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Effect of omission of nutrients on productivity, uptake of nutrients in maize (*Zea mays* L.) and residual soil fertility in Dystrudept of Nagaland

MARY LALFAKZUALI AND Y.K. SHARMA*

Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema - 797106, Nagaland, India

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ABSTRACT

A field experiment was conducted at the research farm, SASRD, Nagaland University, Medziphema during the Kharif season of 2019 to study the productivity of maize (Zea mays L.) as influenced by nutrient omission in Dystrudept of Nagaland. The experiment was laid out in randomized block design (RBD) with three replications and seven treatments. Results revealed that growth, yield attributes and yield of maize were found significantly superior under the treatment where all the nutrients (N, P, K, Zn, B, lime) were applied. It was observed that the most limiting nutrient for the growth and yield of maize was nitrogen followed by phosphorus and lime. Omission of N, P, K, Zn, B and lime reduced grain yield to the extent of 24.6, 21.0, 13.6, 8.0, 9.1 and 17.4%, respectively over all the treatment. The nutrient uptake by maize was found significantly higher in the treatment with all nutrients. Omission of various nutrients significantly reduced the nutrient uptake by maize. Omission of N, P, K, Zn and B reduced their respective uptake by 55.5, 63.1, 43.7, 24.0 and 25.8%, respectively over all the nutrients treatment. Lime omission declined Ca and Mg uptake by 47.2 and 44.5%, respectively. The available major and micro nutrients in post-harvest soil were found significantly higher under the treatment which contains all the nutrients. Omission of N, P, K, Zn and B significantly reduced their respective available content in post harvest soil and lime omission significantly reduced ex. Ca and Mg content of experimental soil. Soil pH was significantly lower and total potential acidity was significantly higher in lime omitted plots.

Keywords: Maize, nutrient omission, growth, yield, nutrient uptake, soil properties

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the agricultural economy of the world both as requirement for man and as feed for the animals. In India, maize is the third most important cereal crop cultivated after rice and wheat and *Kharif* is the most important season which covers about 80% of the total area of maize cultivation in India. Fertilizer use has been the key element of this remarkable situation including the high yielding genotypes to realize the potential yield. Presently there is either a plateau or decline in the productivity of many crops across the country, despite earlier steady increase in productivity. The stagnation in crop productivity has been found due to deficiency of some micro and secondary nutrients. Use of high analysis NPK fertilizers, free from micronutrients, limited use of organic manures and restricted recycling of crop residues are some important factors have contributed towards accelerated exhaustion of secondary and micronutrients from soil. Site specific nutrient management refers to the productive, field specific nutrient management system in a crop or cropping system with a view to optimize the demand and supply of nutrients according to their differences in cycling of nutrients through their soil-plant systems (Wang *et al.* 2007). Almost all the soils in Nagaland are deficient in nitrogen and phosphorus and medium to high in potassium (Konyak *et al.,* 2020), while other micronutrients like Fe, Mn, Cu, B and Mo may be sufficient for low to medium level of crop production but may not be sufficient for high level of crop production. Adoption of Nutrient Expert-based field specific fertilizer recommendations can create opportunities for maximizing fertilizer efficiency and productivity of a crop. Keeping these aspects in view, the present study was undertaken to assessment of nutrient deficiencies in maize through nutrient omission to achieving attainable yield in Dystrudept of Nagaland.

**Corresponding author, Email: yk2310sharma@rediffmail.com, Mobile: 9436263619*

MATERIALS AND METHODS

A field experiment was conducted at School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema Campus, during June to September, 2019 with maize (Var. RCM-76) as test crop. The experimental field is situated at at an elevation of 310 meters above mean sea 25° 45' 43" N latitude and 93° 53' 04" E longitude level. The soil of experimental field was sandy clay loam in texture with pH 5.0, organic carbon 12.8 g kg^{-1}, soil available N, P and K status 220, 22 and 128 kg ha^{-1}, and available Zn and B status 0.68 and 0.33 mg kg^{-1}, respectively. Exchangeable Ca^{2+}, Mg^{2+} and total potential acidity were 1.2, 0.61 and 11.89 cmol kg^{-1}, respectively. The experiment was laid out in randomized block design with three replications. The treatments were T_1: N_{120} P_{60} K_{60} Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}, T_2: N_0 P_{60} K_{60} Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}, T_3: N_{120} P_0 K_{60} Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}, T_4: N_{120} P_{60} K_0 Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}, T_5: N_{120} P_{60} K_{60} Zn_0 $B_{0.5}$ + 300 kg lime ha^{-1}, T_6: N_{120} P_{60} K_{60} Zn_{10} B_0 + 300 kg lime ha^{-1} and T_7: N_{120} P_{60} K_{60} Zn_{10} $B_{0.5}$ + 0 kg lime ha^{-1}. Calculated amount of N, P, K, Zn and B were supplied through urea, single superphosphate, muriate of potash, zinc sulphate ($ZnSO_4 7H_2O$) and boric acid, respectively. Half dose of nitrogen and full dose of phosphorus, potassium, zinc and boron were applied at sowing time as basal application. Remaining dose of nitrogen was applied in two splits *i.e.* half at 30 DAS and the remaining half at 60 DAS as top dressing. Lime ($CaCO_3$) was applied 5 days before sowing as basal. The seed was sown by line sowing at 1.5 cm depth, maintaining row to row 60 cm and plant to plant 20 cm apart on 17th of June, 2019. To maintain the planting geometry, thinning was done at 15 DAS. The weed growth was suppressed by hand weeding as and when required. The data on plant height, cob length, grains per cob, grain and stover yield were recorded at harvest. Nitrogen content in plant samples was determined by Kjeldahl method. Phosphorus, potassium, calcium, magnesium and boron content in plant samples were determined in di-acid (HNO_3-$HClO_4$) digestion by using standard procedures as advocated by Jackson (1973). The Ca and Mg in di-acid digestion of plant samples were determined by versenate (EDTA) method and zinc was determined by atomic absorption spectrophotometer. Nutrient uptake was calculated by multiplying grain and stover yields with their respective nutrient contents. The post harvest soil samples were collected and analyzed for pH, organic carbon, available N, P and K by using standard procedures (Jackson, 1973). For available P, soil samples were extracted with Bray P-1 extractant (Bray and Kurtz, 1945) and phosphorus content in soil extract was determined as described by Jackson (1973). DTPA extractable zinc was determined using atomic adsorption spectrophotometer (Lindsay and Norvell, 1978) and available boron by Azomethine-H method (Gupta, 1967). Exchangeable calcium and magnesium was determined by versenate method. The total potential acidity was determined by $BaCl_2$-triethanolamine buffered extract maintained at pH 8-8.2 as outlined by Baruah and Barthakur (1997). The data were analyzed statistically to compare the treatment effects (Panse and Sukhatme, 1961).

RESULTS AND DISCUSSION

Growth and yield

Omissions of various nutrients significantly affect the plant height of maize (Table 1). Maximum plant height (227.0 cm) was observed in plots treated with all the nutrients followed by omission of K treatment (219.4 cm), meanwhile the minimum plant height (202.6 cm) was observed in N-omitted treatment (202.6 cm). Omission of N, P, K, Zn, B and lime reduced the plant height by 10.8, 6.4, 3.4, 4.6, 4.2 and 6.8%, respectively over all the nutrients. It was observed that the most limiting nutrient for growth was N followed by lime and phosphorus. Application of all nutrients might have enhanced cell division and metabolic activities in plant systems which in resulted enhanced plant growth. Similar result was obtained by Sahu *et al.* (2017), Sushma and Sao. (2018). The cob length of maize was found to be significantly highest (20.1 cm) with all nutrients and lowest (16.3 cm) with omission of N treatment. Maximum decrement in cob length (18.9%) was recorded with omission of N and minimum reduction (6.0%) was observed with potassium omission indicating that nitrogen is very important plant nutrient. The treatment (T_1) which received all the nutrients recorded highest

(447.8) and omission of N (T_2) recorded lowest (370.2) number of grains cob^{-1}, respectively. The grain yield of maize varied from 2.99 to 3.97 t ha^{-1} irrespective of the treatments. Highest grain yield was recorded in all the nutrients treatment (3.97 t ha^{-1}) followed by omission of Zn which was at par with omission of B. The lowest grain yield was found with omission on N. The omission of N, P, K, Zn, B and lime reduced grain yield to the extent of 24.6, 21.0, 13.6, 8.0, 9.1 and 17.4%, respectively over all the nutrients. The reduction in grain yield was higher with the omission of N and P. Irrespective of treatments stover yield of maize varied from 3.94 to 5.10 t ha^{-1}. The highest stover yield was recorded in the treatment which received all nutrients (5.10 t ha^{-1}) followed by omission of B (4.76 t ha^{-1}) which was statistically at par with omission of Zn. The lowest stover yield was recorded in the treatment with omission of N (3.94 t ha^{-1}). Maximum reduction (22.8%) in stover yield was observed with nitrogen omission while minimum (6.6%) with omission of boron Singh, 2018).

Table 1: Effect of nutrient omission on growth and yield of maize

Treatments	Plant height (cm)	Cob length (cm)	Grain cob^{-1}	Yield (t ha^{-1})	
				Grain	Stover
T_1: N_{120} P_{60} K_{60} Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}	227.0	20.1	447.8	3.97	5.10
T_2: N_0 P_{60} K_{60} Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}	202.6	16.3	370.2	2.99	3.94
T_3: N_{120} P_0 K_{60} Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}	212.5	17.1	382.4	3.14	4.16
T_4: N_{120} P_{60} K_0 Zn_{10} $B_{0.5}$ + 300 kg lime ha^{-1}	219.4	18.9	409.6	3.43	4.48
T_5: N_{120} P_{60} K_{60} Zn_0 $B_{0.5}$ + 300 kg lime ha^{-1}	216.7	18.1	397.4	3.65	4.73
T_6: N_{120} P_{60} K_{60} Zn_{10} B_0 + 300 kg lime ha^{-1}	217.5	18.3	402.2	3.61	4.76
T_7: N_{120} P_{60} K_{60} Zn_{10} $B_{0.5}$ + 0 kg lime ha^{-1}	211.5	17.6	392.7	3.28	4.21
SEm±	2.49	0.61	9.62	0.033	0.056
CD (p=0.05)	7.66	1.88	29.64	0.101	0.173

Nutrient Uptake

Omission of different nutrients significantly reduced total N and P uptake by maize (Table 2). Nitrogen uptake was reduced by 55.5, 40.1, 19.8, 19.5, 17.3 and 40.1% due to omission of N, P, K, Zn, B and lime, respectively over all the nutrients treatment (T_1). However, phosphorus uptake was reduced to the extent of 43.4, 63.1, 19.8, 27.2, 19.3 and 46.7%, respectively with omission of N, P, K, Zn, B and lime. Maximum reduction in phosphorus uptake was recorded with omission of P followed by lime and N. Omission of potassium as well as other nutrients significantly reduced the total potassium uptake in maize. The maximum reduction (43.7%) in potassium uptake was recorded with K omission followed by N (35.6%) and P (32.2%) omission. Severe reduction in total calcium and magnesium uptake was observed with lime omission from the treatment. It was also observed that omission of N, P, K, Zn, B and lime reduced Ca uptake by 30.9, 32.4, 19.4, 16.7, 21.3 and 47.2%, respectively over all the nutrients treatment (T_1), however, omission of these nutrients decreased magnesium uptake by 33.9, 35.6, 20.4, 26.2, 23.0 and 44.5%, respectively.

Table 2: Effect of nutrient omission on total nutrient uptake of maize

Treatments	Nutrient uptake (kg ha^{-1})					Zn uptake (g ha^{-1})	B uptake (g ha^{-1})
	N	P	K	Ca	Mg		
T_1	122.3	44.2	104.5	18.7	14.5	54.5	59.2
T_2	54.3	25.0	67.3	12.9	9.6	40.5	44.4
T_3	73.3	16.3	70.8	12.6	9.3	42.6	46.5
T_4	98.1	35.4	58.8	15.0	11.5	46.8	51.0
T_5	98.4	32.2	83.8	15.5	10.7	41.4	54.3
T_6	101.1	35.7	87.1	14.7	11.1	49.0	43.9
T_7	73.2	23.5	73.4	9.8	8.0	44.4	48.2
SEm±	1.13	0.59	1.01	0.48	0.31	0.34	0.38
CD (p=0.05)	3.50	1.83	3.11	1.47	0.97	1.05	1.17

Total zinc uptake was reduced by 25.6, 21.8, 14.2, 24.0, 10.0 and 18.6% and total boron uptake by 25.0, 21.4, 14.0, 8.0, 25.8 and 18.6%, respectively with omission of N, P, K, Zn, B and lime, respectively over all the nutrients (T_1). Reduction of grain and stover yield as well as nutrient content due to omission of various nutrients might have the reason of nutrient uptake reduction. These results are in line with those of Singh (2016), Singh *et al.* (2018).

Soil fertility

A significant effect of omission of nutrients was observed on the soil pH after crop harvest (Table 3). It was recorded that omission of lime reduced pH significantly over all the nutrients (T_1). However, other treatments were at par to each other with regard to soil pH. Lime containing treatments might have reduced H^+ ions from soil complex which resulted more pH. Significantly higher total potential acidity was observed in lime omitted plots as compared to other treatments. Lime omitted treatment (T_7) recorded the highest total potential acidity (11.92 cmol kg^{-1}). Nutrient omission could not show significant effect on the organic carbon content of the post harvest soil. Highest available nitrogen was observed in all the nutrients treatment (235.0 kg ha^{-1}) and the lowest in N omission treatment (207.3 kg ha^{-1}). Highest available phosphorus (28.3 kg ha^{-1}) was recorded in all the nutrients (T_1) and lowest (23.5 kg ha^{-1}) in omission of P treatment (T_3). Omission of phosphorus and lime significantly reduced available phosphorus of post-harvest soil over other treatments. The highest available potassium in the soil (135.2 kg ha^{-1}) was recorded in all the nutrients treatment (T_1) and the lowest (120.5 kg ha^{-1}) K omission treatment (T_4). All the nutrients treatment and zinc omission treatment recorded the highest exchangeable calcium in the soil (1.26 cmol kg^{-1}), while lime omitted treatment recorded the lowest (1.19 cmol kg^{-1}). The highest exchangeable magnesium in the soil (0.63 cmol kg^{-1}) was recorded in all the nutrients and lowest (0.59 cmol kg^{-1}) in lime omission (T_7). The available zinc and boron was affected significantly due to their omission from the all the nutrients treatment (T_1). Minimum zinc and boron content in post harvest soil was recorded in those plots where these nutrients were omitted. The zinc content in soil was reduced from 0.73 to 0.65 mg kg^{-1} with its omission. Available boron was decreased from 0.35 to 0.31 mg kg^{-1} with exclusion of boron. Application of recommended dose of nutrients might have favored their accumulation in the soil and enhanced available nutrient status of post harvest soil (Gadi *et al.*, 2018 and Ao and Sharma, 2021).

Table 3: Effect of nutrient omission on post harvest soil fertility

Treatments	pH	TPA (cmol kg^{-1})	OC (g kg^{-1})	Available nutrients (kg ha^{-1})			Ex. Ca (cmol kg^{-1})	Ex. Mg (cmol kg^{-1})	Av. Zn (mg kg^{-1})	Av. B (mg kg^{-1})
				N	P	K				
T_1	5.41	11.02	12.77	235	28.3	135	1.26	0.63	0.73	0.35
T_2	5.42	11.04	12.70	207	28.0	138	1.24	0.62	0.72	0.34
T3	5.38	11.00	12.60	230	23.5	136	1.24	0.62	0.72	0.34
T_4	5.40	11.05	12.67	232	27.6	120	1.25	0.60	0.73	0.35
T_5	5.40	11.06	12.63	233	28.0	132	1.26	0.60	0.65	0.34
T_6	5.38	11.03	12.67	230	28.0	130	1.25	0.62	0.70	0.31
T_7	4.98	11.92	12.67	225	25.6	133	1.19	0.59	0.71	0.33
SEm±	0.09	0.14	0.04	2.44	0.44	2.08	0.012	0.007	0.012	0.006
CD (p=0.05)	0.27	0.44	NS	7.52	1.37	6.42	0.036	0.022	0.038	0.020

From these results, it may be concluded that application of N, P, K, Zn, B and lime 120, 60, 60, 10, 0.5, 300 kg ha^{-1}, respectively) might be beneficial in Dystrudept of Nagaland for achieving higher productivity of maize. Nitrogen and phosphorus are most limiting nutrients and their omission caused drastic reduction in grain yield. Nutrient status of post harvest soil was also improved with nutrient application.

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