

Balanced use of major nutrients for sustaining higher productivity of maize (*Zea mays*)–wheat cropping system in acidic soils of Jharkhand

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ABSTRACT

A field experiment was conducted with maize (*Zea mays* L.)–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system in acidic soils (Alfisol) of Ranchi, during the rainy and winter seasons from 1997 to 1999, to study the varying higher levels of N (180 to 240 kg/ha), P₂O₅ (60 to 120 kg/ha) and K₂O (100 to 200 kg/ha) on yields and NPK uptake by crops. An increase in grain yields to up to 33 and 30.0% of maize and wheat respectively was noticed, with the higher rates of NPK application (210:90:150 kg/ha) over the state recommended levels (100:60:40 kg/ha) respectively. Total NPK uptake by both the crops was significantly higher under the modified rates of NPK compared with the state fertilizers recommendations. In general, value : cost ratio with varying levels of NPK was higher in wheat than in maize over the state fertilizer recommendations.

Key words : Higher rates of NPK, Yields of maize and wheat, Acid soil

Soils of Jharkhand are acidic in reaction, low in availability of nitrogen and phosphorus, medium to high in potassium and poor in water and nutrient retention capacities. The average yield of cereals particularly maize and wheat in these acidic soils reveal low productivity (<20 q/ha).

The present investigation was carried out to study the response of maize and wheat with varying levels of NPK rates over the state recommended levels of NPK fertilizers to sustain the higher productivity

in acidic soils of Jharkhand state.

MATERIALS AND METHODS

A field experiment was conducted with maize (var. 'Swan') and wheat (var. 'HD 2402') at University Research Farm during 1997–99 in rainy and winter seasons. A set of 10 treatments in combination with 4 levels of nitrogen (0, 180, 210 and 240 kg/ha), 4 levels of phosphorus (0, 60, 90 and 120 kg/ha) and 4 levels of potassium (0, 100, 150 and 200 kg/ha) including a state

recommended levels of NPK (100:60:40 kg/ha) for both crops was made and the experiment was conducted in randomized block design with 3 replicates. Fertilizers sources for NPK were urea, single super-phosphate and muriate of potash respectively. In maize, one-third nitrogen and total quantity of phosphorus and potash were applied before sowing, while remaining nitrogen was applied at the knee-high stage and at tasselling in 2 equal doses. In wheat, total quantity of phosphorus and potash and half of nitrogen were applied at the time of sowing. The remaining quantity of nitrogen was applied at the time of first irrigation at the crown-root initiation. Levels of nitrogen to maize and wheat were determined taking into consideration of a reasonable yield target. Based on the sorption behaviour and critical limit of P and K in soils, the doses for P and K were worked out. Initial soil samples were collected from surface soils (0–0.15 m) before initiating the experiment. Characteristics of the experimental soils were coarse texture (sand 56 to 58%, silt 31 to 33% and clay 9 to 13%), acidic in reaction (5.5 to 5.7), low in organic carbon (0.29 to 0.36%), available N (187.4 to 205.5 kg/ha), available phosphorus (15.5 to 16.2 P₂O₅ kg/ha) and available potassium (107 to 118.0 K₂O kg/ha).

Maize crop was grown in July in 1998 and 1999 and harvested in October in the same year, while wheat crop was grown in December 1997 and 1998 and harvested in April 1998 and 1999 respectively. Plant samples, viz. grain and straw, of both crops collected at harvest were analysed for NPK and the plant uptake of nutrients was calibrated by using grain and straw yield data.

Economics of maize and wheat with varying higher levels of NPK were worked out over the state recommended level of NPK (100 : 60 : 40).

RESULTS AND DISCUSSION

Crop yield

Treatment combinations of N : P : K (210 : 90 : 150 kg/ha) resulted in higher maize grain yield with an additional increase of 33.0% over the state recommended level of NPK fertilization (100:60:40 kg/ha). However, decreasing trend in crop yield (straw and grain) was noticed with higher levels of NPK application (240 : 120 : 200 kg/ha). Differences in crop yields were lower with application of phosphorus and potassium levels than nitrogen levels. In case of wheat, increasing rates of N, P and K application from 180 to 210 kg/ha, 0 to 120 kg/ha and 0 to 100 kg/ha, respectively, significantly increased the grain and straw yields over the state recommended level. Further increase in the level of N (180 to 240 kg/ha) and potassium (150 to 200 kg/ha) decreased the grain yield by 5.0 and 2.0 q/ha respectively. Application of 210 kg N, 90 kg P₂O₅ and 150 kg K₂O/ha yielded higher wheat grain yield (44 q/ha) with 30% increase over the state recommended level of NPK (33 q/ha). Similar results were also reported by Suri and Verma (1999) and Reddy and Ahmad (2000) on the increase of yields of maize and wheat with higher varying rates of NPK application over the state recommended level of NPK in acidic soils.

NPK uptake by crops

The total N and K uptake by maize crop

Table 1. Effect of graded levels of nitrogen, phosphorus and potassium on maize and wheat yield

Fertility (NPK kg/ha)	Maize yield (q/ha)						Wheat yield (q/ha)					
	Grain			Straw			Grain			Straw		
	1998	1999	Mean	1998	1999	Mean	1997-98	1998-99	Mean	1997-98	1998-99	Mean
180:90:150	37.0	31.0	34.0	65.0	68.0	67.0	46.0	34.0	40.0	74.0	59.0	66.0
210:90:150	45.0	35.0	40.0	83.0	67.0	76.0	48.0	39.0	44.0	81.0	63.0	72.0
240:90:150	39.0	30.0	35.0	75.0	65.0	70.0	45.0	34.0	39.0	73.0	55.0	64.0
210:00:150	29.0	24.0	27.0	56.0	42.0	49.0	32.0	21.0	26.0	45.0	29.0	37.0
210:60:150	44.0	35.0	39.0	72.0	64.0	68.0	47.0	32.0	34.0	77.0	51.0	64.0
210:120:150	42.0	32.0	37.0	58.0	62.0	60.0	45.0	38.0	42.0	75.0	65.0	70.0
210:90:00	26.0	19.0	23.0	35.0	37.0	36.0	35.0	24.0	30.0	65.0	47.0	56.0
210:90:100	43.0	34.0	39.0	64.0	64.0	64.0	47.0	38.0	42.0	73.0	64.0	69.0
210:90:200	43.0	32.0	37.0	80.0	60.0	70.0	42.0	36.0	39.0	70.0	62.0	66.0
100:60:40*	31.0	29.0	30.0	56.0	54.0	55.0	38.0	27.0	33.0	68.0	44.0	56.0
CD (P=0.05)	11.0	6.0		10.5	8.0		5.0	9.0		10.0	8.0	

*State recommended level

Table 2. Effect of nitrogen, phosphorus and potassium on total uptake of NPK by maize and wheat (average data of 2 years)

Fertility (NPK kg/ha)	Uptake by maize (kg/ha)			Uptake by wheat (kg/ha)		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
180:90:150	121.3	11.9	139.8	71.0	11.4	71.4
210:90:150	158.0	13.7	160.7	84.9	18.4	70.3
240:90:150	149.5	12.5	146.2	85.1	19.1	65.8
210:00:150	101.9	6.5	103.8	42.6	8.1	39.7
210:60:150	148.5	10.6	145.4	73.2	16.8	68.6
210:120:150	133.9	14.5	129.2	82.9	24.3	70.0
210:90:00	80.8	7.0	53.4	56.0	16.8	44.8
210:90:100	142.5	12.0	133.1	80.7	19.1	60.7
210:90:200	142.8	12.7	160.1	66.8	16.2	74.2
100:60:40	111.1	8.0	73.0	43.6	18.7	50.2
CD (P=0.05)	13.8	1.9	14.7	4.3	1.8	1.4

was higher than that by wheat, with increase in the level of N from 180 to 240 kg/ha and K from 100 to 200 kg/ha over the state recommended level of 100 kg N and 40 kg K₂O/ha (Table 2). However, a reverse trend was noted for phosphorus uptake by crops with application of P rates from 60 to 120 kg/ha. Total NPK by wheat was significantly higher with varying magnitude of added NPK rates. Application of 180 to 240 kg N, 60 to 120 kg P₂O₅ and 100 to 200 kg K₂O/ha resulted in additional higher uptake of nitrogen from 71 to 85.1, phosphorus 16.8 to 24.3 and potassium 60.7 to 74.2 kg/ha by crop over the uptake values of 43.6, 18.7 and 50.2 kg/ha with state recommended levels of NPK application respectively.

Economics

Based on the cost of 1 kg NPK and price of 1 kg of crop produce the value : cost ratio (VCR) was calculated. Value : cost ratio was higher in wheat than that in maize with higher rates of NPK applied. The higher value : cost ratio was obtained with NPK treatment combination of 210 : 60 : 150 kg/ha to maize and 210:90:150 kg/ha to wheat. There was a net profit of Rs 6,875/ha in wheat and of Rs 5,000/ha in maize at higher NPK application rates over the state recommended levels of fertilization. A loss of Rs 1,500 and 3,500 and Rs 4,375 and Rs 1,875 was noticed with no application of phosphorus and potassium to maize and wheat respectively.

Table 3. Economics of NPK fertilizer use with maize and wheat

Fertility (NPK kg/ha)	Cost of NPK/ ha (Rs)	Maize				Wheat			
		Grain yield (q/ha)	Value of produce with NPK application (Rs)	Net profit/ loss over state recom- mended level	Value : cost ratio	Grain yield (q/ha)	Value of produce with NPK application (Rs)	Net profit/ loss over state recomm level	Value : cost ratio
180:90:150	3,690	34.0	17,000	2,000	1.14	40.00	25,000	4,375	2.5
210:90:150	3,930	40.00	20,000	5,000	2.51	44.0	27,500	6,875	3.5
240:90:150	4,170	35.0	17,500	2,500	1.12	39.0	24,375	3,750	1.7
210:00:150	2,580	27.0	13,500	-1,500	-2.34	26.0	16,250	-4,375	-6.8
210:60:150	3,480	39.0	19,500	4,500	2.92	34.0	21,250	625	0.4
210:120:150	4,380	37.0	18,500	3,500	1.43	42.0	26,250	5,625	2.3
210:90:00	3,030	23.0	11,500	-3,500	-3.21	30.0	18,750	-1,875	-1.72
210:90:100	3,630	39.0	19,500	4,500	2.66	42.0	26,250	5,625	3.32
210:90:200	4,230	37.0	18,500	3,500	1.52	39.0	24,375	3,750	1.63
100:60:40*	1,940	30.0	15,000			33.0	20,625		

*State recommended level

Price (Rs/tonne): Wheat 6,250; maize 5,000

Price (Rs/kg) : N, 8; P, 15; K, 6

Thus higher level of NPK showed superiority to state recommended level of NPK fertilization in maize-wheat cropping system for higher yields, greater removal of NPK by crops and optimal economic returns.

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