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Effect of Balanced Nutrition on Yield, Nutrient Uptake and Soil Fertility of Maize (*Zea mays*) in an Inceptisol of Tamil Nadu

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ABSTRACT

A field experiment was conducted during July – October of 2007-2008 and 2008-2009 to study the effect of balanced inorganic fertilizers on yield and nutrient uptake of maize (COHM 5) in Mayamankuruchi soil series of Tamil Nadu. The nutrient sorption study was conducted to evaluate optimum nutrient treatment (ONT). The optimum nutrient requirements were fixed as 200-64- 48 -4.8 kg N-P-K-Zn ha^{-1} for this soil series belongs to the order of Inceptisol. 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 as influenced by various levels of fertilizers in this soil series was found to be significant and the highest grain and stover yield (8.00 and 14.39 t ha^{-1}) was recorded in treatment that received 250-64- 48 -4.8 kg N-P-K-Zn ha^{-1}, respectively. The highest total N and Zn uptake (260.8 and 1.60 kg ha^{-1}) was noted from the application of 250-64- 48 -4.8 kg N-P-K-Zn ha^{-1}. Similarly, the maximum total P and K uptake (74.8 and 216.2 kg ha^{-1}, respectively) was observed from the enhanced levels of P and K application (200-80-48-4.8 and 200-64-60-4.8 kg N-P-K-Zn ha^{-1}. The available N- P-K-Zn content of soil was found to be higher due to the enhanced levels of applied nutrients to the soil. The highest net returns (Rs 38,102 / ha) and net B:C ratios (1.72) were obtained in treatment applied with 250-64-48-4.8 kg N-P-K-Zn ha^{-1}.

Key words : Available nutrients, Grain yield, Inceptisol, Maize, Nutrient uptake, Optimum nutrient treatment.

Maize (*Zea mays* L.) is the third most important cereal crop of world and India after wheat and rice. 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^{-1} (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^{-1} (Anon. 2005). This yield gap is due to inadequate and imbalanced fertilization and lack of distinct fertilizer recommendations for various varieties and hybrids grown. The future sustainability of the crop 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 nutrition for higher yield of maize and soil fertility in benchmark soil series of Mayamankuruchi (Myk) belongs to the order of Inceptisol, which is one of the major maize growing soils in Trichy, Madurai, Dindugal, Tirunelveli and Tuticorin districts of Tamil Nadu with a total extent of 1,97,020 ha.

MATERIAL AND METHODS

The field was located in Ramayanpatti village in Tirunelveli district of Tamil Nadu. The Mayamankuruchi series is a member of fine, mixed, isohyperthermic family of *Typic* Haplusteps. Typically this series soils are sandy loam to sandy clay loam, neutral to non-calcareous in A horizon, clay loam to clay or gravelly clay, mild alkaline in B horizon, moderately well drained with neutral to mildy alkaline, deep with moderately rapid permeability. The soil reaction was 8.07 and the soluble salt content is within the permissible limits. The cation exchange capacity of the soil was 31.2 c mol (p^+) kg^{-1}. The soil was low in available nitrogen (230.3 kg ha^{-1}) and medium in available phosphorus (18.4 kg ha^{-1}) and high in available potassium (292 kg ha^{-1}). It contained 31.5 c mol (p^+) / kg exchangeable Ca and 6.7 c mol (p^+) / kg exchangeable Mg. The available Zn, Fe, Cu and Mn were 2.91, 42.5, 4.26 and 20.4 mg kg^{-1}, 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)

Table 1. Effect of treatments on yield parameters, economics of hybrid maize 'COHM 5'. (2 years pooled data)

S. No.	Treatments	Cob length (cm)	Cob girth (cm)	Grain rows cob^{-1}	Grainsrow^{-1}	100 grainswt (g)	Grain yield (kg ha^{-1})	Stover yield (t ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
1.	$N_0P_2K_2Zn$	14.4	12.3	12.7	27.5	21.70	3.22	6.19	19,408	4,918	0.25
2.	$N_1P_2K_2Zn$	15.7	13.4	14.2	30.3	23.86	6.17	10.25	21,038	25,159	1.19
3.	$N_2P_2K_2Zn$ (ONT)	19.2	14.9	14.7	33.9	25.69	7.26	12.22	21,583	32,872	1.52
4.	$N_3P_2K_2Zn$	19.7	15.3	15.4	37.8	28.06	8.00	14.39	22,133	38,102	1.72
5.	$N_2P_0K_2Zn$	15.3	12.4	13.4	28.8	23.85	3.78	7.90	20,533	8,266	0.40
6.	$N_2P_1K_2Zn$	16.3	13.6	14.3	31.2	24.59	6.31	10.11	21,733	25,143	1.16
7.	$N_2P_3K_2Zn$	18.3	14.8	14.8	35.5	26.52	7.07	11.25	22,533	30,278	1.34
8.	$N_2P_2K_0Zn$	16.2	13.4	13.2	29.3	24.32	3.95	7.09	21,223	8,513	0.40
9.	$N_2P_2K_1Zn$	17.2	14.1	14.1	30.8	25.07	6.23	9.93	21,493	24,817	1.54
10.	$N_2P_2K_3Zn$	18.3	14.7	14.6	35.9	26.98	7.17	11.75	21,673	31,267	1.44
11.	$N_2P_2K_2$ -Zn	16.0	13.1	13.2	31.2	23.34	5.86	9.25	20,985	22,721	1.08
12.	Blanket	17.3	13.2	13.7	31.9	25.42	6.08	9.56	20,903	24,329	1.16
13.	Control	13.3	11.8	12.2	24.8	20.61	2.80	5.51	17,150	3,957	0.23
	SEm±	0.18	0.10	0.10	0.24	0.35	1.18.	0.15	-	-	-
	CD (P=0.05)	0.38	0.21	0.21	0.49	0.71	2.44	0.30	-	-	-

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 2007-2008 and 2008-2009 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 0-64-48-4.8 kg ha^{-1} ,
T_{2-} $N_1P_2K_2Zn$ as 150-64-48-4.8 kg ha^{-1} ,
T_3- $N_2P_2K_2Zn$ (ONT) as 200-64-48-4.8 kg ha^{-1}
T_4- $N_3P_2K_2Zn$ as 250-64-48-4.8 kg ha^{-1}
T_5- $N_2P_0K_2Zn$ as 200-0-48-4.8 kg ha^{-1}
T_6-$N_2P_1K_2Zn$ as 200-48-48-4.8 kg ha^{-1}
T_7-$N_2P_3K_2Zn$ as 200-80-48-4.8 kg ha^{-1}
T_8- $N_2P_2K_0Zn$ as 200-64-0-4.8 kg ha^{-1}
T_9- $N_2P_2K_1Zn$ as 200-64-36-4.8 kg ha^{-1}
T_{10}- $N_2P_2K_3Zn$ as 200-64-60-4.8 kg ha^{-1}
T_{11}- $N_2P_2K_2$ -Zn as 200-64-48-0 kg ha^{-1}
T_{12}- RDF as 135-62.5-50-5.5 kg ha^{-1}
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^{-1} 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 guide lines of Crop Production Guide of Tamil Nadu Agricultural University. 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). Full dose of P, K and Zn and one third of N were applied to maize as basal at the time of sowing. The remaining dose of N was top dressed in two equal splits at 25 and 45 days after sowing. Growth and yield attributes were recorded as per standard procedures. The observations of biometric and yield attributes such as plant height (45 and 75

Table 2. Effect of treatments on nutrient uptake (kg ha^{-1}) by maize COHM 5 .

Treatment	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})			Zn uptake (kg ha^{-1})		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
$N_0P_2K_2Zn$	46.2	26.3	72.5	12.3	14.8	27.1	23.1	78.0	101.1	0.30	0.37	0.68
$N_1P_2K_2Zn$	87.2	62.7	149.9	21.8	20.4	42.3	35.9	107.8	143.7	0.40	0.55	0.95
$N_2P_2K_2Zn$ (ONT)	122.5	96.9	219.4	31.2	30.0	61.3	47.5	153.5	201.0	0.57	0.78	1.35
$N_3P_2K_2Zn$	140.9	119.9	260.8	26.1	24.0	50.1	44.4	132.3	176.6	0.66	0.94	1.60
$N_2P_0K_2Zn$	63.2	46.4	109.6	10.1	10.8	20.8	24.5	91.1	115.7	0.37	0.42	0.79
$N_2P_1K_2Zn$	91.6	68.5	160.1	26.2	19.7	45.9	34.7	102.5	137.2	0.42	0.56	0.98
$N_2P_3K_2Zn$	124.5	84.8	209.3	39.1	35.7	74.8	42.0	140.7	182.7	0.50	0.68	1.18
$N_2P_2K_0Zn$	70.3	36.8	107.1	13.9	17.1	31.1	20.5	61.5	81.9	0.38	0.42	0.79
$N_2P_2K_1Zn$	100.4	57.1	157.6	23.6	21.2	44.8	31.3	103.5	134.8	0.43	0.59	1.03
$N_2P_2K_3Zn$	122.6	88.9	211.5	28.9	28.6	57.5	53.9	162.3	216.2	0.53	0.70	1.23
$N_2P_2K_2$ -Zn	71.4	42.4	113.9	16.5	15.9	32.4	29.8	91.4	121.2	0.24	0.32	0.56
RDF	87.0	45.5	132.5	20.2	19.3	39.6	31.4	98.0	129.4	0.39	0.45	0.85
Control	30.0	18.2	48.2	8.5	8.1	16.7	14.0	53.8	67.8	0.20	0.18	0.38
SEm±	3.46	1.39	7.73	0.73	1.64	2.16	1.28	3.56	6.94	0.02	0.04	0.05
CD (P=0.05)	7.13	2.88	15.96	1.51	3.37	4.46	2.64	7.35	14.32	0.04	0.09	0.99

DAS and at harvest), cob length, cob girth, grain rows / cob, number of grains / row, test weight, grain yield, dry matter production and the benefit : cost ratio were calculated and statistically analysed. 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.

RESULT AND DISCUSSION

Yield attributes and yield

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 (19.7 cm), maximum cob girth (15.3 cm), highest number of grain rows per cob (15.4), grains / row (37.8) and the test weight (28.1) were obtained from the treatment with 250-64-48-4.8 kg N-P-K- Zn /ha followed by the optimum nutrient treatment with 200-64-48-4.8 kg N-P-K-Zn / ha (19.2 cm), (14.9 cm), (14.7), (33.9) and (25.7g) (Table 1). The recommended dose fertilizer gave the lower values of growth and yield attributes than the ONT (T_3). The treatments were omitted with N or P or K recorded the lowest values which was closer to the absolute control. Similar findings were also reported earlier by Singh *et al.*, (2006) and Sahoo and Mahapatra (2007) on yield attributes of maize as influenced by higher dose of NPK application.

Significantly highest grain and stover yield (8.00 and 14.39 t ha^{-1}) were recorded with the application of 250-64-48-4.8 kg N-P-K-Zn ha^{-1} . The

Table 3. Nutrient balance (kg ha^{-1}) after harvest of maize COHM 5

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	64	48	72.5	27.1	101.1	217	20.7	315	-13.3	2.3	23
$N_1P_2K_2Zn$	150	64	48	149.9	42.3	143.7	236	21.7	321	5.7	3.3	29
$N_2P_2K_2Zn$ (ONT)	200	64	48	219.4	61.3	201.0	244	23.9	335	13.7	5.5	43
$N_3P_2K_2Zn$	250	64	48	260.8	50.1	176.6	256	22.9	330	25.7	4.5	38
$N_2P_0K_2Zn$	200	0	48	109.6	20.8	115.7	233	16.6	310	2.7	-1.8	18
$N_2P_1K_2Zn$	200	48	48	160.1	45.9	137.2	237	21.9	318	6.7	3.5	26
$N_2P_3K_2Zn$	200	80	48	209.3	74.8	182.7	240	24.7	325	9.7	6.3	33
$N_2P_2K_0Zn$	200	64	0	107.1	31.1	81.9	231	20.8	281	0.7	2.4	-11
$N_2P_2K_1Zn$	200	64	36	157.6	44.8	134.8	233	21.9	312	2.7	3.5	20
$N_2P_2K_3Zn$	200	64	60	211.5	57.5	216.2	239	22.7	338	8.7	4.3	46
$N_2P_2K_2$ -Zn	200	64	48	113.9	32.4	121.2	229	20.6	308	-1.3	2.2	16
RDF	135	62.5	50	132.5	39.6	129.4	231	21.1	312	0.7	2.7	20
Control	0	0	0	48.2	16.7	67.8	208	15.8	278	-22.3	-2.6	-14

*Initial status 230.3-18.4-292 kg N-P-K ha^{-1} (A)

application of 200-64-48-4.8 kg N-P-K-Zn ha^{-1} resulted in the next highest grain and stover yields (7.26 and 12.22 t ha^{-1}, respectively). The recommended dose of fertilizer recorded the lower grain and stover yield (6.08 and 9.56 t ha^{-1}) than the treatment enhanced with N or P or K. The treatments omitted with N or P or K or Zn was preformed with poor yield and which were very closer to the absolute control. The treatment with 250-64-48-4.8 kg N-P-K-Zn ha^{-1} gave 31.7 % highest grain yield than recommended dose fertilizer and the treatment with 200-64-48-4.8 kg N-P-K-Zn ha^{-1} recorded 19.6 % higher grain yield than RDF. The increase 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. These findings are in close conformity with the earlier findings of Verma *et al.,* (2005) and Parasuraman, (2006).

Nutrients uptake

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 250:64:48:4.8 kg N-P-K-Zn ha^{-1} recorded the highest N and Zn uptake (260.8 and 1.60 kg ha^{-1}) that was significantly higher than that of RDF with 135-62.5-50-5.5 kg N-P-K-Zn ha^{-1} (132.5 and 0.85 kg ha^{-1}). The treatment without N application gave the lowest N uptake (72.5 kg ha^{-1}) and which was on par with the absolute control (48.2 kg ha^{-1}). This increase was mainly due to higher N application. The findings of Rana and Choudhary (2006) and Hile *et al*. (2007) confirmed these results. The highest P uptake (74.8 kg ha^{-1}) was recorded with the application of 200:80:48:4.8 kg N-P-K-Zn ha^{-1} than that of RDF with 135-62.5-50-5.5 kg N-P-K-Zn ha^{-1} (39.6 kg ha^{-1}). The higher doses of P fertilizers had influenced higher uptake. Similar results were reported by Kedar Prasad *et al*. (2005). The highest K uptake (216.2 kg ha^{-1}) was noticed for the treatment with

200:64:60:4.8 kg N-P-K-Zn ha^{-1} . This was due to the balanced supply of all nutrients to plants at all stages of crop growth. It is in accordance with the finding of Surendra Singh and Sarkar (2001). The lowest uptake of N, P, K and Zn was in treatments were omitted with N or P or K and in absolute control.

Economics

Net returns and B:C ratio was significantly influenced by various levels of fertilization (Table 2). Net return and B:C ratio increased significantly with each successive increase in fertility level and on mean basis, net returns and B:C ratio were highest (Rs 38,102 and 1.72) with application of 250-64-48-4.8 kg N-P-K-Zn ha^{-1} . The recommended dose of fertilizer with 135-62.5-50-5.5 kg N-P-K-Zn ha^{-1} recorded the net income of Rs.24,329 ha^{-1} with the benefit : cost ratio of 1.16.

Effect on soil fertility

Available nutrient in soil after harvest were affected significantly due to various fertility levels. Significant variation in available N, P and K in soil was observed with each successive increase in fertility level (Table 3). The highest available N (256 kg ha^{-1}) and the balance (11.1%) was recorded with 250:64:48:4.8 kg N-P-K-Zn ha^{-1} over initial soil fertility level. The highest available Zn was also found for this treatment. Similar trend was found with available P and K. The highest available P (24.7 kg ha^{-1}) and the balance (34.2 %) was observed with the application of 200:80:48:4.8 kg N-P-K-Zn ha^{-1} . The highest available K (338 kg ha^{-1}) and the balance (15.7 %) was observed with the application of 200:64:60:4.8 kg N-P-K-Zn ha^{-1} . 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. It was confirmed by the findings of Mahua Banerjee *et al*., (2006) and Law Fang Wu and Zhu Ouyan (2006).

Significantly higher soil fertility (244, 23.9, 335 and 3.38 kg N, P, K and Zn ha^{-1}) were recorded with 200:64:48:4.8 kg N-P-K-Zn ha^{-1} compared to the recommended dose fertilizer with 135-62.5-50-5.5 kg N-P-K-Zn ha^{-1} . The balance of N, P and K over initial soil fertility was 5.9, 29.9 and 14.7 % , respectively with application of 200:64:48:4.8 kg N-P-K-Zn ha^{-1} . The increase in P and K content might be due to an increased level of P and K fertilizers added in the soil. Similar results were reported by Arvind Verma *et al*. (2005).

It was concluded that to get maximum productivity and profitability from hybrid maize variety COHM 5 in Inceptisol of Tamil Nadu, the crop should be fertilized with 250:64:48:4.8 kg N-P-K-Zn ha^{-1} .

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