MICRONUTRIENT CONTENT OF MAIZE GROWN UNDER CONTINUOUS CROPPING AND LONG TERM FERTILIZER USE IN AN ULTISOL IN NIGERIA

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Abstract

The micronutrient content of maize grown under continuous cropping and long term fertilizer use in an Ultisol in Nigeria was studied in 2014 and 2015 cropping seasons. The four sites studied were; 12 years Organic Fertilizer Amendment (OFT) site at 200 Kg.ha^{-1}yr^{-1} , 10 years inorganic fertilizer amendment (IFT) site at 200 Kg.ha^{-1} year^{-1}, 10yrs Organic and Inorganic Fertilizer Amendment (CFT) site at 300 Kg.ha^{-1} year^{-1} and a 15years fallow land of Zero fertilizer amendment (CONT) at O Kg.ha^{-1} year^{-1}. The experiment was laid out in a Completely Randomized Design with three replications. The raw data were subjected to analysis of variance (ANOVA) and mean differences were separated using F-LSD at p=0.05. Plant parts used in the experiment were the roots and above ground portion of the maize plant. Measurements were measured at 4 and 8 Weeks after Planting (WAP). The micronutrient content in the plant portions was compared with standards to establish toxicity levels. The results showed the content of micronutrient in maize was affected by long term fertilizer amendment, above ground portion and growth stages. At both 4 and 8 WAP, the OFT showed significantly higher content of Cu, Zn,and Fe than maize from other treated sites. At 4 WAP Cu, Zn, Fe content in the root and above ground portion of maize were 1.65, 2.30, 0.46 mg.plant^{-1} and 2.47, 34.17, 34.17 and 4.82 mg.plant^{-1}respectively. But, manganese was found to be exceptionally higher in maize plants grown at CFT site compared to other site while the maize from the control site recorded the least values in all the plant parts studied. All the micronutrients studied were within the normal limit in the plant parts sampled.

Keywords: Micronutrients, Fertilizers, Application, Cropping and Soil

Introduction

Micronutrients are nutrients elements required in small quantities by crop plants. Iron (Fe), Manganese (Mn), Copper (Cu) and Zinc (Zn) are essential micronutrients for plant growth. Through their involvement in various enzymes and other physiologically activities in plants, these micronutrients are important for gene expression, biosynthesis of proteins, nucleic acids formation, chlorophyll formation and secondary metabolites synthesis, metabolism of carbohydrates and lipids, etc. (Rengel, 2003).Micronutrient deficiencies in soil not only limit crop production but, it also has negative effects on human health. Intensification of agriculture coupled with increasing use of fertilizer has remarkably increased food production but, it brought with it host of problems related to quick depletion of micronutrients from agricultural lands (Gao *et al., 2008*). Optimum crop performance is only possible when macro and micro nutrient elements are in balanced proportion (Effiong *et al*., 2006). The impact of micronutrients deficiency in crop production is well documented as loss of yield (Singh, 2009). The yield loss resulting from micronutrient deficiency could reach as high as 100% (Katyal, 1975). Maize (*Zea mays*) is one of the most important cereals in the world and is extensively produced in Nigeria(Dut, 2005). Maize is ranked third most cultivated crop in Nigeria (Ayeni, 1987).It was in consideration of the importance of maize in world nutrition that it was chosen as attest crop in an experiment involving micronutrient uptake.Therefore, this study was conducted to assess the micronutrient content of maize in both the ground (root) and above ground (stem +leaf) portions of maize under different fertilizer amendments.

Materials and Methods

Location of study site:

The study areas lie within the humid tropical climate with rainy season occurring in March to October and dry season in November to March. The annual rainfall of the area ranges from 2,200 mm to 2,500 mm, while average air temperature ranged from 26 to 28^{o}C. In the rainy season, the relative humidity of the study area ranges from 75 to 85% but can be as low as 25% in the dry season. The study was conducted in Imo state, southeast Nigeria. There were four study treatments, namely Organic Fertilizer Amended site (OFT), Inorganic Fertilizer Amended site (IFT), Organic and Inorganic Fertilizer Amended site (CFT) and fallow land of Zero Fertilizer Amendment (CONT). The treatments were replicated three times to give a total of 12 experimental sites.

Field Studies:

All the study sites except the control were arable lands that have been under continuous cropping and fertilizers amendment for the past 10-12years. In the late July, 2013 all the experimental sites were cleared, burnt and the tillage operations manually done with hoe, cutlass and rakes. Then, small mounds were made on flat land in all the experimental study sites. Weeding was done as often as the need arises, and root, stem+ leaf portions of the maize plant was harvested at 4 and 8 Weeks after Planting (WAP) and was used to determine micronutrient concentration in the plant portions examined. At each sites three Oba super (1) maize variety seeds were sown at a planting distance of 25 x 75 cm. the plants were thinned down to 2 plants per hole to give a plant population of 53333 per hectare.

Crop sampling/Laboratory Analysis:

At each site, and on each replicate 2 plants were pulled out carefully not to break the root from the ground. The plant root sample was cut off and the root washed in a running tap to completely remove soil particles from them. Then, the above ground portion (stem + leaf) was dried in the oven for 72 hours at 105 + 1^{0}C. At the end of this period the dried root, stem + leaf sample was ashed in afurnace and the micronutrient extracted using nitric per chloric - sulphuric acid mixture (Tel and Hagarty, 1984). The micronutrients were read out using atomic absorption spectrophotometer.

Statistical Analysis:

All data generated were subjected to analysis of variance (ANOVA) and micronutrient values of crop plants samples separated using FischerLeast Significance Difference (F-LSD) at p=0.05 levels. The mean values were compared with standards to establish toxicity levels.

Results and Discussion

Micronutrient Content of Maize root (below ground portion):

The mean content of maize in all the sites at 4 and 8 WAP is shown in Tables 1 and 2. At 4 WAP, the maize root content of Cu, Fe, Zn were 1.65, 0.35, 2.30 mg.plant^{-1} at OFT site were significantly higher when compared with the other fertilizer treated site. There were also significant differences in the Cu, Zn and Fe concentration across the treatments. But, the IFT site recorded significantly higher Mn when compared other fertilizer treated sites.This could be that these micronutrients are mostly phyto-available in the organic fraction just as the OFT site was significantly higher than other treatment sites in SOC and SOM. Tisdale, *et al*. (2003) observed that the availability of micronutrients in soil depend on soil pH and SOC contents. Also, soluble Mn in soil solution is mainly involved in organic forms. Humic acid is reported to reveal a large binding capacity for copper elements. While manganese which was found in lower concentration from the maize plant at the Organic and Inorganic Fertilizer and Organic Fertilizer Treated sites were significantly lower relative to the Inorganic Fertilizer Treatment. Gardested*et al*. (2009) asserted that continuous cultivation was capable of gradually removing trace metals via harvesting. Micronutrient content of the maize plant at 8 WAP was different from the results obtained at 4 WAP. Micronutrient content of the ground portion of maize reduced relative to other fertilizer treated sites including the control. The Organic and Inorganic Fertilizer Treated site recorded significantly higher iron, manganese and zinc at 0.36, 0.36, 0.32mg.plant^{-1},respectively. The organic fertilizer site produced maize plants with significantly higher copper when compared with the other fertilizer treated sites. This result of higher micronutrient content occurring at the organic and inorganic fertilizer treated site might imply that, as time increased under long term organic and Inorganic Fertilizer Treatment maize roots responded better to absorption of micronutrient. Van Reuler and Jansen, 1996 had identified ash to supply sulphur and small amounts of Zn and Cu in addition to SOM, N,P, K, Ca and Mg. The higher Cu contentsthat occurred at organic fertilizer treatment site may be due to the humic acid content of organic fertilizer applied. However, the micronutrient content of ground portion (root) of maize at both 4 and 8 WAP portion were within normal range (Longan and Chaney,1983) in all the long term fertilizer treated site including the control site.

Micronutrient Content of Maize Stem+ Leaf (Above Ground Portion)

At 4 WAP, the stem + leaf with Cu, Fe, Zn contents of 1742, 9.72 and 48.20 mg.kg^{-1} as recorded at the Organic Fertilizer Treatment site was significantly higher than other fertilizer treatment sites. But, the Organic and Inorganic Fertilizer Treatment site exceptionally has significantly higher manganese of 8.62 mg.kg^{-1} as comparable to other fertilizer treatment. The humic acid content of organic matter in providing binding site to the adsorption of metallic cations may have led to the result as obtained with the Organic Fertilizer Treated site with copper, iron and zinc. This result may also imply that organic fertilizer treatment could be a reliable means of supplying micronutrients to maize plant during growth and development stages. The manganese that that was significantly higher at Organic and Inorganic Fertilizer Treated site was comparable to other fertilizer treated sites which may imply that manganese is either bioavailable in organic – inorganic faction than with organic or inorganic fraction alone. Manganese may also be contained as impurity in both organic and inorganic fertilizer so, the combination of both organic and inorganic fertilizer would result to higher manganese content as recorded in this study at CFT site.

Micronutrient content of maize at above ground level was higher at 8 WAP than at 4 WAP. Thus, stem + leaf content of Cu, Fe, Mn, Zn were 40.97, 17.43, 23.82, 28.47, 29.63 mg.kg^{-1} at Organic and Inorganic Fertilizer Treated site and the control recorded the least values in the selected micronutrients. This result obtained from the above ground portionof maize showed high variation relative to the result obtained from theroot (below ground portion). The above ground portion of the maize plant obtained from the site treated with organic fertilizer revealed significantly higher copper, iron and zinc relative to control. It implies that organic and inorganic fertilizer combination may be capable of releasing micronutrient for maize absorption as the plant is ageing. It seemed that since the stem + leaf maize portion contained higher micronutrient thanthe root at all stages growth, this may be indicative of rapid root-shoot nutrient transfer.

Fe^{2+} has been shown to be able to escape from the oxidative barrier and permeate into the roots, part is retained in the root and the remainder is trans-located to the shoot via the xylem (Marshner, 1995). Also, Jones and Clement, 1972 observed that even lead (though a heavy metal) shows similar trend by a small portion of it being taken up by plant roots, and the rest trans-located to the shoot.

Table 1: Mean Micronutrient Content of Maize as Influenced by Long Term Fertilizers Use and Continuous Cropping at 4 WAP

Treatments	Root (mg/plant)				Stem + leaf (mg/plant)				Total (mg/plant)				Grand Total (mg/Hectare)			
	Cu	**Zn**	**Fe**	**Mn**	**Cu**	**Zn**	**Fe**	**Mn**	**Cu**	**Zn**	**Fe**	**Mn**	**Cu**	**Zn**	**Fe**	**Mn**
CONT	0.12	0.11	0.01	0.01	0.30	0.02	0.15	0.01	0.42	0.13	0.16	0.02	4.200	1.300	1.600	2.00
OFT	1.65	2.30	0.35	0.19	2.47	34.17	4.82	3.42	4.12	36.47	5.17	3.61	41.200	264.700	517.200	36.100
IFT	0.14	0.46	0.12	0.46	0.64	0.21	0.99	0.29	0.78	0.67	1.11	0.75	7.800	6.700	11.110	7.500
CFT	0.09	1.32	0.28	0.25	2.16	25.34	0.03	5.45	2.25	26.66	0.31	5.70	22.500	266.600	3.100	5.700
FLSD(0.05)	0.14	0.27	0.03	0.05	0.04	0.32	0.01	0.05	0.01	0.01	0.01	0.00	0.00	173.0	1149.1	199.8

Note: CONT = Control site, OFT= Organic Fertilizer Treatment, IFT = Inorganic Fertilizer Treatment, CFT = Organic and Inorganic Fertilizer Treatment site, WAP = Weeks After Planting

Table 2: Mean Micronutrient Content of Maize as Influenced By Long Term Fertilizer Use ~~&~~ and Continuous Cropping At 8 WAP

Treatment	Root (mg/plant)				Stem + leaf (mg/plant)				Total (mg/plant)				Grand Total (mg/He~~ctare~~)			
	Cu	**Zn**	**Fe**	**Mn**	**Cu**	**Zn**	**Fe**	**Mn**	**Cu**	**Zn**	**Fe**	**Mn**	**Cu**	**Zn**	**Fe**	**Mn**
CONT	0.02	0.03	0.01	0.02	0.02	0.15	0.04	0.05	0.04	0.18	0.05	0.07	400	1,800	500	700
OFT	0.45	0.35	0.20	0.30	30.20	31.00	12.97	30.28	30.65	31.35	13.17	30.58	306,500	313,500	131,700	305,800
IFT	0.13	0.11	0.09	0.10	6.30	5.25	3.330	0.85	6.43	3.44	3.42	0.95	64,300	34,400	34,200	9,500
CFT	0.28	0.32	0.36	0.36	17.43	23.82	28.47	29.63	17.71	24.14	28.83	30.10	177.100	241,400	288,300	301,000
F-LSD(0.05)	0.04	0.02	0.10	0.13	1.04	0.93	0.29	0.03	0. 65	0.04	0.04	0.09	89.9	230.7	223.4	156,241

Note: CONT = Control site, OFT= Organic Fertilizer Treatment, IFT = Inorganic Fertilizer Treatment, CFT = Organic and Inorganic Fertilizer Treatment site, WAP = Weeks After Planting

Conclusion

The importance of micronutrients cannot be over emphasized as several healths' related issues have been correlated to their availability or unavailability in humans, animals or crops. This study examined the micronutrient content of ground (root) and above ground (stem + leaf) portions of maize under long term fertilizers treatment at 4 and 8 Weeks after Planting (WAP). Long term organic fertilizer treatment showed higher content to Cu, Zn, and Fe in both root and stem + leaf portions of maize than other fertilizers use while, Mn was higher under the organic and inorganic fertilizer treatment. Though, all the micronutrients examined were within the normal tolerance limit in the plant portions, long term organic fertilizer treatment as compared to other fertilizer treatment is recommended as a reliable means of improving and providing micronutrients to maize crops.

References

Ayeni, A.O. (1987). Maize Production in Nigeria: problems and prospects. *J. Fd.Agric*. 2:123-129.

Dut, S. (2005). A handbook of agriculture. ABD Publishers, Indian.PP.116-118

Effiong, G.S. Ogburia, M.N. Ndoeyo, N.U. and Uduk, E.M. 2006). Response of maize (*Zea mays*) to foliar application of liquid manure in acid sands of Akwa Ibom State South Eastern Nig. *Journal of sustainable tropical Agricultural Research*. 17:60-65.

Gao, S; Yau, R; and Chan F (2008). Effect of Cu on growth, antioxidant Enzymes and ammonia lyase activities in Jatropha curcas *plant and soil environment.* 54:11.

Gardestedt, C., Plea, Nilsson, M., Jacks B.and Jacks, G. (2009) Zinc in soils, crop and meals in the Niger Delta. *Mali Ambio*. 38:334-338.

Jones, L.H.P, and Clement, C.R. (1972).Lead uptake by plants and its significance for animals. P. 29-33. In :*leadintheenvironment*.Inst. Of Petroleum, London.

Logan T.J. and Chaney R.[1983]. Metals. p. 235-329. in A.L. page (ed.). Utilization of municipal wasteland and sludge on land. Univ. of Califonia, Riverside, CA.

Katyal, J.C. (1975). Research achievements of all India coordinated scheme of micro nutrients in soils and plants. *Fertilizers News.* 30 (4): 67-80.

Marschner, H. (1995). Mineral nutrition of Higher Plants Ed. 2 Academic Press, London. P. 889.

Rengel, Z. (2003). Heavy metals as essential nutrients. In: Prasad, M.N.V. Hagemeyer, J. (eds): Heavy Metal Stress in plants: Molecules to Ecosystems. Springer-Verlag, Berlin, Heidelberg, 271-294.

Singh G. (2009). Salinity-related desertification and management strategies; Indian experience. *Land degradation and development* 20:367-385.

Tel, D.A. and Hagarty, M. (1984). Soil and Plant Analysis IITA Department of land Resource Science, University of Fuelph, Guelph, Ontari Canada, pp. 227

Tisdale, S. L., Nelson, W. L. Beaton, J. D. and Havlin, J. L. (2003). *Soil Fertility and fertilizers 5th edition.* Prentice – Hall of India.

Van Reuler, H. and Janseen R.H. (1996). Comparison of fertilizing effects of ash from burnt secondary vegetation and of mineral fertilizers in upland in Southeast Cote d' Voire. *Fertilizer Research.* 45, 1 -11