Annals of Plant and Soil Research 16(4): 349-352 (2014)

RESPONSE OF MAIZE TO INTEGRATED NUTRIENT MANAGEMENT IN ACIDIC SOILS OF NAGALAND

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Received: May, 2014; Revised accepted: September, 2014

ABSTRACT

A green house experiment was conducted at SASRD, Nagaland University, Medziphema, Nagaland during rainy (kharif) seasons of, 2012 to evaluate the effect of integrated nutrient management on yield, quality of maize and soil health of acidic Dystrochrepts. Results revealed that plant height and grains per cob were affected significantly with the different treatments. Among all the treatments, recommended dose of NPK + 6t FYM ha^{-1}+ lime + biofertilizer (Azotobacter) recorded maximum plant height and yield attributes. Maximum grain and stover yields of maize were recorded at 100% NPK + 6t FYM ha^{-1}+ 20% lime of LR+ Azotobacter followed by 75% NPK + 6t FYM ha^{-1} + 20% lime of LR+ Azotobacter (T_8), respectively. The T_{12} and T_8 treatments enhanced the grain and stover yield to the extent of 60.9 and 36.9 % over control, respectively. The 75% NPK + 6t FYM ha^{-1} + 20% lime of LR+ Azotobacter treatment proved optimum which increased by grain yield 53.3 % over control. Nitrogen, P, K, Ca and Mg uptake by the crop increased with different treatments over control. Addition of NPK fertilizers along with organic manure, lime, and biofertilizers increased pH, organic carbon and available N, P and K status of the soil. Lower total and exchangeable acidity were reported in soils treated with lime (20% lime of LR).

Key words: Maize, integrated nutrient management, yield, dystrochrepts

INTRODUCTION

Maize (*Zea mays* L.) is high calorie cereal, rich in carbohydrate and protein and fairly good source of iron, phosphorus and vitamins. Maize is the most versatile of all cereals, providing nutrient for humans and livestock, serves as raw material in industrial production of starch, oil, protein, alcoholic beverages, food sweeteners, in pharmaceuticals, as well as bio-fuel. Soil acidity has been shown to play a key role in determining nutrient availability to plants and in many instances by specific mineral stress problems. Soil acidity is the most important cause of low yield for many crops (Patiram, 2007). Soil acidification is an increasing problem in the world because of acid rain, removal of natural plant coverage from large production areas and the use of ammonium-based fertilizers. Acid soil infertility is a syndrome of problems that affect plant growth in soils with low pH. Integrated nutrient management has been considered as essential component of sustainable crop production system (Harmsan and Kelly, 1993). Keeping in view the increasing gap between removal and supply of essential plant nutrients (Tiwari, 2002), search for alternative plant nutrients sources has gained momentum. In situation like in Nagaland, where agricultural production systems always creates jeopardy owing to problems like soil acidity, high loss of nutrients through soil erosion, lower availability and greater fixation of nutrients coupled with little use of external nutrient inputs, judicious integration of all the resources available at hand seems to be the only viable option (Ramesh *et al.*, 2007). Keeping in view the various types of recommendations of nutrient management, the present investigation was undertaken to study the performance of maize to integrated nutrient management under acid soil.

MATERIALS AND METHODS

A green house experiment was conducted in the Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema, (Nagaland) with maize (cv. All Rounder) as the test crop. The experimental soil was sandy loam with EC 0.23 dSm^{-1}, pH 5.9, lime requirement 5.2 t ha^{-1}, organic carbon 16 g kg^{-1}, available NPK 220, 12 and 175 kg ha^{-1}, respectively. The experiment was laid out in CRD design with twelve treatments viz. T_1- control, T_2- 100 % RD of NPK, T_3- 12 t FYM ha^{-1}, T_4- 20% lime of LR, T_5- 75% NPK + 6 t FYM ha^{-1}, T_6- 75% NPK + 6 t FYM ha^{-1} + 20% lime of LR, T_7- 75% NPK + 6 t FYM ha^{-1}+ *Azotobacter*, T_8- 75% NPK + 6 t FYM ha^{-1} + 20% lime of LR+ *Azotobacter*, T_9- 100 % NPK + 6 t FYM ha^{-1}, T_{10}- 100 % NPK + 6 t FYM ha^{-1}+ 20% lime of LR, T_{11}-100 % NPK + 6 t FYM + *Azotobacter* and T_{12}- 100 % NPK + 6 t FYM ha^{-1}+ 20% lime of LR+ *Azotobacter*. Earthen pots of 30cm diameter size were filled with 8 kg of soil. The N, P_2O_5 and K_2O @ 120, 60 and 60 kg ha^{-1}, respectively were used as recommended doses for the maize crop. The N, P and K were supplied through urea, single superphosphate and muriate of potash, respectively. Lime was supplied through agriculture

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grade calcium carbonate. The maize seeds were treated with a strain of *Azotobacter* @ 200 g per 10 kg of seed before sowing as per treatment requirement and three seeds in each pot were sown on 17 May, 2012 at a depth of 5 cm at optimum soil moisture level to ensure proper germination. Thinning was done three weeks after germination and only 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 cobs plant^{-1}, number of grains cob^{-1}, grain and stover yield were recorded. Plant samples were analysed for N by Kjeldahl method. Phosphorus, potassium, calcium and magnesium in plant samples were determined in diacid (HNO_3, $HClO_4$) extract by adopting standard procedure (Jackson, 1973). Soil samples collected after crop harvest were analyzed for pH, EC, total and exchangeable acidities, organic carbon and available nitrogen, phosphorus and potassium using standard procedures (Jackson 1973).

RESULTS AND DISCUSSION

Yield

A perusal of data (Table 1) indicates that significantly taller plants were produced with different treatments over control and maximum plant height was recorded with 100% NPK + 6t FYM ha^{-1}+ 20 % lime of LR+ *Azotobacter* followed by 75% NPK + 6t FYM ha^{-1}+ *Azotobacter*. The combined application of fertilizers, FYM, lime and biofertilizers gave better plant growth than sole application of inorganic fertilizer (NPK) or FYM. Number of cobs per plant was not affected significantly with various treatments. Number of grains per cob was affected significantly by different treatments. Number of grains cob^{-1} increased significantly with application of 100 % NPK over control. Maximum number of grains per cob was recorded with 100 % NPK + 6 t FYM ha^{-1}+ 20% lime of LR+ *Azotobacter*. But number of grains was not affected significantly by FYM and lime application in comparison to control. This might be due to the role of *Azotobacter* which met the requirement of nitrogen for maize in combination with chemical fertilizers and manures. These findings corroborates with the results obtained by Shanthi *et al.* (2012). A critical analysis of the data revealed that different treatments had significant beneficial effect on grain and stover yield of maize. Grain and stover yield increased significantly with application of recommended dose of NPK over control. Application of 75 % NPK + 6t FYM ha^{-1} + 20 % lime of LR+ *Azotobacter* increased grain yield by 53.3 % over control. Maximum grain yield was recorded under 100 % NPK@ + 6 t FYM ha^{-1}+ 20 % lime of LR+ *Azotobacter* treatment which increased grain yield to the extent of 60.9 % over control. However, maximum stover yield was reported under 75 % NPK + 6 t FYM ha^{-1} + 20 % lime of LR+ *Azotobacter* treatment and this treatment enhanced stover yield by 36.9 % over control. The factors mainly responsible for variation in the grain yield of maize due to different levels of integration of manures and fertilizers might be due to variations in the yield components. Integrated nutrient management provides optimum supply of nutrients at right time of crop requirement and crop absorbed required nutrients from soil for effective dry matter production and translocation of photosynthates from leaves to the sink for better development of grains (Verma *et al.*, 2014 and Singh *et al.*, 2013).

Table 1: Effect of INM on growth and yield of maize

Treatment	Plant height (cm)	Cobs plant^{-1}	Grain cob^{-1}	Grain yield (g pot^{-1})	Stover yield (g pot^{-1})
T_1- control	105.0	1.0	304.0	31.01	59.71
T_2- 100 % RD of NPK	149.7	1.0	321.0	44.30	73.80
T_3- 12t FYM ha^{-1}	138.0	1.0	315.3	39.10	70.10
T_4- 20% lime of LR	127.7	1.0	314.3	35.83	69.27
T_5- 75% NPK + 6t FYM ha^{-1}	152.7	1.0	327.0	46.11	76.88
T_6- 75% NPK + 6t FYM ha^{-1} + 20% lime of LR	154.7	1.0	328.3	46.62	78.52
T_7- 75% NPK + 6t FYM ha^{-1}+ *Azotobacter*	158.0	1.0	331.0	47.33	78.61
T_8- 75% NPK + 6t FYM ha^{-1} + 20% lime of LR+ *Azotobacter*	162.7	1.0	341.3	48.47	81.79
T_9- 100 % NPK + 6t FYM ha^{-1}	158.3	1.0	331.3	47.71	79.94
T_{10}- 100 % NPK + 6t FYM ha^{-1}+ 20% lime of LR	161.3	1.0	332.0	47.48	79.48
T_{11}-100 % NPK + 6t FYM ha^{-1}+ *Azotobacter*	156.0	1.0	334.7	47.86	80.19
T_{12}- 100 % NPK + 6t FYM ha^{-1}+ 20% lime of LR+ *Azotobacter*	165.7	0.0	349.0	49.91	81.20
SEm ±	2.5	NS	4.5	0.66	0.78
CD (P=0.05)	9.0		15.2	2.58	2.76

Nutrient uptake

A perusal of data (Table 2) indicates that there was a significant increase in total nitrogen uptake by maize crop. Highest total uptake by maize was recorded in T_{12} (100 % NPK + 6 t FYM ha^{-1} + 20 % lime of LR+ *Azotobacter*) treatment while the minimum in control. Phosphorus uptake ranged from 181 to 478 mg pot^{-1} and highest total uptake was reported in T_{12} (100 % NPK + 6 t FYM ha^{-1} + 20 % lime of LR+ *Azotobacter*). The potassium uptake was affected markedly by various nutritional schedules and ranged from 615 to 1700 mg pot^{-1}. Among the various treatments, T_{12} (100 % NPK + 6 t FYM ha^{-1} + 20 % lime of LR+ *Azotobacter*) recorded the highest total K uptake. Calcium and magnesium uptake increased significantly with application of various treatments over control and maximum Ca and Mg uptake was recorded under T_{12} (100 % NPK + 6 t FYM ha^{-1} + 20 % lime of LR+ *Azotobacter*). All the treatments enhanced magnesium uptake significantly over control. A significant increase in uptake of nutrients might be due to availability of plant nutrients in balance and sufficient quantities and conducive soil environment for plant growth throughout the crop growing period with application of fertilizers, manures and biofertilizer which support more absorption of plant nutrients resulted higher yield and nutrient uptake. These results are in agreement with those of Singh *et al.* (2013) and Singh *et al.* (2013)

Table 2: Effect of INM on total uptake of nutrients (mg pot^{-1}) by maize

Treatment	N	P	K	Ca	Mg
T_1- control	670	181	615	289	217
T_2- 100 % RD of NPK	1197	361	1178	593	362
T_3- 12t FYM ha^{-1}	986	274	965	473	306
T_4- 20% lime of LR	869	228	836	555	281
T_5- 75% NPK + 6t FYM ha^{-1}	1285	349	1313	660	383
T_6- 75% NPK + 6t FYM ha^{-1} + 20% lime of LR	1315	377	1394	701	382
T_7- 75% NPK + 6t FYM ha^{-1}+ *Azotobacter*	1383	396	1458	678	403
T_8- 75% NPK + 6t FYM ha^{-1} + 20% lime of LR+ *Azotobacter*	1497	427	1615	751	430
T_9- 100 % NPK + 6t FYM ha^{-1}	1371	384	1504	718	408
T_{10}- 100 % NPK + 6t FYM ha^{-1}+ 20% lime of LR	1379	393	1537	749	414
T_{11}-100 % NPK + 6t FYM ha^{-1}+ *Azotobacter*	1447	407	1583	726	414
T_{12}- 100 % NPK + 6t FYM ha^{-1}+ 20% lime of LR+ *Azotobacter*	1584	478	1700	789	470
SEm ±	33.4	17.0	52.9	13.6	37.1
CD (P=0.05)	118.3	60.2	187.2	48.2	131.3

Soil fertility

pH of the post harvest soil ranged from 5.90 to 6.43 (Table 3). A significant increase in the pH was reported in lime treated soil. A slight reduction in soil pH was recorded with 100 % NPK + 6 t FYM + *Azotobacter* as compared to control. Use of lime replaces the H^+ and Al^{3+} ions from the soil exchange sites resulted increase in soil pH. These findings are in accordance with Sharma and Tripathi (1989). The EC of the soil ranged from 0.10 to 0.23 dSm^{-1} which was not affected significantly with INM treatments. Total and exchangeable acidity of the soils varied from 2.16 to 2.56 and 0.71 to 1.22 cmol (p^+) kg^{-1}, respectively but was not significantly affected by integrated nutrient management. Lowest total and exchangeable acidity were reported with application of 20% lime of LR. Organic carbon content of soil varied from 13.7 to 15.9 g kg^{-1} and highest value was recorded with 100 % NPK + 6 t FYM ha^{-1} + 20% lime of LR + *Azotobacter*. This may be attributed to the higher contribution of biomass to the soil in the form of larger root biomass, crop stubbles and residues after harvest and additive effect of FYM in accumulation of organic carbon (Choudhary *et al.*, 2013). Among the treated soils lowest organic carbon content was found in only lime treated soils (20% lime of LR). This might be due to enhanced oxidation of organic carbon by lime application and hence suppressed its accumulation (Chernikov *et al.*, 1988). Available N status ranged from 218.7 to 259.1 kg ha^{-1} and highest value was recorded at 100 % NPK + 6 t FYM ha^{-1} + 20% lime of LR + *Azotobacter* which was at par with 100 % NPK + 6 t FYM ha^{-1}. Available P ranged from 11.3 to 16.2 kg ha^{-1} and low available P in control pots might be due to no addition of any external input and its mining from the soil by crop. There was a significant increase in available K content of the soil after crop harvest. The available K of soils was increased from 175.3 kg ha^{-1} (initial) to 210.4 kg ha^{-1} at 100 % NPK + 6 t FYM ha^{-1} + 20% lime of LR + *Azotobacter*. Application of NPK alone or along with FYM enhanced the available N, P and K status of the soil. Hence integrated nutrient management system may be helpful in improving the soil health in terms of available plant nutrients. Similar findings have been also reported by Singh *et al.* (2008), Verma and Mathur (2009), and Datta and Singh (2010). It is concluded from the results that the integrated use of fertilizer in combination with lime, organic manure and biofertilizers increased growth, yield and nutrient uptake of maize. It also improved the fertility status of post harvest soil.

Table 3: Effect of INM on soil properties

Treatment	pH	EC (dSm^{-1})	Forms of acidity [cmol (p^+) kg]		Org. C ($g\ kg^{-1}$)	Avail. nutrients ($kg\ ha^{-1}$)		
			Total	Exchangeable		N	P	K
T_1- control	5.97	0.10	2.34	1.22	13.7	218.7	11.3	189.9
T_2- 100 % RD of NPK	6.00	0.23	2.46	1.02	15.3	251.2	13.3	205.6
T_3- 12t FYM ha^{-1}	6.07	0.18	2.31	0.91	15.5	226.7	12.9	195.7
T_4- 20% lime of LR	6.40	0.13	2.16	0.71	14.0	223.4	11.5	194.0
T_5- 75% NPK + 6t FYM ha^{-1}	6.03	0.15	2.48	0.73	15.6	249.6	14.3	213.0
T_6- 75% NPK + 6t FYM ha^{-1} + 20% lime of LR	6.47	0.18	2.38	0.89	15.4	248.2	14.4	214.0
T_7- 75% NPK + 6t FYM ha^{-1}+ *Azotobacter*	6.17	0.22	2.48	0.96	15.6	248.7	14.8	214.4
T_8- 75% NPK+6t FYM ha^{-1}+20% lime of LR+ *Azotobacter*	6.40	0.22	2.49	0.77	15.7	250.5	15.4	216.9
T_9- 100 % NPK + 6t FYM ha^{-1}	5.93	0.21	2.46	0.95	15.8	256.8	15.3	214.7
T_{10}- 100 % NPK + 6t FYM ha^{-1}+ 20% lime of LR	6.40	0.23	2.42	0.87	15.5	256.0	15.3	217.8
T_{11}-100 % NPK + 6t FYM + *Azotobacter*	5.87	0.20	2.56	0.90	15.6	258.6	15.6	219.0
T_{12}-100 % NPK+6t FYM ha^{-1}+20% lime of LR+ *Azotobacter*	6.43	0.22	2.48	0.76	15.9	259.1	16.2	229.3
SEm ±	0.09	0.03	0.07	0.09	0.1	2.12	0.30	2.8
CD *(P=0.05)*	0.309	NS	N S	N S	0.5	7.50	1.08	10.1
Initial	5.94	0.23	2.45	1.12	1.44	220.7	12.5	175.3

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