	280(108.5)	14.9(119.2)	466(93.2)
Potash levels K_2O (kg/ha)						
K-0	7.45	0.53	6.6(104.8)	272(105.4)	12.8(102.4)	412(82.8)
K-40	7.50	0.50	7.2(114.3)	275(106.6)	13.9(111.2)	472(94.4)
Initial (1977-78)	7.52	0.54	6.3	258	12.50	500.00

Figures in parentheses are per cent over initial status

cent under the response of nitrogen , 6.8 to 9.8 per cent under the response of phosphorus and 5.59 per cent to 12.2 per cent under the response of potash application as compared to initial status (1977-78). The increase in organic carbon, nitrogen and phosphorus status in the soil in fertilized plots is probably due to improved root growth, leading to accumulation of more organic residues in rice-wheat cropping system (Yadav and Kumar, 2009). The available potassium status after 35 years of field experiment was found to decreased under the effect and NPK. It may be due to more depletion of potash by rice and wheat crop. Yadav and Kumar (2009) also reported the similar findings from Faizabad in rice-wheat cropping system.

However, a stagnating or declining trend in productivity and profitability of rice-wheat system has been reported in the region due to several soil and water related constraints (Bhandari *et al.*, 2002; Hobbs and Morris, 1996; Yadav, 1998 and Yadav *et al.*, 1998).

Similarly results were obtained by Yadav *et al.* (2013).

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