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Balanced use of inorganic fertilizers on maize (*Zea mays*) yield, nutrient uptake and soil fertility in alfisols

M. PARAMASIVAN, P. MALARVIZHI AND S. THIYAGESWARI

Department of Soil Science and Agricultural Chemistry
Tamil Nadu Agricultural University, Coimbatore -641 003, Tamil Nadu, India.

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Abstract : A field experiment was conducted during July – October of 2006-2007 and 2007-2008 to study the effect of balanced inorganic fertilizers on yield and nutrient uptake of maize (COHM 5) in Palaviduthi soil series of Tamil Nadu. The nutrient sorption study was conducted to evaluate optimum nutrient treatment (ONT). The optimum nutrient requirements were fixed as 200-76-88-7.4 kg N-P-K-Zn / ha for this soil series belongs to the order of Alfisol. The experiment was laid out in RBD replicated thrice with 13 treatments of different levels of inorganic fertilizers. The grain and stover yield of maize influenced by various levels of fertilizers in this soil series was found to be significant and the highest grain and stover yield (7.71 and 14.05 t / ha) was recorded in treatment that received 250-76-88-7.4 kg N-P-K-Zn / ha, respectively. The highest total N and Zn uptake (243.44 and 1.41 kg / ha) was noted from the application of 250-76-88-7.4 kg N-P-K-Zn / ha). Similarly, the maximum total P and K uptake (73.82 and 206.50 kg / ha, respectively) was observed from the enhanced levels of P and K application (200-95-88-7.4 and 200-76-110-7.4 kg N-P-K-Zn / ha. The trend of available N, P, K and Zn were also same as to that of uptake pattern due to the enhanced levels of nutrients at post harvest soil. The highest net returns (Rs 35,137 / ha) and net B:C (1.52) were obtained in treatment applied with 250-76-88-7.4 kg N-P-K-Zn / ha.

Keywords: Alfisol, Available nutrients, Grain yield, Nutrient uptake

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop of world and India after wheat and rice. Maize is a miracle crop called "Queen of Cereals" and is grown in more than 130 countries. In world maize is cultivated in 146 m ha with production of 685 million tonnes and an average production of 4.7 t /ha. In India, maize is cultivated in 8.11 m ha with a production of 19.77 m t and the average yield is 2.44 t / ha (Anon., 2008). In Tamil Nadu maize is cultivated in an area of 0.18 m ha with a production of 0.29 m t and an average productivity of 1.55 t/ha (Anon., 2005). By 2020, the requirement of maize for various sectors will be around 100 m t, of which poultry sector needs 31 m t. Hence, it is a challenging task for us to increase the maize production from the present level (Seshaiah, 2000). The future sustainability of the maize production will greatly depend on the improvement in soil resource base through the balance fertilization. The concept of balanced fertilization paves the way for optimum plant nutrient supply to realize full yield potential of crop. However, continuous use of imbalance fertilizers causes decline in soil fertility and yield reduction. Keeping these points in view, the present study was undertaken to investigate the effect of balanced fertilization for higher yield of maize and soil fertility in benchmark soil series of Palaviduthi (Pvd) belongs to the order of Alfisol, which is one of the major maize growing soils in Dindigul, Theni and Trichy districts of Tamil Nadu with a total extent of 1,39,876 ha.

Material and Methods

The field located in Kamatchipuram village in Periyakulam taluk of Theni district of Tamil Nadu. The experimental soil was Alfisol having sandy clay loam texture with 52.8 % sand, 24.2 % clay and 22.5 % silt. This soil series was a member of fine, mixed isohyperthermic family of Typic Rhodustalfs, fine loamy, moderately well drained. The soil reaction was 7.5 and low in EC (0.07 dS/m). The cation exchange capacity of the soil was 19.7 c mol (p^+) / kg. The soil of the experimental field was low in organic carbon (0.41 %) and available N (177 kg / ha), medium in available P (14.4 kg / ha) and K (272 kg / ha). It contained 11.3 c mol (p^+)/ kg exchangeable Ca and 3.97 c mol (p^+)/kg exchangeable Mg. The available Zn, Fe, Cu and Mn content were 2.6, 41.1, 4.4 and 15.3 mg / kg, respectively.

Nutrient sorption study was conducted in the experimental soil through the Agro Service International (ASI) method proposed by Portch and Hunter (2002). Nutrient sorption study was conducted to know if any of the applied plant nutrient, *viz.,* P, K, S and Zn react (fix or complex) abnormally with the soil. Nutrient sorption study was carried out by adding a specific amount of the plant nutrient in solution to a specific volume of soil and allowing it to incubate for 72 hours in a dust free environment. The air dried sample was then analysed for respective nutrient element. Based on the data of sorption study, the optimum nutrient treatment (ONT) was arrived.

Field experiment was conducted during July – October of 2006-2007 and 2007-2008 in the farmers' field with maize variety of COHM 5. The field experiment consisted of thirteen treatment combinations *viz*., T_1- $N_0P_2K_2Zn$ as 0-76-88-7.4 kg / ha, T_2- $N_1P_2K_2Zn$ as 150-76-88-7.4 kg / ha, T_3- $N_2P_2K_2Zn$ (ONT) as 200-76-88-7.4 kg / ha, T_4- $N_3P_2K_2Zn$ as 250-76-88-7.4 kg / ha, T_5- $N_2P_0K_2Zn$ as 200-0-88-7.4 kg / ha, T_6-$N_2P_1K_2Zn$ as 200-57-88-7.4 kg / ha, T_7-$N_2P_3K_2Zn$ as 200-95-88-7.4 kg / ha, T_8- $N_2P_2K_0Zn$ as 200-76-0-7.4 kg / ha, T_9- $N_2P_2K_1Zn$ as 200-76-66-7.4 kg / ha, T_{10}- $N_2P_2K_3Zn$ as 200-76-110-7.4 kg / ha, T_{11}- $N_2P_2K_2$ -Zn as 200-76-88-0 kg / ha, T_{12}- RDF as 135-62.5-50-5.5 kg / ha, and T_{13}- Absolute control

The optimum nutrient treatment (ONT) formed the central treatment ($N_2P_2K_2Zn$). In each case of N, P and K, there were three more levels, *viz.*, a zero level, one below and another above the ONT level. There was one treatment which was ONT minus

Zn. Except this treatment all the other treatments received Zn as in ONT. A recommended dose of fertilizer *i.e.* 135-62.5-50-5.5 kg N-P-K-Zn / ha was included for comparison. The treatments were replicated three times in a Randomized Block Design (RBD). The crop was sown at 60 × 25 cm spacing in 20m^2 plot (5m × 4m) in first week of July and harvested in third week of October. The cultivation practices were followed as per the guidelines of Crop Production Guide of Tamil Nadu Agricultural University (Anon, 2005). The fertilizer sources used were urea for N (46 per cent N), single super phosphate for P (16 per cent water soluble P_2O_5), muriate of potash for K (60 per cent of K_2O) and zinc sulphate for Zn (22 per cent Zn). Growth and yield attributes were recorded as per standard procedures. The cost of cultivation, net returns and benefit : cost ratio were calculated on the basis of prevailing market price of different inputs and outputs. The nutrient use (kg grain/ kg nutrient) was calculated by dividing the grain yield with total nutrients. The nutrient content and uptake by maize were analysed through prescribed laboratory procedures. The post harvest soil samples were collected from 0-20 cm depth for analysing available nutrient status. Soil samples were analysed for alkaline permanganate oxidizable N, 0.5 M $NaHCO_3$-extractable P and 1 N NH_4OAC-exchangeable K.

Results and discussion

The yield attributes such as cob length, cob girth, number of grain rows/cob, number of grains/row and hundred grain weight grain and stover yield were significantly influenced by various treatments (Table 1). The longest cob (19.0 cm), maximum cob girth (15.2 cm), highest number of grain rows per cob (15.1), grains/row (36.9) and hundred grains weight (27.49g) were obtained from the treatment with 250-76-88-7.4 kg N-P-K- Zn /ha followed by the optimum nutrient treatment with 200-76-88-7.4 kg N-P-K-Zn / ha (18.3 cm), (14.6 cm), (14.6), (35.5) and (26.34g) (Table 1). The recommended dose fertilizer gave the lower values of growth and yield attributes than the ONT. The treatments were omitted with N or P or K recorded the lowest values which was closer to the absolute control. These results are in conformity with Sahoo and Mahapatra (2007).

Significantly higher grain and stover yields (7.71 and 14.05 t /ha) were recorded with the application of 250-76-88-7.4 kg N-P-K-Zn / ha. The application of 200-76-88-7.4 kg N-P-K-Zn / ha resulted in the next highest grain and stover yields (7.18 and 12.06 t / ha, respectively). These two treatments were on par and which gave the increased per cent grain yields of 30.3 and 21, respectively. The increased in grain yield of maize might be due to the increased availability of essential nutrients from the enhanced level of nutrients applied to the crop. The recommended dose of fertilizer recorded the lower grain and stover yield (5.92 and 9.06 t / ha) than the treatment enhanced with N or P or K. The treatments omitted with N or P or K or Zn recorded poor yields and which were very closer to the absolute control. This might be due to lower content of nutrients in the plant and reduced yield of maize. These findings are in close conformity with the earlier findings of Parasuraman, (2006).

Nutrient uptake by maize was affected significantly due to various treatments (Table 2). The uptake of N, P, K and Zn by plants increased significantly with successive increase in fertility level, which led to maximum N, P, K and Zn uptake. The treatment with 250-76-88-7.4 kg N-P-K-Zn / ha recorded the highest N and Zn uptake (243.4 and 1.4 kg / ha) that was significantly higher than that of RDF with 135-62.5-50-5.5 kg N-P-K-Zn / ha (127.0 and 0.7 kg / ha). This increase was mainly due to higher level of applied nutrients. The findings of Rana and Choudhary (2006) confirmed these results. The highest P uptake (73.8 kg / ha) was recorded with the application of 200-95-88-7.4 kg N-P-K-Zn / ha than that of RDF with 135-62.5-50-5.5 kg N-P-K-Zn / ha (38.7kg / ha). The higher doses of P fertilizers had influenced higher uptake. Similar trend was found with uptake of K. The highest K uptake (206.5 kg / ha) was noticed for the treatment with 200-76-110-7.4 kg N-P-K-Zn / ha. Significantly higher nutrients uptake (NPK) were recorded with 200-76-88-7.4 kg N-P-K-Zn / ha. This is due to the balanced supply of all nutrients to plants at all stages of crop growth. It is in accordance with the finding of Kedar Prasad *et al.* (2005). The lower uptake of N, P, K and Zn was in treatments omitted with N or P or K and in absolute control.

Table 1. Grain yield, yield parameters and economics of maize as influenced by different nutrients levels (Pooled)

Treatments	Cob length (cm)	Cob girth (cm)	Grain rows / cob	Grains / row	100 grains weight (g)	Grain yield	Stover yield (t / ha)	Cost of cultivation (t / ha)	Net return (₹ / ha) (₹ / ha)	B:C
$N_0P_2K_2Zn$	14.0	12.2	12.6	27.0	21.73	3.15	6.10	20,322	3,507	0.17
$N_1P_2K_2Zn$	16.3	13.4	14.2	31.0	25.26	6.07	9.93	21,232	24,237	1.14
$N_2P_2K_2Zn$ (ONT)	18.3	14.6	14.6	35.5	26.34	7.18	12.06	22,497	31,377	1.39
$N_3P_2K_2Zn$	19.0	15.2	15.1	36.9	27.49	7.71	14.05	23,047	35,137	1.52
$N_2P_0K_2Zn$	14.8	12.3	13.2	28.5	22.35	3.72	7.79	20,547	7,743	0.15
$N_2P_1K_2Zn$	15.7	13.5	14.2	30.1	24.59	6.23	10.03	21,971	24,611	1.12
$N_2P_3K_2Zn$	17.8	14.5	14.3	34.1	25.48	7.09	11.07	22,923	30,049	1.31
$N_2P_2K_0Zn$	16.1	13.3	13.1	28.9	22.47	3.87	6.96	21,785	7,426	0.34
$N_2P_2K_1Zn$	16.9	14.3	14.0	30.3	25.24	6.14	9.43	22,280	23,372	1.04
$N_2P_2K_3Zn$	18.2	14.7	14.5	34.3	26.91	7.08	11.78	22,609	30,373	1.34
$N_2P_2K_2$ -Zn	15.3	13.1	13.1	30.2	23.18	5.75	9.05	21,537	21,397	0.99
RDF	15.9	13.2	13.4	30.3	24.35	5.92	9.06	20,903	23,237	1.11
Control	13.3	116.0	12.0	24.4	20.43	2.67	5.06	17,050	3,119	0.18
S.Em±	0.32	0.09	0.08	0.24	0.38	0.11	0.21	-	-	-
C.D. (P = 0.05)	0.66	0.20	0.17	0.49	0.78	0.22	0.55	-	-	-

RDF : Recommended dose of fertilizer

Table 2. Nutrients uptake by maize as influenced by different nutrient levels

Treatment	Nutrients uptake (kg / ha)											
	N			P			K			Zn		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
$N_0P_2K_2Zn$	43.09	20.91	64.0	13.88	14.13	28.0	21.38	76.59	97.97	0.306	0.357	0.66
$N_1P_2K_2Zn$	80.66	54.94	135.6	21.97	19.07	41.0	31.81	104.84	136.6	0.333	0.463	0.79
$N_2P_2K_2Zn$ (ONT)	119.25	90.18	209.4	33.08	33.73	66.8	40.68	151.60	192.3	0.516	0.677	1.19
$N_3P_2K_2Zn$	139.98	103.46	243.4	31.10	31.66	62.7	39.53	138.11	177.6	0.607	0.807	1.41
$N_2P_0K_2Zn$	57.51	48.04	105.5	11.75	11.33	23.1	21.98	91.89	113.9	0.326	0.377	0.70
$N_2P_1K_2Zn$	87.89	56.25	144.1	24.18	19.10	43.3	34.43	105.37	139.8	0.427	0.463	0.89
$N_2P_3K_2Zn$	115.75	83.56	199.3	35.48	38.34	73.8	37.85	138.50	176.3	0.496	0.613	1.10
$N_2P_2K_0Zn$	68.08	39.66	107.7	15.24	15.15	30.4	18.21	63.66	81.8	0.316	0.393	0.70
$N_2P_2K_1Zn$	94.48	49.65	144.1	22.85	19.57	42.4	31.34	101.40	132.7	0.407	0.483	0.89
$N_2P_2K_3Zn$	114.10	84.40	198.5	28.25	23.58	51.8	45.05	161.45	206.5	0.507	0.653	1.16
$N_2P_2K_2$ -Zn	73.91	47.59	121.5	18.86	16.00	34.8	29.33	92.18	121.5	0.236	0.307	0.54
RDF	77.73	49.31	127.0	20.30	18.43	38.7	31.03	95.99	127.0	0.337	0.417	0.75
Control	30.56	16.67	47.2	9.57	7.62	17.2	13.83	51.22	65.0	0.173	0.187	0.36
S.Em±	2.23	1.58	7.30	1.07	1.28	2.20	1.12	1.99	6.74	0.02	0.02	0.43
C.D. (P=0.05)	4.61	3.26	15.06	2.20	2.64	4.54	2.31	4.12	13.94	0.05	0.04	0.88

Table 3. Nutrient balance (kg / ha) in soil after harvest of maize as influenced by different nutrient levels

Treatment	Nutrients added			Nutrients removed (B)			Soil available nutrients (C)			Actual gain/loss (C-A*)		
	N	P	K	N	P	K	N	P	K	N	P	K
$N_0P_2K_2Zn$	0	76	88	64.0	28.0	97.97	152	15.3	276	-27	0.9	4
$N_1P_2K_2Zn$	150	76	88	135.6	41.0	136.6	166	16.1	285	-11	1.7	13
$N_2P_2K_2Zn$ (ONT)	200	76	88	209.4	66.8	192.3	177	19.0	302	0	4.6	30
$N_3P_2K_2Zn$	250	76	88	243.4	62.7	177.6	190	18.5	292	13	4.1	20
$N_2P_0K_2Zn$	200	0	88	105.5	23.1	113.9	157	11.3	276	-20	-3.1	4
$N_2P_1K_2Zn$	200	57	88	144.1	43.3	139.8	165	16.5	281	-12	2.1	9
$N_2P_3K_2Zn$	200	95	88	199.3	73.8	176.3	172	19.8	287	-5	5.4	15
$N_2P_2K_0Zn$	200	76	0	107.7	30.4	81.8	155	15.5	256	-22	1.1	-16
$N_2P_2K_1Zn$	200	76	66	144.1	42.4	132.7	162	17.0	286	-15	2.6	14
$N_2P_2K_3Zn$	200	76	110	198.5	51.8	206.5	170	18.2	316	-7	3.8	44
$N_2P_2K_2$ -Zn	200	76	88	121.5	34.8	121.5	160	14.3	268	-17	-0.1	-4
RDF	135	62.5	50	127.0	38.7	127.0	162	14.9	273	-15	0.5	1
Control	0	0	0	47.2	17.2	65.0	144	9.40	250	-33	-5	-22

*Initial status 177-14.4-272 kg N-P-K / ha (A)

Net returns and B:C were significantly influenced by various levels of fertilization (Table 1). Net returns and B:C increased significantly with each successive increase in fertility level and on mean basis, net returns and B:C were higher (₹ 35,137 and 1.52) with application of 250-76-88-7.4 kg N-P-K-Zn / ha. The recommended dose of fertilizer with 135-62.5-50-5.5 kg N-P-K-Zn / ha recorded the net income of ₹23,237 / ha with the benefit : cost of 1.11.

Available nutrients in soil after harvest were affected significantly due to various fertility levels (Table 3). Significant variation in available N, P and K in soil was observed with each successive increase in fertility level. The highest available N (190 kg / ha) and the balance (7.34 %) was recorded with 250-76-88-7.4 kg N-P-K-Zn / ha over initial soil fertility level. The highest available Zn was also found in this treatment. Similar trend was found with available P and K. The highest available P (19.8 kg / ha) and the balance (37.5 %) was observed with the application of 200-95-88-7.4 kg N-P-K-Zn / ha. The highest available K (316 kg / ha) and the balance (16.2 %) were observed with the application of 200-76-110-7.4 kg N-P-K-Zn / ha. With increase in the level of fertility (N, P and K) also assured the availability of these nutrients to the crop plants in adequate amount and remained in soil in substantial quantity after fulfilling the crop requirement that ultimately improved the soil fertility. These results are in agreement with the findings of Brar *et al.* (2006).

Significantly higher soil fertility (177, 19, 302 and 3.02 kg N, P, K and Zn / ha) were recorded with 200-76-88-7.4 kg N-P-K-Zn / ha compared to the recommended dose fertilizer with 135-62. 5-50-5.5 kg N-P-K-Zn / ha. The balance of N, P and K over initial soil fertility was 0, 31.9 and 11.1 % , respectively with application of 200-76-88-7.4 kg N-P-K-Zn / ha. The increase in P and K content might be due to an increased level of P and K fertilizers added to the soil. Similar results were reported by Arvind Verma *et al.* (2005) and Mahua Banerjee *et al.* (2006).

It was concluded that to get maximum productivity and profitability from hybrid maize variety COHM 5 in Alfisols of Tamil Nadu, the crop should be fertilized with 250-76-88-7.4 kg N-P-K-Zn / ha.

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