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Response of fertilizers in maize (*Zea mays*)-wheat (*Triticum aestivum*)-cowpea (*Vigna unguiculata*) cropping system

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ABSTRACT

A field experiment was conducted for 3 years on a Typic Ustochrept of Delhi under the All-India Co-ordinated Research Project on Long-Term Fertilizer Experiments with different fertilizer combinations following maize (*Zea mays* L.)-wheat (*Triticum aestivum* L. emend. Fiori & Paol.)-cowpea [*Vigna unguiculata* (L.) Walp.] (fodder) sequence. Soil-test based 100% optimum recommended dose of 120,60 and 40 kg/ha N, P_2O_5 and K_2O for wheat and maize and 20, 40 and 20 kg/ha for cowpea showed significantly higher grain and straw or stover yields of both grain crops as well as the dry-fodder yield of cowpea during all the 3 years than unfertilized plots. Use of N or NP alone yielded quite low, comparable to 50% of the recommended dose. NPK + FYM gave as high yield of maize as the superoptimal dose of 150% and consistently higher yield of wheat grain. Use of S or Zn or hand-weeding showed no yield advantage. The FYM treatment maintained high level of fodder yield of cowpea.

Key words: Yield, Maize, Wheat, Cowpea

Crop response to N, P and K fertilizers is high in high-yielding varieties (HYVs) particularly when these elements are applied in appropriate amounts and proportion. Use of N alone or NP for years is known to produce quite low in comparison to optimum NPK dose. The findings of the All-India Co-ordinated Research Project on Long-Term Fertilizer Experiments compiled by Nambiar (1994) indicate that the response to N in absence of P or K in many agro-climatic regions had been low and the deteriorating soil productivity was associated with the imbalance in secondary and micronutrients. Sulphur has been found to be yield-limiting factor in many cases and Zn in some. Both these elements along with NPK provided good yield responses of maize, wheat and rice crops under these experiments. The present paper deals with the crop yields obtained on an Inceptisol of Delhi for 3 years under varying fertilizer doses in the experiments initiated in 1971 for which such information is quite limited.

MATERIALS AND METHODS

A field experiment was conducted at New Delhi during 1993-96 on maize-wheat-

cowpea cropping sequence with 10 fertilizer treatments as: T_1, 50% soil test-based optimum NPK; T_2, 100% soil test-based optimum NPK; T_3, 150% soil-test based optimum NPK; T_4, T_2 + hand-weeding; T_5, T_2 + Zn; T_6, 100% soil test-based optimum NP; T_7, 100% soil test-based optimum N; T_8, T_2 + FYM; T_9, T_2 + S; and T_{10}, control.

The soil test-based optimum NPK doses (kg/ha) as worked out in 1971 for these experiments were $N_{120}P_{60}K_{40}$ (120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha) for maize and wheat and $N_{20}P_{40}K_{20}$ for cowpea (fodder). FYM @ 15 tonnes/ha was applied only once in a year to maize crop, while Zn was applied @ 10 kg zinc sulphate/ha only to wheat crop. Chemical weed-control measures were adopted in all treatments except in T_4 (NPK + hand weeding). The S was applied through single superphosphate as the P source (containing 12% S). The fertilizers used were urea and diammonium phosphate (DAP) for N, DAP/single superphosphate (SSP) for P and muriate of potash (MOP) for K. The treatments were replicated 4 times in randomized block design. The soil was a sandy loam Typic Ustochrept and initially had pH 8.1, electrical conductivity 0.45 dS/m, organic carbon 0.44%, Olsen's available P 16.0 kg/ha, available K 155 kg/ha, cation-exchange capacity 10.6 cmol (p+)/kg, available S 22.5 ppm and available Zn 1.10 ppm. The soil samples analysed in 1994 showed no change in pH and EC, organic carbon 0.42%, Olsen's P 15.5 kg/ha, average K 179 kg/ha, average S 19.6 mg/kg and DTPA-extractable Zn 1.10 mg/kg. The data on the crop yields of 'GS 2' maize for 1994,1995 and 1996, of 'HD 2329' wheat for 1993-94, 1994-95 and 1995-96 and of 'EC 4216' cowpea for 1994, 1995 and 1996 were processed statistically. Maize crop during 1994 had to be harvested as fodder due to weather-delayed sowing.

RESULTS AND DISCUSSION

Maize

The dry-matter yield of maize (stover) achieved under the control (no fertilizer plots) was significantly lower than all other

Table 1. Maize yield under different fertilizer treatments

Treatment	Maize yield (q/ha)				
	1994	1995		1996	
	Dry fodder	Grain	Stover	Grain	Stover
50% opt. NPK (T_1)	15.83	18.59	24.14	19.95	25.70
100% opt. NPK (T_2)	16.52	20.37	27.11	22.57	29.37
150% opt. NPK (T_3)	20.81	22.26	31.01	25.52	37.30
T_2 with hand-weeding	17.99	19.65	28.36	21.55	29.07
T_2 + Zn	18.60	21.40	34.22	22.50	29.02
100% opt. NP	16.17	17.57	25.62	20.67	25.42
100% opt. N	15.89	17.42	25.47	19.47	24.02
T_2 + FYM	18.42	21.31	36.95	25.65	36.47
T_2 + S	18.06	19.37	35.94	23.92	29.75
Control	9.10	9.68	13.05	12.65	17.60
CD (P = 0.05)	3.300	1.248	3.904	3.172	3.569

Table 2. Wheat yield under different fertilizer treatments

Treatment	Yield (q/ha)					
	1993–94		1994–95		1995–96	
	Grain	Straw	Grain	Straw	Grain	Straw
50% opt, NPK (T_1)	47.12	52.45	43.71	54.37	40.20	52.11
100% opt. NPK (T_2)	49.68	53.51	48.04	66.62	45.27	53.54
150% opt. NPK (T_3)	51.72	53.25	44.94	64.12	51.01	55.71
T_2 with hand-weeding	48.59	50.31	49.68	66.87	43.62	52.81
T_2 + Zn	50.44	53.43	46.66	68.37	46.25	51.86
100% opt. NP	48.28	50.24	46.04	57.50	40.44	50.67
100% opt. N	47.25	48.09	47.41	55.87	37.41	46.64
T_2 + FYM	51.87	56.86	47.86	67.75	54.11	60.34
T_2 + S	48.28	50.36	46.60	72.25	49.86	53.10
Control	27.03	27.45	24.33	33.37	24.23	29.17
CD (P = 0.05)	4.62	5.77	4.01	7.85	2.58	3.34

fertilizer treatments (Table 1). Continuous use of 50% dose of NPK or NP or N alone gave quite low yields, indicating the necessity of balancing of fertilizer nutrients. Use of FYM or S-containing P source (SSP) had hardly any effect on stover yield in 1994 but led to significant jump in stover yield during 1995 . However, FYM treatment had no significant influence on maize grain production. In all cases the manual control of weeds (hand-weeding) instead of the use of weedicide showed no effect on yield, though it is undoubtedly an environmentally sound practice. The yield levels under various treatments during 1996 were higher, but the trend was similar to 1995. The superoptimal dose and NPK + FYM performed equally well both in terms of grain as well as stover yield. Similar yield trends were reported by Anand Swarup and Ghosh (1979) and Nambiar and Ghosh (1984).

Table 3. Dry-matter yield of cowpea (fodder) under different fertilizer treatments during 3 years

Treatment	Dry-matter yield (q/ha)		
	1994	1995	1996
50% opt. NPK (T_1)	3.52	4.32	5.02
100% opt. NPK (T_2)	3.66	4.75	5.68
150% opt. NPK (T_3)	3.87	4.75	6.24
T_2 with hand-weeding	3.39	4.51	5.19
T_2 + Zn	3.64	4.92	5.50
100% opt. NP	3.10	4.40	5.04
100% opt. N	2.99	4.14	4.90
T_2 + FYM	4.10	5.40	6.65
T_2 + S	4.00	4.64	6.09
Control	1.77	2.15	3.63
CD (P = 0.05)	1.04	0.54	0.32

Wheat

The grain yield of wheat increased significantly due to all levels of fertilizers and nutrients over the control in all the 3 years (Table 2). The higher yields during 1993-94 and 1995-96 were obtained with optimum NPK + FYM treatment. However, the yields obtained during 1994-95 happened to be against expectation and have no immediate explanation. Increasing dose from 50% to 150% optimum increased grain yield progressively in 1995-96 but not in 1994-95 where 100% optimum NPK dose yielded better, though the overall yield levels showed no particular trend.

During these 3 years the grain yield showed a declining trend particularly with NP. Addition of Zn and S did not significantly increase the grain yield in any of the 3 years. The different fertilizer treatments did not show significant differences amongst themselves during first 2 years in this respect except NPK + FYM which showed significant increase over the control or N alone in 1993-94. The treatment differences during 1995-96 were, however, quite sharp in grain yields.

Wheat straw yield, like grain also showed significant positive effect of all the treatment combinations over the control and the highest (significant) straw yields in 1993-94 and in 1995-96 were recorded under NPK + FYM. The N or NP alone generally proved inferior to a balanced dose. These results confirm the finding of Nambiar and Ghosh (1984) and Nambiar (1994).

Cowpea

Fodder dry-matter yield of cowpea indicated no advantage of high fertilizer use (Table 3). Even low doses of 50% optimum NPK yielded as good as 100% optimum level in 1994 and 1995. The NPK + FYM treatment showed a better growth and yield in 1995 and 1996 but not during 1994. Poor dry-fodder yields with N alone were of course apparent during 1995 and 1996 where the yields were significantly lower than those with 100% NPK. The results of the present study corroborate the findings of Singh and Nambiar (1986).

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