Annals of Plant and Soil Research 20(4): 349-353 (2018)

Maize (*Zea mays* L) productivity and soil properties as affected by fertility levels under Nagaland condition

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Received: August, 2018; Revised accepted:, October, 2018

ABSTRACT

A green house experiment was conducted in the Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema, Nagaland during May to September, 2016 to evaluate the effect of fertility levels on the performance of maize (Zea mays L.). The nine treatments were evaluated in crd with three replications. It was observed that plant height and number of grains per cob were affected significantly with the application of different treatments. Among the treatments, application of 120:50:50 kg NPK ha^{-1} along with biofertilizer (PSB) recorded maximum plant height and yield attributes. Maximum grain (55.2 g pot^{-1}) and stover yields (75.3 g pot^{-1}) of maize were recorded at T_9 treatment (120:50:50 kg NPK ha^{-1} + PSB). The T_9 treatment enhanced the grain and stover yield to the extent of 67.7% and 59.1% over control, respectively. Addition of biofertilizer (PSB) along with NPK proved to have a significant effect on the N, P and K content and their uptake by maize crop over control. Maximum N, P and K uptake was recorded in T_9 treatment. Addition of NPK fertilizers along with bio-fertilizer (PSB) increased the status of available nitrogen, phosphorus and potassium in the post harvest soil. Soil pH, cation exchange capacity and base saturation were not affected significantly with fertility levels. The minimum values of these parameters were recorded in control.

Key words: Maize, fertility levels, yield, nutrient uptake, soil properties

INTRODUCTION

Maize (*Zea mays* L) is an important cereal crop belonging to family *Poaceae* and has its centre of origin in Mexico. Maize is mainly a *kharif* season crop but also cultivated in *rabi* season in some places. It is grown throughout the temperate, tropical and sub-tropical zones of the world. Maize is used as human food; livestock feed and provides raw materials for industrial and pharmaceutical sectors. The demand for maize is expected to double worldwide by 2050 (Cairns *et al.* 2012). India ranks 4th in area and 7th in production of maize at the world level. Maize is considered as the third most important food crop among the cereals in India and contributes to nearly 9% of the national food basket. It is cultivated in an area of 8.55 million hectare producing 21.7 million tons with an average productivity of 2.5 t ha^{-1} (Paramasivan *et al.* 2012). In Nagaland, maize is cultivated in an area of 68,780 hectare with a production of 135,440 metric tons (Anonymous 2014). Ideal soils are rarely found in nature. Hence, soils have to be improved to suit the crop not only by adding nutrients but also by other soil amendments, like organic matter for maintaining the activity of soil organisms. As heavy feeder of nutrients, maize productivity is largely dependent on nutrient management because of which it needs fertile soil to express its yield potential. It is an exhaustive crop and requires all types of macro and micro nutrients for better growth and yield potential. Fertilizer application is one major farming operation needed to correct deficiencies in the soil in order to ensure proper growth and functioning of crops with the aim of increasing yield. However, for effective soil fertility management, the right quantity of fertilizer needs to be applied. Hybrids and composite varieties of maize exhibit their full yield potential only when supplied with adequate quantities of nutrients at proper time (Singh *et al.* 2017, Singh *et al.* 2018). Bio-fertilizers play a very significant role in maintaining soil fertility by fixing atmospheric nitrogen, both in association with plant roots and without it, solubilising insoluble phosphates and producing plant growth substance in soil. Proper application of bio-fertilizers increases the crop yield to 15-20% under field conditions. In order to realize the above mentioned aspects, an attempt was made to study the effect of fertility levels on the performance of maize and soil properties under acidic soil condition of Nagaland.

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MATERIALS AND METHODS

A pot experiment was carried out in the pot house of the Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema, Nagaland with maize (RCM-76) as the test crop. The experimental soil was sandy clay loam with pH 5.30, organic carbon 14.7 g kg^{-1}, CEC 8.8 cmol (P^{+}) kg^{-1}, base saturation 31.7% and available N, P and K status 313.6, 12.4 and 111.5 kg ha^{-1}, respectively. The experiment was laid out in CRD with nine fertility levels viz. T_1- control, T_2- 60 kg N ha^{-1}, T_3- 60 kg N + 50 kg P_2O_5 ha^{-1}, T_4- 60 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1}, T_5- 60 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1} + PSB, T_6- 120 kg N ha^{-1}, T_7- 120 kg N + 50 kg P_2O_5 ha^{-1}, T_8- 120 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1} and T_9- 120 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1} + PSB. Earthen pots of 30cm diameter size were filled with 8 kg of soil. Nitrogen, phosphorus and potash were applied through urea, single superphosphate and muriate of potash, respectively. All fertilizers were incorporated into pots two days prior to sowing of the seed. PSB was applied as soil treatment method. The pots, according to the treatment were treated with PSB (*Pseudomonas striata*) @ 5 kg ha^{-1} before sowing the seeds. Three seeds in each pot were sown on 23rd May, 2016 at a depth of 5 cm at optimum soil moisture level to ensure proper germination. Thinning was done after ten days of germination and one healthy plant in each pot was allowed to grow. Weeding was done at regular interval to check the weed growth. The data on plant height, number of leaves $plant^{-1}$, rows cob^{-1}, cob length, number of grains per cob and grain and stover yield were recorded. Nitrogen content in plant samples was analyzed by micro-Kjeldahl method **(**Jackson, 1973). Phosphorus and potassium in plant samples were determined in diacid (HNO_3, $HClO_4$) extract by advocating standard procedure (Jackson, 1973). Post crop harvest soil samples were collected and analyzed for pH, cation exchange capacity (Chapmam, 1965), base saturation, organic carbon and available N and K 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). The recorded data was analyzed statistically to compare the treatment effects (Panse and Sukhatme, 1961).

RESULTS AND DISCUSSION

Growth and yield attributes

A perusal of data (Table 1) indicates that significantly higher plant height was recorded with application of different fertility levels. All the fertility levels increased plant height significantly over control. Noticeable increase in plant height was observed with PSB application along with NPK. Application of 120 kg N ha^{-1} enhanced plant height significantly over 60 kg N ha^{-1}. Maximum plant height was recorded under treatment T_9 (120, 50, 50 kg ha^{-1} N, P_2O_5, K_2O and PSB). This shows that inorganic fertilizer application along with PSB gave better performance than sole application of inorganic fertilizers. Nitrogen application along with other nutrients increased the cell division and cell enlargement resulted improved the plant height. Number of leaves per plant and number of rows $cobs^{-1}$ could not be statistically affected by application of different fertility levels. However, the highest values of these parameters were observed with treatment T_9 (NPK @120:50:50 kg ha^{-1} + PSB) while the lowest were recorded in control. The cob length of maize increased significantly with application of different fertility levels. Cob length varied from 16.6 to 18.1 cm and the highest was found at treatment T_9 which was statistically at par with T_8 and T_7 and the lowest cob length was recorded in control. Number of grains per cob was affected significantly by different fertility levels. Application of nitrogen along with phosphorus and potassium significantly improved the number of grains per cob (Singh *et al.*, 2018). The highest number of grains per cob (372.0) was obtained from fertility level T_9. Balanced application of N, P and K improved the enzymatic and metabolic activities within plant system and photosynthates translocated to reproductive parts of the plants resulted grains per cob enhanced. PSB application increased phosphorus availability to plants by solubilising the insoluble phosphorus and improved the grain formation in the plants. These results are in accordance with those of Hameeda *et al.* (2008) and Viruel *et al.* (2014).

Table 1: Effect of fertility levels on growth, yield attributes and yield of maize

Treatment	Plant height (cm)	Leaves plant^{-1}	Rows cob^{-1}	Cob length (cm)	Grains cob^{-1}	Yield (g pot^{-1})	
						Grain	Stover
T_1: Control	124.9	6.7	9.3	13.6	290.3	32.9	47.3
T_2: 60 kg N ha^{-1}	133.0	7.0	11.0	14.7	316.0	38.6	51.3
T_3: 60 kg N + 50 kg P_2O_5 ha^{-1}	134.3	7.0	11.0	14.8	330.0	43.5	52.7
T_4: 60 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1}	136.1	7.3	11.3	15.6	337.0	45.2	55.7
T_5: 60 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1} + PSB	143.6	7.3	11.6	15.3	338.3	46.6	58.4
T_6: 120 kg N ha^{-1}	]153.5	7.6	12.3	15.4	348.3	45.1	60.4
T_7: 120 kg N + 50 kg P_2O_5 ha^{-1}	157.6	7.7	12.0	16.8	356.3	49.7	62.1
T_8: 120 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-} 1	159.3	8.3	12.0	17.2	362.8	54.1	66.1
T_9: 120 kg N+50 kg P_2O_5 + 50 kg K_2O ha^{-1} + PSB	167.2	9.3	12.6	18.1	372.0	55.2	78.9
SEm ±	3.85	0.11	0.12	0.60	12.09	2.80	4.59
CD (*P=0.05)*	13.32	NS	NS	2.08	41.82	9.69	15.88

Yield

A critical examination of the data (Table 1) revealed that different fertility levels had significant effect on grain yield of maize. Application of 60 kg N ha^{-1} (T_2) alone did not increase grain yield significantly over control, but higher amount of nitrogen (120 kg ha^{-1}, T_6) enhanced grain yield significantly over control. Phosphorus and potassium application along with nitrogen further enhanced grain yield significantly over control. The T_8 (NPK @ 120:50:50 kg ha^{-1}) increased grain yield by 64.4% over control. Similar results were reported by Singh *et al.* (2018). Maximum grain yield was recorded under T_9 fertility level (NPK @ 120:50:50 kg ha^{-1} + PSB) and this treatment increased grain yield to the extent of 67.7% over control. The application of nitrogen, phosphorus and potassium in combination with PSB provides optimum supply of nutrients at right time of crop requirement and maize responds well to fertilizer application as a result of its well developed root system. The increase in grain yield due to different fertility levels were mainly due to more number of grains per cob and better grain development due to adequate nutrient supply. Use of PSB in combination with inorganic fertilizers gave maximum grain yields. Similar results have been reported by Rajeshwari *et al.* (2007) and Amer *et al.* (2014). Different fertility levels affected stover yield remarkably over control. Treatment of T_9 resulted in highest stover yield which was found to be at par with treatment T_8 but markedly the lowest stover yield (47.3 g pot^{-1}) was recorded in T_1 (control). Application of PSB along with NPK fertilizers further increased stover yield of maize. The T_9 fertility level enhanced stover yield by 59.1% over control. The increase in stover yield may be attributed to the increased growth of maize through combine application of fertilizers and biofertilizers.

Content and uptake nutrients

Nitrogen content in grain and stover of maize increased significantly by NPK and PSB application (Table 2). The nitrogen content ranged from 1.07 to 1.70% in grain and 0.33 to 0.98% in stover. Maximum N content in grain and stover was recorded at T_9 fertility level (NPK @ 120:50:50 kg ha^{-1} + PSB), while minimum was recorded in control. Total N uptake by maize enhanced significantly with application of different fertility levels. Increase in nitrogen uptake by maize due to application T_9 fertility level (NPK @ 120:50:50 kg ha^{-1} + PSB) was recorded 227.9% over control. Phosphorus content of grain and stover improved significantly with NPK and PSB application. The P content in grain and stover ranged from 0.31 to 0.68% and 0.11 to 0.21%, respectively. Phosphorus content in stover was not affected significantly with fertility levels. Maximum P content was recorded under T_9 fertility level. The P uptake by maize increased significantly with NPK and PSB application. The data further revealed that phosphorus uptake by maize enhanced from 153.4 mg pot^{-1} in control to 525.8 mg pot^{-1} in T_9 fertility level. The T_9 fertility level enhanced P uptake by 242.7% over control. The K content in grain and stover of maize improved markedly with NPK and PSB application. Remarkable improvement in K content was observed in those pots which received potassium. The K content in

grain and stover varied from 0.32 to 0.57% and 0.80 to 1.43%, respectively. The K uptake by maize increased significantly with the application of NPK and PSB. Maximum K uptake was recorded at T_9 fertility level. Increase in potassium uptake by maize due to T_9 fertility level was 181.5% over control. Highest N, P and K uptake were recorded under T_9 treatment because of higher grain and stover yields as well as nutrient content. Combined application of NPK with biofertilizer promotes nutrient uptake in both grain and stover than the sole fertilizer application. The combined treatments improved nutrient concentration in the soil solution which was efficiently exploited by the maize plant. These findings are in accordance with those of Amer *et al.* (2014).

Table 2: Effect of fertility levels on nutrient content and their uptake by maize

Treatment	Nutrient content (%)						Nutrient uptake (mg pot^{-1})		
	N		P		K		N	P	K
	Grain	Stover	Grain	Stover	Grain	Stover			
T_1	1.07	0.33	0.31	0.11	0.32	0.80	502.1	153.4	478.3
T_2	1.32	0.52	0.42	0.14	0.34	0.86	784.3	246.3	582.8
T_3	1.36	0.57	0.55	0.17	0.41	0.92	883.7	330.5	652.8
T_4	1.44	0.60	0.58	0.18	0.55	1.14	968.5	362.9	843.0
T_5	1.42	0.61	0.63	0.19	0.54	1.17	1019.5	406.2	937.1
T_6	1.33	0.85	0.40	0.14	0.36	0.95	1117.3	271.9	738.9
T_7	1.55	0.95	0.56	0.18	0.43	1.04	1376.5	395.4	845.3
T_8	1.67	0.96	0.66	0.19	0.57	1.36	1542.6	475.5	1198.5
T_9	1.70	0.98	0.68	0.21	0.57	1.43	1646.6	525.8	1346.6
SEm ±	0.05	0.03	0.05	0.02	0.02	0.09	81.54	25.20	60.84
CD (*P=0.05)*	0.18	0.13	0.18	NS	0.09	0.32	281.95	87.14	210.37

Soil properties

The pH of the soil was not affected significantly with the application of NPK and PSB. The CEC, base saturation and organic carbon content of soil were also not affected significantly with application of different fertility levels (Table 3). The available N status ranged from 292.6 to 343.2 kg ha^{-1}. Available N enhanced remarkably with N application. Available P ranged from 11.5 to 20.5 kg ha^{-1}. A significant increase in available P status was reported with phosphorus application over control. Low available P in control pots might be due to no addition of any external input and its mining from the soil by crop. Use of PSB along with other nutrients also improved the available P of the soil might be due to secretion of some organic acid which solubilised the fixed phosphorus and convert it to plant available form. Available K content of the soil increased significantly with its application over control. A part of the added nutrients through fertilizers are utilized by the plants and rest amount is retained by the soil particles which ultimately improve the fertility status of the soils.

Table 3: Effect of fertility levels on soil properties

Treatment	pH	CEC [cmol (P^+) kg^{-1}]	BS (%)	Organic carbon (g kg^{-1})	Available nutrients (kg ha^{-1})		
					N	P	K
T_1	5.30	8.70	30.90	13.5	292.6	11.5	105.3
T_2	5.36	8.80	31.60	13.6	320.5	12.8	104.3
T_3	5.33	8.90	32.00	14.1	325.7	19.6	107.0
T_4	5.16	8.76	31.76	13.8	325.8	19.6	138.7
T_5	5.26	8.96	33.46	15.3	326.6	20.5	143.6
T_6	5.23	9.20	32.53	15.0	341.8	13.6	100.7
T_7	5.30	9.44	33.66	14.3	340.4	19.6	109.1
T_8	5.26	9.55	34.70	14.9	341.5	19.7	144.6
T_9	5.33	9.66	34.80	14.4	343.2	20.5	146.3
SEm ±	0.08	0.16	2.03	0.06	15.24	2.04	7.46
CD (*P=0.05)*	NS	NS	NS	NS	52.72	7.06	25.80

Hence N, P and K application may be helpful in improving the soil health in terms of available nitrogen, phosphorus and potassium. Similar findings have been reported by Verma and Mathur (2009).The results of the present study lead to a conclusion that application of NPK @ 120:50:50 kg ha^{-1} + PSB produced taller plants higher, cob length, number of grains cob^{-1}, grain and stover yield of maize. The N, P and K contents and their uptake improved remarkably by NPK and PSB application. Available N, P and K status of the post crop harvest soil also improved with the use fertilizers. Hence, application of NPK @ 120:50:50 kg ha^{-1} + PSB is recommended for better yield of maize in Nagaland.

REFERENCES

Amer, W., Sharma, Y. K. and Sharma, S. K. (2014) Response of maize to integrated nutrient management in acidic soils of Nagaland. *Annals of Plant and Soil Research* **16**(4):349-352.

Anonymous (2014) Statistical Handbook of Nagaland. Directorate of Agriculture, Nagaland, Kohima.

Bray, R.H. and Kurtz, L.T. (1945) Determination of total, organic and available forms of phosphorus in soils. *Soil Science* **59**: 39-45.

Cairns, J. E., Sonder, K., Zaidi, P. H., Verhulst, N., Mahuku, G., Babu, R., Nair, S. K., Das, B., Govaerts, B., Vinayan, M. T.,Rashid, Z., Noor, J. J., Devi, P., Vicente, F. S. and Prasanna, B. M. (2012) Maize production in a changing climate: Impacts, adaptation and mitigation strategies. *Advances in Agronomy* **114**(1):1-58.

Chapmam, H.D. (1965) Cation exchange capacity: in Methods of Soil Analysis, Part II (C.A. Black, Ed) 891-901*, American Society of Agronomy,* Madison, Wisconsin, USA.

Hameeda, B., Harini, G., Rupela, O. P., Wani, S. P. and Reddy, G. (2008) Growth promotion of maize by phosphate-solubilizing bacteria isolated from composts and macrofauna. *Microbiological Research* **163(2):**234-242.

Jackson, M.L. (1973) Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd. New Delhi.

Panse, V.G. and Sukhatme, P.V. (1961) *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.

Paramasivan, M., Malarvizhi, P. and Thiyageswari, S. (2012) Balanced use of inorganic fertilizers on maize *(Zea mays*) yield, nutrient uptake and soil fertility in Alfisols*. Karnataka Journal of Agriculture* **25(4)**:423-426.

Rajeshwari, R. S., Hebsur, N. S., Pradeep, H. M. and Bharamagoudar, T. D. (2007) Effect of integrated nutrient management on growth and yield of maize. *Karnatake Journal of Agriculture Sciences* **20(2)**:399-400.

Singh, M.V., Kumar, N. and Srivastava, R. K.(2017) Effect of nitrogen and its scheduling on growth, yield and economics of rabi maize (*Zea mays* L.). *Annals of Plant and Soil Research* **19** (3): 307-610

Singh, M.V., Kumar, N. and Srivastava, R.K. (2018) Effect of nutrient management on maize (*Zea mays*) hybrid in eastern zone of Uttar Pradesh. *Annals of Plant and Soil Research* **20**(1):99-102*.*

Verma, G. and Mathur, A. K. (2009) Effect of INM on active soils of soil organic matter under maize-wheat system of a typic Haplustept*. Journal of the Indian Society of Soil Science* 57**(3)**:317-322.

Viruel, E., Erazzu, L. E., Calsina, L. M., Ferraro, M. A., Lucca, M. E. and Sineriz, F. (2014) Inoculation of maize with phosphate solubilizing bacteria: effect in plant growth and yield. *Journal of Soil Science and Plant Nutrition* **14(4)**:819-831.