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The Response of Tomato (*Lycopersicon esculentum*) to the Application of Molybdenum in a Semi-arid Soil of North Eastern Nigeria

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ABSTRACT

The objective of the experiment was to study the response of tomato (*Lycopersicon esculentum* L. var. Roma) to the application of molybdenum (Mo) to the soil contained in three kg capacity pots. The experiment consisted of four levels of Mo (i.e.0, 0.5, 1.0 & 2.0 mg kg^{-1} as MoO_3). Basal nutrients were also applied to the pots. Tomato seedlings were raised in a nursery and two seedlings were transplanted in to each of the pot four weeks after sowing. The shoots and roots were harvested six weeks after transplanting and were oven dried at 65^{o}C, weighed, ground and analyzed for N, P, K and Mo contents. Increasing levels of Mo did not significantly ($P<0.05$) affect the dry matter yields and percentage N, P and K concentrations of tomato plant. It however significantly increased the Mo concentration and uptake by tomato plant. The results showed that application of 0.5 to 1.0 mg kg^{-1} Mo to tomato plant improved the dry matter yields and nutrient concentration in the plant. Highest shoot and root dry matter yields were obtained at 0.5 mg kg^{-1} Mo level, which were about 19.35 and 37.65%, respectively above the control. Highest Mo concentration (2.13 µg g^{-1}) and uptake (8.19 µg pot^{-1}) were observed at the 2 mg kg^{-1} Mo level. The Mo concentration at this level was far below the threshold of 10 mg kg-^{1} for causing molybdenosis.

Key Words: Tomato; Molybdenum; North eastern Nigeria

INTRODUCTION

Molybdenum is a trace element essential to both plants and animals. It largely occurs in the soil as an oxycomplex (MoO_4^{2-}).It is an essential component of two major enzymes in plants, nitrogenase and nitrate reductase. The enzyme nitrogenase plays an important role in nitrogen fixation. A decrease in the activities of nitrate reductase and glutamine synthase had been reported at reduced supply of Mo and Cu to the growth medium of pea (Hristozkova *et al*., 2006). Mo fertilization can improve resistance to verticillium wilt in tomato (Graham & Stangoulis, 2005). Molybdenum deficiencies are reported in many agronomic crops throughout the world (Murphy & Walsh, 1972). The yellow spot disease of citrus and whiptail in cauliflower are well known Mo deficiency symptoms (Katyal & Randhawa, 1983; Duval *et al*., 1991).

Molybdate is so readily absorbed by plants that it can accumulate in amounts higher than the optimum requirement (Kubota *et al*., 1967; Pasricha & Randhawa, 1971). Such an enhanced Mo accumulation seldom retards plant growth but forages containing Mo in concentration higher than 10 ppm are toxic to ruminants and can give rise to molybdenosis (Underwood, 1962; Thomson *et al.*, 1972; Hagin & Tucker, 1982). It is a Mo induced copper deficiency, which is caused by Mo concentrations in forage above 10 µg g^{-1} (Ferguson *et al*., 1943) or an imbalance of the Cu: Mo ratio in the diet. Miltimore and Mason (1971) suggested a minimum Cu: Mo ratio of 2.0, while Alloway (1973) suggested a value of 4.0. The adverse effects of high Mo can be mitigated by Cu supplementation of the animals (O,Connor *et al*., 2001).

Reviews by Reisenauer (1965) and later by Cox and Kamprath (1972) indicated that many soil factors other than extractable Mo levels affect plant uptake. The availability of Mo to the growing plants is known to be affected by a number of soil characteristics such as soil pH (Davies, 1956; Gupta, 1997; Kabata-Pendias & Pendias, 2001; Goldberg *et al*., 2002), soil wetness (Kubota *et al.*, 1961), mineralogical composition (Wells, 1956; Williams & Moore, 1962), levels of available phosphate (Gupta & Cuttclitte, 1968), soil organic matter content (Karimian & Cox, 1978; Lombin, 1985) and level of available sulphates in soil (Stout *et al*., 1951; Gupta & Lipsett, 1981). The interactions of these soil

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factors may affect the critical level of available Mo below, which responses of fertilizer Mo could be expected.

Tomato (*Lycopersicon esculentum* L.) is an important vegetable in the diet of many Nigerians and intensive plant production practices have increased crop yields, resulting in greater removal of micronutrients from soils. Presently, fertilizer recommendations in North Eastern Nigeria for most crops exclude micronutrients, which subsequently affect plant growth. It is therefore necessary to incorporate micronutrients such as Mo to the fertilizer requirement of crops for improving resistance to fungal infections, sustaining increased yields and maintenance of soil fertility at optimum level. This experiment was therefore undertaken with the objective of studying the response of tomato to the application of molybdenum in a semi arid soil of North Eastern Nigeria.

MATERIALS AND METHODS

Pot experiment was conducted with soil sample (0-20 cm) collected from the Faculty of Agriculture, Teaching and Research Farm, University of Maiduguri, Nigeria located at latitude 11^o 50' N and longitude 13^o 5' E and altitude of about 354 m above sea level. The experiment was conducted in the third quarter of 2004 with the objective of studying the response of tomato to the application of molybdenum (Mo). Prior to the commencement of the experiment, the soil was air dried and sieved through 2 mm stainless sieve. Physico-chemical properties of the soil were determined as follows: particle size analysis of the soil sample was carried out by the hydrometer method (Bouyoucos, 1962), soil organic matter was determined by the Walkley and Black oxidation method (1934). Total nitrogen was determined by the Kjeldahl method (Bremner, 1965) and available phosphorus by the method of Bray and Kurtz (1945). Exchangeable cations were determined by the ammonium acetate extraction. The available Mo of the soil sample was determined following the method described by Reisenauer (1965) and Kubota and Cary (1982). The experiment consisted of four levels of Mo (0, 0.5, 1.0 & 2.0 mg kg^{-1} as MoO_3), replicated three times and arranged in a Randomized Complete Block Design. The following basal nutrients were applied to each of the twelve pots:100 mg kg^{-1} N as NH_4NO_3, 50 mg kg^{-1} P as Ca $(H_2PO_4)_2.H_2O$, 50 mg kg^{-1} K as KCL, 2 mg kg^{-1} Mn as $MnCl_2.4H_2O$, 2 mg kg^{-1} Zn as $ZnSO_4.7H_2O$, 2 mg kg^{-1} Cu as $CuSO_4.5H_2O$ and 2 mg kg^{-1} Fe as $FeSO_4.7H_2O$. Tomato (var.Roma) seedlings were raised in a nursery and two seedlings were transplanted in to each of the pots (3 L containing 3 kg soil) four weeks after sowing. Deionised water was used for irrigation. The soil moisture content was maintained at approximately 70% of water holding capacity. The shoots and roots were harvested six weeks after transplanting and were oven dried at 65^{o}C, weighed and ground. The plant material was digested with 4% perchloric-sulphuric acid mixture for the determination of macronutrients (N, P, K). Mo in the plant sample was analyzed by dry ashing one gram of plant material in a muffle furnace for three hours at 500^{o}C. The ash was dissolved in 50% HCl and evaporated to dryness. It was redissolved in HCl and filtered in to a 50 mL volumetric flask and the volume was made up to the mark with distilled water. Mo was determined colorimetrically (Kubota & Cary, 1982). Nitrogen in the digest was determined by Kjeldahl method, P on a spectrophotometer and K on a flame photometer. The data collected were subjected to analysis of variance (ANOVA) and significant differences among means were compared using the least significant difference (LSD).

RESULTS AND DISCUSSION

The soil used for the experiment was slightly acidic and had low electrical conductivity, total nitrogen, organic carbon, exchangeable potassium and sodium (Table I). The textural class of the soil was sandy loam and had been tentatively classified as Typic Ustipsamment by Rayar (1983). The soil had available molybdenum of 0.10 mg kg^{-1}. Low level of Mo conformed to the work of Lombin (1985). Anderson (1956) quoted Mo values critical for plant growth ranging from 0.04 to 0.12 mg kg^{-1}, while Grigg (1953, 1960) estimated values of between 0.14 and 0.20 mg kg^{-1}. The low content was attributed to the low organic matter content and coarse texture of the soil (Lombin, 1985). Karimian and Cox (1978) had earlier reported a close relationship between the concentration of available Mo and soil organic matter.

Increasing levels of Mo did not significantly ($P<0.05$) affect the dry matter yields and N, P, K concentrations of tomato plant (Table II). Highest shoot and root dry matter yields were obtained at 0.5 mg kg^{-1} Mo level, which was about 19.35 and 37.65%, respectively above the control. At the 2 mg kg^{-1} Mo level, the increase of the shoot and root dry matter yields over the control were 14.37 and 7.06, respectively. Karimian and Cox (1979) had earlier found that applied Mo increased dry weight and Mo concentration of cauliflower grown in most of the soils studied.

The percentage N, P and K of the plant ranged from

Table I. Physicochemical properties of the soil used for the experiment

Characteristic	Value
pH	6.13
EC (ms cm^{-1})	0.05
N (g kg^{-1})	0.76
Available P (mg kg^{-1})	5.95
Organic carbon (g kg^{-1})	3.9
Available Mo (mg kg^{-1})	0.10
Exchangeable K(Cmol kg^{-1})	0.19
Exchangeable Na (Cmol kg^{-1})	0.11
Particle Size Analysis (%)	
Sand	80.3
Silt	4.1
Clay	15.6
Textural Class	Sandy Loam

Table II. Effects of molybdenum application on the shoot dry matter yield (g), root dry matter (g), percentage nitrogen, phosphorus, potassium, Mo concentration (μg g^{-1}) and Mo uptake (μg pot^{-1}) of tomato

	Dry matter yield (g $plant^{-1}$)						
Mo Levels (mg kg^{-1})	**Shoot**	**Root**	**%N**	**%P**	**K (%)**	**Mo content (μg g^{-1})**	**Mo uptake (μg pot^{-1})**
0.0	3.41	0.85	2.21	0.65	3.25	0.09	0.30
0.5	4.07	1.17	3.96	0.58	4.32	0.34	1.34
1.0	3.65	1.00	4.71	0.77	3.67	1.74	6.18
2.0	3.90	0.91	3.05	0.59	3.58	2.13	8.19
Mean	3.76	0.98	3.48	0.65	3.71	1.08	4.00
LSD(P<0.05)	NS	NS	NS	NS	NS	0.59	2.49

2.2 to 4.71; 0.58 to 0.77; and 3.25 to 4.32 with mean values of 3.48, 0.65 and 3.71, respectively (Table II). The concentrations were sufficient for plant growth (Plank, 1989). Highest concentrations were obtained at the 1.0 mg kg^{-1} Mo level. The results showed that application of 2.0 mg kg^{-1} Mo decreased the N, P and K concentration of tomato plant. Mo concentration and uptake by tomato plant, however, increased with increasing application of Mo. Ryding (1982) observed that increasing the rate of Mo application increased Mo concentration and uptake by plants. There were highly significant differences ($P<0.001$) in the Mo concentration and uptake by tomato plant between the treatments. Highest Mo concentration and uptake were observed at the 2.0 mg kg^{-1} Mo level. The level of Mo in the control (0.09 mg kg^{-1}) was deficient, where as all the other levels had sufficient concentrations of Mo (0.34-2.31 mg kg^{-1}). Plant (1952) had established 0.5 ppm Mo as an adequate level for Brassica and lettuce. Reisenauer (1956) found 0.4 to 0.5 ppm leaf Mo as an adequate level in alfalfa, which would be lower if both leaves and stems were analyzed together. The results showed that application of 0.5 to 1.0 mg kg^{-1} Mo to tomato plant improved its yields and nutrient concentrations. The problem of molybdenosis could not be experienced in this study as the highest treatment had Mo concentration of 2.13 μg g^{-1}, which was far below the threshold of 10 mg kg^{-1} for causing molybdenosis.

CONCLUSION

Increasing levels of Mo did not significantly affect the dry matter yields and N, P and K concentrations of tomato plant. The results however showed that application of 0.5 to 1.0 mg kg^{-1} Mo to tomato plant improved its yields and nutrient concentration.

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