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Productivity and Uptake Pattern of NPK in Maize (*Zea mays* L.) as a Function of Continuous Cropping and Fertilization in Typic Haplustic Soils

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Abstract

The experiment was conducted at Udaipur to study the performance and nitrogen, phosphorous, potassium utilization by PEHM-2 under influence of integrated nutrient management. The study showed that the conjoin application of recommended dose of NPK and 10 tonnes/ha farm yard manure resulted in significantly higher grain (4075 kg/ha) and stover yields compared to either inorganic fertilizer alone or organic sources or 50 % of recommended dose of inorganic fertilizers. Application of recommended dose of NPK along with seed inoculation of Azotobacter resulted in higher net returns and B:C ratio of maize crop. The integrated nutrient management resulted in better uptake of nitrogen, phosphorous and potassium at different growth stages and less losses of nutrients from soil.

Key words: *Maize, continuous cropping and fertilization, Nutrient uptake pattern, Farmyard manure, Yield*

Introduction

The major objective of an efficient fertilization program is to be certain that adequate N, P and K are available during the growing season so that plant growth and yields are not limited by nutrient supplies[4,6]. The maize plant requires N and P soon after germination to initiate the growth of stems, leaves and ear structures. Inadequate N availability during the first two to six weeks after planting can result in reduced yield potentials. Attempts have been made by researchers to understand peak growth stages of N accumulation by crops, optimum time of application, and movement and translocation of N within the plant[1,2,3,5].

Apart from integration of nutrient sources application of mineral nutrients in a proper balance also has a role in nutrient removal by maize crop. Keeping the above facts in consideration, an experiment was carried out to study the influence of continuous cropping and fertilization on productivity and the response of maize crop to added nutrients as N P K at different growth stages and total uptake of nutrients by maize crop.

Material and Methods

The field study was conducted during rainy (*kharif*) season 2010 in the Long Term Fertilizer Experiments initiated in *kharif*, 1997 at the Instructional Farm of the Rajasthan College of Agriculture, Udaipur situated in south-eastern part of Rajasthan at an altitude of 579.5 m above mean sea level, at 24°35' N latitude and 74°42' E longitude with maize "PEHM-2" maize. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in reaction (pH 8.2), medium in available nitrogen (427 kg/ha) and phosphorus (22.4 kg/ha) and high in available potassium (671 kg/ha), sulphur (21.0 mg/kg) and zinc (3.76 mg/kg). The twelve treatments, viz. T_1 100% NPK, T_2 100% NPK + Zn, T_3 100% NPK + S + Zn, T_4 100% NPK + S, T_5 100% NPK + seed treatment with *Azotobacter*, T_6 farmyard manure 10 tonnes/ha + 100% NPK (-NPK content of farmyard manure), T_7 100% NPK + farmyard manure 10 tonnes/ha,

T_8 farmyard manure 20 tonnes/ha, T_9 150% NPK, T_{10} 100% NP, T_{11} 100% N and T_{12} control were replicated four times in randomized block design. Urea, di - ammonium phosphate (adjusted for its N content) and murate of potash were used as sources of N P and K, respectively. Mineral gypsum and zinc sulphate ($ZnSo_4.7H_2O$) were used to supply S and Zn. The other sources of nutrients were farm yard manure and biofertilizer (*Azotobacter chroococcum*) as seed treatment. The biofertilizer for seed inoculation was used at 600 g/ha. According to soil-test fertilizer recommendation, the 100% NPK dose for maize was 120:60:30 kg/ha. The dose for sulphur and zinc were 40 kg and 5 kg/ha, respectively. A basal dose of well rotten farm yard manure was applied prior to sowing in the specific plots as per technical programme and thoroughly mixed with soil. Full dose of P and K along with ½ dose of N was given as a basal dose and thoroughly mixed with soil. The remaining ½ dose of the nitrogen was applied in two splits, first at 30 days after sowing and second 45 days after sowing. "PEHM-2" maize was sown at the seed rate of 25 kg/ ha in rows 60 cm x 20 cm apart.

Results and Discussion

Application of plant nutrients in the form of chemical fertilizer, organic sources or integrated form resulted in significantly higher grain yield of maize compared to absolute control. The minimum increase was observed by applying 100% N only (62.5 %) which was at par to FYM 20 tonnes/ha (64.1 %). The overall range of yield enhancement achieved by integrated nutrient management was 62.5 to 183.4 per cent and stover yield by 57.96 to 170.19 per cent (Table 1).

Table 1 Effect of nutrient management on grain and stover yield of maize and nitrogen uptake by maize

Treatments	Yield (kg/ha)		N uptake (kg/ha)					
	Grain	Stover	30 DAS	45 DAS	60 DAS	At harvest		
						Grain	Stover	Total
100% NPK	3408	5218	34.51	79.97	100.69	50.32	25.51	75.83
100% NPK + Zn	3595	5507	37.43	88.17	115.37	55.00	29.62	84.62
100% NPK + S + Zn	3690	5556	38.24	90.31	120.86	56.33	30.16	86.49
100% NPK + S	3460	5324	36.46	84.97	113.69	52.54	28.40	80.94
100% NPK + *Azotobacter*	3508	5342	36.02	84.10	106.24	52.85	26.43	79.28
Farmyard manure 10 t ha^{-1} + 100% NPK (–NPK of Farmyard manure)	3469	5322	35.09	83.58	108.18	55.04	26.14	81.19
100% NPK + Farmyard manure 10 t ha^{-1}	4075	6055	41.54	97.29	134.75	65.78	32.26	98.04
Farmyard manure 20 t ha^{-1}	2360	3540	28.03	63.14	67.12	33.75	17.75	51.50
150 % NPK	3777	5567	41.05	91.71	123.31	60.09	32.02	92.11
100% NP	2950	4556	31.24	70.22	90.00	44.42	22.96	67.38
100 % N	2337	3687	27.75	61.14	74.04	33.04	16.74	49.78
Control	1438	2241	17.59	40.98	40.34	14.86	8.92	23.79
S.Em. ±	123.9	189.5	0.92	1.51	2.35	2.05	1.12	2.75
C.D. (P = 0.05)	354.3	546.2	0.65	4.36	6.78	5.90	3.22	7.93

An application of 100% NPK + farm yard manure 10 tonnes/ha resulted in maximum grain (4075 kg/ha) and stover yields (6055 kg/ha) which was at par to 150% NPK in grain yield. While an application of 150% NPK or 100% NPK + S + Zn achieved

statistical equivalence in stover yields. Application of 100% N or NP or farm yard manure 20 tonnes/ha alone significantly increased the grain and stover yield bur the yield levels were inferior 100% NPK.

The data pertaining to the N uptake by maize are also indicative of superiority of balanced and integrated nutrient application in significantly greater removal of nutrients by maize (Table 1 and Fig.1). The N uptake was 41.54 kg/ha at 30 DAS and increased at (97.29 kg/ha) at 45 DAS. At 60 DAS was maximum as 134.75 kg/ha and decreased at maturity (75.83 kg/ha). Maximum N at 30 DAS and total uptake at harvest was recorded with the application of 100% NPK + farmyard manure 10 tonnes/ha and an application of 150% NPK achieved statistical equivalence to it. An application of 100% NPK + farmyard manure 10 tonnes/ha were significantly superior over rest of the treatments with respect to N uptake by maize crop at 45 and 60 DAS. P uptake followed the same general trend as plant growth (Table 2).

Table 2 Effect of nutrient management on phosphorus uptake by maize

Treatments	P uptake (kg/ha)					
	30 DAS	45 DAS	60 DAS	At harvest		
				Grain	Stover	Total
100% NPK	3.99	8.88	11.18	9.14	6.04	15.18
100% NPK + Zn	3.90	9.69	12.29	9.06	6.00	15.06
100% NPK + S + Zn	3.88	9.63	12.59	9.39	6.13	15.52
100% NPK + S	4.12	9.55	12.35	9.77	6.07	15.84
100% NPK + *Azotobacter*	3.83	9.54	11.69	9.35	6.79	16.14
Farmyard manure 10 t ha^{-1} + 100% NPK (–NPK of Farmyard manure)	3.83	9.54	11.96	10.11	6.36	16.47
100% NPK + Farmyard manure 10 t ha^{-1}	4.64	11.53	15.13	12.02	7.70	19.71
Farmyard manure 20 t ha^{-1}	3.11	7.24	8.83	6.29	3.93	10.21
150 % NPK	4.57	11.17	13.97	10.36	7.55	17.92
100% NP	3.63	8.06	10.42	7.85	5.20	13.06
100 % N	3.07	6.48	7.93	5.63	3.16	8.78
Control	2.09	4.56	5.38	3.26	1.99	5.25
S.Em. ±	0.14	0.15	0.24	0.337	0.246	0.530
C.D. (P = 0.05)	0.42	0.44	0.70	0.971	0.710	1.528

P uptake increased from 30 DAS with increase in growth stages of maize crop and was maximum at harvest. Though maximum P uptake 4.64 kg/ha and 11.53 kg/ha was recorded by soil application of 100% NPK + farmyard manure 10 tonnes/ha, however, its effect was at par to that of 150% NPK (4.57 kg/ha) at 30 and 45 DAS respectively. At 60 DAS and total P uptake at harvest was 15.13 kg/ha and 19.71 kg/ha respectively, under influence of an application of 100% NPK + farmyard manure 10 tonnes/ha was significantly superior over rest of the treatments. With reference to K accumulation the similar trend as of nitrogen was noticed in maize at different groth stages (Table 3).

Table 3 Effect of nutrient management on potassium uptake by maize

Treatments	K uptake (kg/ha)					
	30 DAS	45 DAS	60 DAS	At harvest		
				Grain	Stover	Total
100% NPK	25.34	59.95	91.97	15.40	64.93	80.34
100% NPK + Zn	26.75	65.40	105.28	16.65	67.65	84.31
100% NPK + S + Zn	26.42	65.10	98.17	17.94	70.19	88.13
100% NPK + S	26.48	62.94	99.67	15.60	64.32	79.92
100% NPK + *Azotobacter*	26.46	64.33	95.89	16.11	66.37	82.48
Farmyard manure 10 t ha^{-1} + 100% NPK (–NPK of Farmyard manure)	27.16	65.45	105.42	16.29	65.65	81.95
100% NPK + Farmyard manure 10 t ha^{-1}	29.17	72.80	119.87	20.29	74.18	94.47
Farmyard manure 20 t ha^{-1}	17.98	42.84	56.21	10.66	43.59	54.24
150 % NPK	27.69	65.52	104.71	17.85	71.97	89.82
100% NP	21.70	51.43	75.56	12.05	50.59	62.63
100 % N	19.58	45.43	64.51	9.57	41.28	50.85
Control	12.41	31.27	43.19	5.85	24.28	30.13
S.Em. ±	0.78	1.15	0.96	0.531	2.479	2.916
C.D. (P = 0.05)	2.25	3.32	0.28	1.531	7.145	8.406

Maximum K was accumulated at 60 DAS and decreased at maturity. The conjoint application of 100% NPK + farmyard manure 10 tonnes/ha brought about maximum enhancement in K uptake but its effect was at par to that of 150% NPK and + farmyard manure 10 tonnes/ha + 100% NPK (-NPK of farmyard manure) at 30 DAS but at 45 and 60 DAS 100% NPK + farmyard manure 10 tonnes/ha brought about maximum enhancement in K uptake as 72.80 kg/ha and 119.87 kg/ha respectively, which was significantly superior to all the other treatments.. Total K uptake at harvest was also maximum (94.47 kg/ha) with conjoint application of 100% NPK + farmyard manure 10 tonnes/ha and was at par to those of 150% NPK and 100% NPK + Zn + S.

As compared to control the uptake of all nutrients by maize was significantly higher in the plots receiving fertilizers plus manure. This highlights the importance of integrated nutrient management and balanced fertilization in crop production (Singh and Nand Ram 2005). Economic evaluation of treatments indicated that application of 100% NPK + FYM 10 t/ha gave a highest net return which was on par with 100% NPK in combination with Zn or both Zn and S, seed inoculation with *Azotobacter* and 150% NPK (Table 4). However, application of 100 % NPK + *Azotobacter* seed inoculation registered maximum value of B C ratio.

Table 4 Effect of nutrient management on net returns and B C ratio in maize

Treatments	Cost of cultivation ($^{x}10^{3}$ Rs/ha)	Net return (₹ ha^{-1})	B C ratio
100 % NPK	26.6	26570	1.84
100 % NPK + Zn	28.0	27988	1.83
100 % NPK + Zn + S	28.6	28600	1.82
100 % NPK + S	26.8	26791	1.80
100 % NPK + *Azotobacter*	27.7	27701	1.91
FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM)	25.7	25732	1.61
100 % NPK + FYM 10 t ha^{-1}	31.3	31253	1.79
FYM 20 t ha^{-1}	10.7	10743	0.61
150 % NPK	29.6	29562	1.87
100 % NP	21.3	21340	1.50
100 % N	15.3	15295	1.18
Control	5.7	5718	0.49
S.Em.±	1.42	1424.24	0.09
C.D. (P = 0.05)	4.10	4104.90	0.27

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