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Effect of integrated nutrient supply on growth, yield and nutrient uptake by maize *(Zea mays)*–wheat *(Triticum aestivum)* cropping system

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ABSTRACT

A long-term fertilizer experiment initiated in 1997 at Instructional Farm of the Rajasthan College of Agriculture, Udaipur, was selected for this investigation during 2000–01 and 2001–02, to evaluate the effect of integrated nutrient supply on productivity and nutrient uptake of maize (*Zea mays* L.)–wheat *(Triticum aestivum* L. emend. Fiori & Paol.) cropping system. Maximum plant height and leaf-area index (LAI) of maize were observed by applying 150% NPK, while dry matter was found maximum with 100% NPK + FYM 10 tonnes/ha. The results of both these treatments were at par in all growth parameters. Highest maize grain and stover yields were obtained by applying 150% NPK, though the results were at par with those obtained with 100% NPK + FYM 10 tonnes/ha. Application of 100% NPK + FYM 10 tonnes/ha showed highest values of growth parameters and grain yield of wheat, while maximum straw yield was recorded with 150% NPK. However, these 2 treatments were found at par. The balanced and integrated nutrient supply to maize and wheat showed significantly higher uptake of primary nutrients.

Key words : Integrated nutrient supply, Maize–wheat cropping system, Growth, Yield, Nutrient uptake

Maize–wheat cropping system is an important sequence in irrigated belt of South Eastern Rajasthan. With the development of high-yielding, fertilizer-responsive varieties and also with the availability of irrigation facilities, this cereal-based intensive cropping system has substituted the less productive systems. But continuity of profit-motivated cultivation of intensive cropping with application of imbalanced fertilization is the matter of great concern for sustained production of the system. In spite of heavy inputs the crop yields are declining because of limitation of one or more micro-nutrients (Swarup *et al.,* 1998). Use of organic manure in crop production and beneficial effect of its integration with inorganic fertilizer is often regarded as a panacea to sustain higher levels of productivity coupled with environment safety. Keeping the above facts under consideration, an experiment was carried out to study the response of continuous maize–wheat cropping under integrated nutrient supply system on growth, yield, and nutrient uptake of the cropping system.

MATERIALS AND METHODS

A field experiment was conducted during 2000–01 and 2001–02 on the Instructional Farm of Rajasthan College of Agriculture, Udaipur. The experiment was initiated in rainy season *(kharif)* 1997 under the auspices of All-India Coordinated Research Project on Long Term Fertilizer Experiment. The soil of the experimental site was sandy clay loam, slightly alkaline and calcareous. The initial pH 8.10–8.20, electrical conductivity 0.56–0.64 dS/m, organic carbon 7.20–10.70 g/kg, available nitrogen 282–470 kg/ha, available phosphorus 18.20–22.70 kg/ha, available potassium 615–801 kg/ha, available sulphur 15.84–23.94 mg/kg and DTPA Zn 2.60–3.97 mg/kg were recorded before maize in 2000. The experiment consisted of 12 treatments, viz. 100% NPK (T_1), 100% NPK + Zn (T_2), 100% NPK + S (T_3), 100% NPK + S + Zn (T_4), 100% NPK + *Azotobacter* seed treatment (T_5), FYM 10 tonnes/ha + 100% NPK (–NPK of FYM) (T_6), 100% NPK + FYM 10 tonnes/ha (T_7), FYM 20 tonnes/ha (T_8), 150% NPK (T_9), 100% NP (T_{10}) and 100% N (T_{11}) and control (T_{12}). These treatments were evaluated under randomized block design with 4 replications. Maize (cv. 'Ganga 2') and wheat (cv. 'Raj 3077') were taken as test crops.

The soil test-based optimum NPK doses worked out in 1997 for this experiment were 90 kg N, 30 kg P_2O_5. 15 kg K_2O/ha for maize as well as for wheat crops. The FYM, S and Zn were applied as per the treatment requirements only once in a year to rainy season *(kharif)* crop. Similarly, sulphur and zinc were applied @ 100 kg/ha and 5 kg/ha respectively. The sources for the nutrients taken were urea, diammonium phosphate, muriate of potash, elemental sulphur and zine sulphate. During both the years, maize

was sown in second fortnight of July while wheat was sown in third week of November.

RESULTS AND DISCUSSION

Maize growth

Maize plant height, leaf-area index and dry matter showed their best expression in the treatment involving either 150% NPK or 100% NPK with FYM 10 tonnes/ha (Table 1). Maximum plant height at harvest was achieved by 150% NPK, which was at par with 100% NPK with Zn + S or FYM 10 tonnes/ha. While the treatments 150% NPK and 100% NPK + FYM 10 tonnes/ha achieved the highest leaf-area index at 60 days after sowing (DAS). Compared to the control, application of N or NP or FYM alone resulted in significantly higher growth in terms of leaf-area index, dry matter and plant height. These results confirm the findings of Singh and Singh (1989) and Totawat *et al.* (2001).

Wheat growth

The wheat plant height at harvest, and leaf-area index at 60 days after sowing and dry matter were significantly increased by different nutrient applications over the control (Table 2). The growth parameters showed the best expression in the treatment involving organic matter application @ 10 tonnes/ha along with 100% NPK. Its applica-

Table 1. Effect of integrated nutrient supply on growth, yield and nutrient uptake of maize (pooled)

Treatment	Plant height (cm) at harvest	Leaf-area index at 60 DAS	Dry matter (g/plant) at harvest	Nutrient uptake (kg/ha)			Yield (q/ha)	
				N	P	K	Grain	Stover
T_1: 100% NPK	208.1	3.41	128.68	77.01	13.36	68.29	31.21	42.26
T_2: 100% NPK+Zn	210.3	3.48	137.68	85.26	14.44	73.34	32.90	45.02
T_3: 100% NPK+S	207.9	3.42	146.35	78.21	13.95	65.07	31.83	42.28
T_4: 100% NPK+Zn+S	214.7	3.53	133.00	88.01	14.90	72.99	33.62	46.56
T_5: 100% NPK+ *Azotobacter*	210.9	3.48	138.05	80.88	14.37	68.62	32.37	44.91
T_6: FYM @ 10 tonnes/ha + 100% NPK (–NPK of FYM)	206.4	3.38	138.60	77.95	13.96	69.65	31.11	40.30
T_7: 100% NPK + FYM @ 10 tonnes/ha	218.9	3.59	159.00	88.11	16.99	77.18	33.98	42.96
T_8: FYM @ 20 tonnes/ha	199.3	2.68	113.56	61.42	14.23	58.05	25.48	34.12
T_9: 150% NPK	221.3	3.59	156.62	92.15	16.82	78.39	34.15	47.65
T_{10}: 100% NP	201.0	2.85	119.81	74.12	13.09	59.73	29.97	41.73
T_{11}: 100% N	196.9	2.54	98.94	58.70	9.67	51.02	25.10	34.93
T_{12} : control	178.6	2.22	71.22	41.08	6.97	40.03	18.96	27.14
CD (P=0.05)	14.3	0.19	10.21	6.53	1.12	6.53	2.56	4.66

Table 2. Effect of integrated nutrient supply on growth, yield and nutrient uptake of wheat (pooled)

Treatment	Plant height (cm) at harvest	Leaf-area index at 60 DAS	Dry matter (g/plant) at harvest	Nutrient uptake (kg/ha)			Yield (q/ha)	
				N	P	K	Grain	Straw
T_1: 100% NPK	81.87	3.29	585.03	71.99	14.05	66.80	36.15	46.30
T_2: 100% NPK+Zn	82.85	3.28	609.05	79.45	15.34	69.85	38.03	47.52
T_3: 100% NPK+S	81.64	3.32	664.21	73.18	14.75	68.06	37.09	46.95
T_4: 100% NPK+Zn+S	83.90	3.36	569.45	80.50	15.29	71.63	38.84	48.59
T_5: 100% NPK+*Azotobacter*	82.11	3.31	602.53	73.09	14.46	67.28	36.54	45.82
T_6: FYM @ 10 tonnes/ha + 100% NPK (–NPK of FYM)	82.68	3.39	635.46	75.36	16.01	68.91	36.61	45.74
T_7: 100% NPK+FYM @ 10 tonnes/ha	85.36	3.67	756.30	89.93	18.72	75.93	40.75	48.78
T_8: FYM @ 20 tonnes/ha	74.21	3.12	466.31	57.78	12.26	55.53	29.87	37.61
T_9: 150% NPK	84.98	3.63	709.50	88.90	19.01	75.43	40.52	51.63
T_{10}: 100% NP	80.49	3.26	514.41	63.09	12.68	57.34	33.35	42.19
T_{11}: 100% N	76.57	3.13	422.10	53.84	10.77	48.01	29.11	37.25
T_{12}: control	69.35	2.79	337.55	32.91	5.90	29.89	18.01	23.33
CD (P=0.05)	5.47	0.17	56.59	5.70	1.19	5.55	2.51	3.79

tion enhanced crop dry matter and plant height at harvest and leaf-area index at 60 days after sowing by 116.6, 23.2 and 31.5%, respectively, over the control. However, these parameters were statistically at par with 150% NPK. The findings are in the close conformity with that of Totawat *et al.* (2001).

Maize yield

Application of nutrients either through fertilizers (N, P, K, Zn and S) or FYM or their combination and *Azotobacter* seed treatment in combination with NPK increased the grain yield 32.1 – 44.5% and stover yield by 28.7–75.5% over the control (Table 1). An application of 150% NPK resulted in highest grain yield and stover yield. However, with respect to grain yield its performance was at par with that obtained by combined application of 100% NPK + Zn or S or Zn + S or *Azotobacter* seed inoculation or FYM 10 tonnes/ha, while NPK + Zn or Zn + S or *Azotobacter* seed treatment performed statistically equal with respect to stover yield. Statistically these treatments were followed by 100% NPK either through fertilizers or both FYM 10 tonnes/ha + fertilizers. Application of NP was found superior to N and FYM 20 tonnes/ha but inferior to aforesaid treatments. Continuous use of 100% NPK or NP or N alone gave quite low yields, underlining the importance of higher rates and balanced use of fertilizers. Application of FYM alone or with chemical fertilizer increased the grain and stover yields of maize over no fertilization. Singh *et al.* (1999) also reported similar yield trends.

Wheat yield

The results (Table 2) indicate that addition of plant nutrients through fertilizers, organic sources and their combinations proved beneficial in enhancing grain and straw yields of wheat. During the first year, maximum yield advantage over the control was recorded when crop was fertilized with 150% NPK, while during the second year higher yield benefit over the control was realized with the application of 100% NPK with FYM 10 tonnes/ha. The maximum grain yield was obtained by 100% NPK + FYM 10 tonnes/ha, while maximum straw yield advantage was obtained by fertilizing the crop with 150% NPK. However, the results of both these treatments were at par with each other for grain and straw yields of wheat. Application of 100% NPK with Zn + S proved superior to 100% NPK for grain yield only. The results are in line with those reported by Singh and Swarup (2000).

Table 3. Effect of integrated nutrient supply on N, P and K uptake (kg/ha) by maize–wheat cropping system

Treatment	N	P	K
T_1	149.0	27.4	135.1
T_2	164.7	29.8	143.2
T_3	168.4	30.2	144.6
T_4	151.4	28.7	133.1
T_5	154.0	28.8	135.9
T_6	153.3	30.0	138.6
T_7	178.0	35.7	153.1
T_8	119.2	23.5	113.6
T_9	181.1	35.9	153.8
T_{10}	137.2	25.8	117.1
T_{11}	112.6	20.4	99.0
T_{12}	74.0	12.9	69.9
CD (P=0.05)	8.4	1.7	9.0

Nutrient uptake

The application of NPK enhanced N uptake over only 100% N or FYM 20 tonnes/ha, while addition of Zn or Zn + S with 100% NPK gave significantly higher yield over 100% NPK. Enrichment of soil with 150% NPK, 100% NPK + FYM 10 tonnes/ha and Zn + S brought about 124.3, 114.5, 114.2% increase in N uptake by maize crop respectively. The balanced and integrated nutrient supply also resulted in significantly higher phosphorus and potassium uptake by maize crop. However, 150% NPK and 100% NPK + FYM 10 tonnes/ha resulted in significantly higher uptake of these nutrients (Table 1).

The data are also indicative of superiority of balanced and integrated nutrient application, *viz.* 150% NPK and 100% NPK + FYM 10 tonnes/ha, in significantly greater removal of N, P and K from the soil by wheat crop (Table 2). On cropping system basis, significantly higher NPK uptake (Table 3) by maize–wheat cropping system was recorded by the application of 100% NPK + FYM @ 10 tonnes/ha and 150% NPK.

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