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Productivity of Maize (*Zea mays* L.) as Influenced by Nutrient Omission in Inceptisols of Nagaland

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A B S T R A C T

A field experiment was conducted at the instructional farm, Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, during the *Kharif* season of 2019 to study the productivity of maize (*Zea mays* L.) as influenced by nutrient omission in Inceptisols of Nagaland. The experiment was laid out in randomized block design with three replications and seven treatments. The growth, yield attributes and yield of maize were found to be superior in the treatment where all nutrients (N, P, K, Zn, B, lime) were applied. Maximum grain and stover yield (3975.03 and 5107.66 kg ha^{-1}, respectively) were recorded with treatment T_1whereas the lowest was observed with omission of N (2996.91 and 3940.51 kg ha^{-1}, respectively).N, P, K, Zn, B and lime omission reduced grain yield to the extent of 24.6, 21.0, 13.6, 8.0, 9.1 and 17.4 % respectively over T_1 treatment. The per cent grain yield reduction based on limiting nutrients were found in the order N>P > Lime >K>B > Zn. The nutrient uptake by maize, available nitrogen, phosphorus, potassium, exchangeable calcium and magnesium, available zinc and boron in post-harvest soil were found significantly higher under the treatment T_1.

Introduction

Maize (*Zea mays* L.) belongs to family *Poaceae*, 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. *Kharif* is the most important season which covers 80% of the total area of maize cultivation in India. In the Northeast India context, maize is the second most important crop of cereal after rice, which is mostly grown in the region of upland acidic soil conditions (Marwein *et al.*, 2016).

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). Maize is a crop with wide spacing which have slow rate of growth in its early stage of crop cycle, leading to losses of water and nutrient through weed and evaporation, respectively. The key aspect of increasing production and productivity of maize relies on the application of plant nutrients in adequate and balanced quantities.

Nagaland has four types of soil based on their order *i.e.* Alfisols, Entisols, Inceptisols and Ultisols. Majority of the soils in this region falls under Inceptisols (66%). Almost all the soils in Nagaland are deficient in nitrogen and phosphorus and medium to high in potassium, 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. Proper and timely nutrition of crop in a correct amount and proper ratios and adequate supply of all essential nutrients based on crop needs is the solution in order to achieve high crop yields.

Materials and Methods

A field experiment was conducted at the instructional farm, Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, during the *Kharif* season of 2019 to study the productivity of maize (*Zea mays* L.) as influenced by nutrient omission in Inceptisols of Nagaland. The experiment was laid out in randomized block design (RBD) with three replications and seven treatments *viz.* T_1 (All- N, P, K, Zn, B, Lime), T_2 (All-N), T_3 (All-P), T_4 (All-K), T_5 (All-Zn), T_6 (All-B) and T_7 (All-Lime). The soil of the experimental farm was categorized as sandy clay loam. The recommended dose of fertilizer was 120: 60: 60: 10: 0.5: 300 N: P: K: Zn: B: Lime kg ha^{-1} 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. Seeds were sown on 17th of June, 2019.From each plot five plants were selected randomly and plant growth parameters were recorded at regular interval. Yield attributes were recorded at the time of harvest.

Nitrogen content was estimated by alkaline potassium permanganate method (Subbiah and Asija, 1956), phosphorus and potassium content by Bray's No.1 method (Brays and Kurtz, 1945) and flame photometer methods (Hanway and Heidal, 1952), respectively.

Exchangeable calcium and magnesium was determined by Versenate method (Cheng and Bray, 1951), zinc content was extracted by DTPA extractable micronutrients method (Lindsay and Norvell, 1978) and boron content was extracted by Azomethine-H colorimetric method (Berger and Truog, 1939).

Results and Discussion

Growth and yield attributes of maize

The plant height (cm) at 30 DAS was not significantly influenced by the omission of nutrients. However at 60 and 90 DAS, significant difference in the plant height was observed. The maximum height of the plant was observed in T_1 which received all nutrients (227.07 cm) followed by T_4 (219.41 cm) with omission of K, meanwhile the minimum plant height was observed in N-omitted plot T_2 (202.62 cm). It was observed that the most limiting nutrient for the growth of maize crop was N followed by lime and phosphorus (Sahu *et al.*, 2017; Sushma and Sao, 2018).

The yield attributes parameters such as number of cobs $plant^{-1}$ was not found to be significantly influenced by omission of

nutrients, while the cob length and number of grains cob^{-1} showed significant variation among the various treatments.

The cob length of maize was found to be significantly highest (20.10 cm) with T_1 which received all nutrients and lowest (16.30 cm) with omission of N treatment (T_2). Similarly, T_1 (447.83) recorded highest and T_2 (370.23) recorded lowest number of grains cob^{-1}.

Yield of maize

The grain and stover yield of maize varied from 2996.91 to 3975.03 kg ha^{-1} and 3940.51 to 5107.66 kg ha^{-1} respectively, irrespective of the treatments. The highest grain yield was recorded in T_1 with all the nutrients provided (3975.03 kg ha^{-1}) followed by T_5 with omission of Zn (3656.83 kg ha^{-1}) which was at par with T_6 with omission of B (3612.25 kg ha^{-1}). The lowest grain yield was found in T_2 with omission on N (2996.91 kg ha^{-1}). It was observed that N, P, K, Zn, B and lime omission reduced grain yield to the extent of 24.6, 21.0, 13.6, 8.0, 9.1 and 17.4 % respectively over T_1 treatment (Mishra *et al.*, 2007). The highest stover yield was recorded in T_1 which received all nutrients (5107.66 kg ha^{-1}) followed by T_6 with omission of B (4768.82 kg ha^{-1}) which was statistically at par with T_5 with omission of Zn (4730.60 kg ha^{-1}). The lowest stover yield was recorded in T_2 with omission of N (3940.51 kg ha^{-1}).

Table.1 Initial soil properties of the experimental field

Soil parameters	Value	Methods employed
pH	4.9	Digital pH meter (Jackson, 1973)
Organic carbon (g kg^{-1})	12.8	Walkley and Black method (Jackson, 1973)
Available N (kg ha^{-1})	220.8	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P (kg ha^{-1})	25.6	Bray's No.1 method (Bray and Kurtz, 1945)
Available K (kg ha^{-1})	128.3	Flame Photometer (Hanway and Heidal, 1952)
Exchangeable Ca (cmol kg^{-1})	1.2	Versenate Method (Cheng and Bray, 1951)
Exchangeable Mg (cmol kg^{-1})	0.61	Versenate Method (Cheng and Bray, 1951)
Available Zn (mg kg^{-1})	0.68	DPTA extractable micronutrients method (Lindsay and Norvell, 1978)
Available B (mg kg^{-1})	0.33	Azomethine-H method (Gupta, 1967)
Total potential acidity (cmol kg^{-1})	11.89`	$BaCl_3$-Triethanolamine extract method (Baruah and Barthakur, 1999)
Particle size distribution (%) **i) Sand** **ii) Silt** **iii) Clay**	 49.5 26.2 24.3	International pipette method (Piper, 1966)
Textural Class	Sandy Clay Loam	

Table.2 Effect of nutrient omission on growth, yield attributes and yield of maize

Treatments	Plant height (cm)			No. of cobs plant^{-1}	Cob length (cm)	No. of grains cob^{-1}	Yield (kg ha^{-1})	
	30 DAS	60 DAS	90 DAS				Grain	Stover
T_1 : All	73.80	202.57	227.07	1.33	20.10	447.83	3975.03	5107.66
T_2 : All-N	66.67	174.50	202.62	1.00	16.30	370.23	2996.91	3940.51
T_3 : All-P	66.27	183.47	212.50	1.00	17.17	382.47	3140.06	4160.28
T_4 : All-K	71.30	188.70	219.41	1.33	18.90	409.67	3435.15	4482.60
T_5 : All-Zn	69.30	185.50	216.71	1.00	18.17	397.43	3656.83	4730.60
T_6 : All-B	72.63	184.03	217.53	1.00	18.37	402.27	3612.25	4768.82
T_7 : All-Lime	69.23	183.13	211.53	1.00	17.67	392.70	3283.86	4210.45
SEm±	3.98	2.31	2.49	0.16	0.61	9.62	33.00	56.35
CD (p=0.05)	NS	7.11	7.66	NS	1.88	29.64	101.69	173.62

Note: NS = Non-significant at 5% level of significance

Table.3 Effect of nutrient omission on macro and micro nutrients uptake by maize under Inceptisol of Nagaland

	Nutrient uptake (kg ha^{-1})					Nutrient uptake (g ha^{-1})	
	N	P	K	Ca	Mg	Zn	B
T_1 : All	122.32	44.26	104.59	18.71	14.53	54.55	59.29
T_2 : All-N	54.38	25.04	67.30	12.97	9.60	40.59	44.45
T_3 : All-P	73.30	16.34	70.86	12.64	9.35	42.66	46.57
T_4 : All-K	98.10	35.46	58.87	15.07	11.56	46.82	51.00
T_5 : All-Zn	98.41	32.20	83.88	15.59	10.72	41.44	54.31
T_6 : All-B	101.14	35.73	87.12	14.72	11.18	49.07	43.96
T_7 : All-Lime	73.24	23.57	73.44	9.87	8.06	44.40	48.26
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

Fig.1 Effect of nutrient omission on macro nutrients uptake by maize under Inceptisol of Nagaland

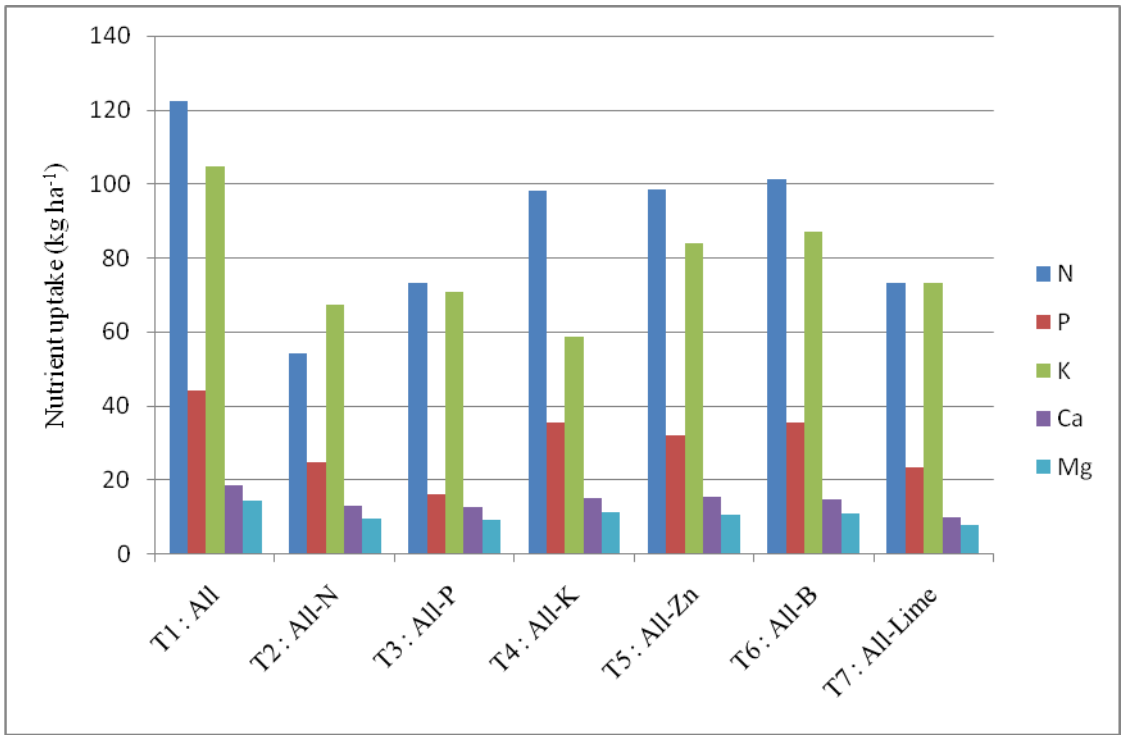
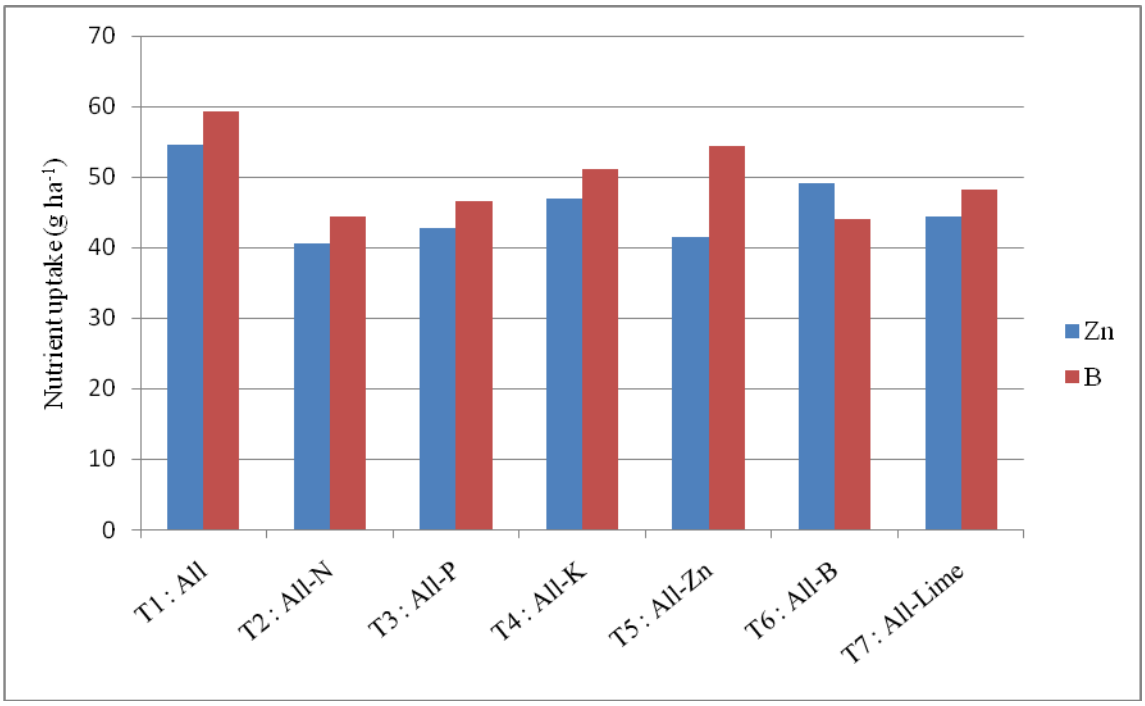


Fig.2 Effect of nutrient omission on micro nutrients uptake by maize under Inceptisol of Nagaland



Maximum reduction (22.8%) in stover yield was observed with nitrogen omission while minimum reduction (6.6%) was recorded when boron was omitted from treatments. This was in conformity with Singh *et al.,* (2018). The reductions in grain and stover yield were high with the omission of N and P. N was the most critical nutrient for optimum grain yield of the crop. The yield was significantly high where all the nutrients (N, P, K, Zn, B, Lime) were incorporated.

Nutrient uptake

Nitrogen uptake was highest in treatment T_1 (122.32 kg ha^{-1}) where all nutrients were applied and lowest was observed in nitrogen omitted plot T_2 (30.47 kg ha^{-1}). Total 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 T_1 treatment.These results are in line with those of Mishra *et al.,* (2007). All nutrients treatment T_1 (44.26 kg ha^{-1}) recorded the highest P uptake and maximum reduction was noted with omission of P (16.34 kg ha^{-1}) followed by lime and N.It was observed that omission of N, P, K, Zn, B and lime reduced total phosphorus uptake by maize to the extent of 43.4, 63.1, 19.8, 27.2, 19.3 and 46.7% respectively over T_1 (Singh, 2018). Maximum reduction (43.7%) in total potassium was recorded with K omission (58.87 kg ha^{-1}) followed by omission of N (35.6%) and P (32.2%). The highest K uptake was recorded in T_1 (104.59 kg ha^{-1}).

Calcium uptake was significantly highest in T_1 (18.71 kg ha^{-1}) and the lowest Ca uptake was observed in T_7 (9.87 kg ha^{-1}).Omission of N, P, K, Zn, B and lime reduced total Ca uptake by 30.9, 32.4, 19.4, 16.7, 21.3 and 47.2%, respectively over T_1.T_1 (14.53 kg ha^{-1}) where all nutrients were applied recorded the highest Mg uptake while lime omitted T_7 (8.06 kg ha^{-1}) recorded the lowest.Omission of N, P, K, Zn, B and lime decreased the total magnesium uptake by 33.9, 35.6, 20.4, 26.2, 23.0 and 44.5%, respectively over T_1. The zinc uptake was significantly superior in all nutrients treatment T_1 (54.55 g ha^{-1}) over all other treatments, while the lowest was recorded in N omitted treatment T_2 (40.59 g ha^{-1}). Total zinc uptake was reduced by 25.6, 21.8, 14.2, 24.0, 10.0 and 18.6% with omission of N, P, K, Zn, B and lime, respectively over T_1. T_1 recorded the highest boron uptake (59.29 g ha^{-1}) and B omitted treatment T_2 (43.96 g ha^{-1}) recorded the lowest. Omission of N, P, K, Zn, B and lime reduced total boron uptake by 25.0, 21.4, 14.0, 8.0, 25.8 and 18.6%, respectively over T_1 treatment.

Based on the above findings, 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 for achieving higher productivity of maize under Inceptisols of Nagaland. The most limiting nutrient for the growth and yield of maize was nitrogen followed by phosphorus and lime.

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