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Full Length Research Paper

Effects of Manganese and Zinc Fertilizers on Shoot content and Uptake of N, P and K in Sesame (*Sesamum indicum L.*) on Lithosols

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ABSTRACT

Field experiments were conducted during the 2005 and 2006 rainy season at the Food and Agriculture Organisation/Tree Crop Programme (FAO/TCP) Teaching and Research farm of the Adamawa State University, Mubi to assess the effects of Mn and Zn on shoot content, uptake and utilization of N, P and K in Sesame (*Sesamum indicum* L.). The treatments consist of N, P and K (75 kg N, 45 kg P_2O_5 and 22.5 kg K_2O ha^{-1}), and various rates of Mn and Zn as: NPK + 0.5 kg Mn ha^{-1}, NPK + 0.5 kg Zn ha^{-1}, NPK + 1 kg Mn ha^{-1}, NPK + 1 kg Zn ha^{-1}, NPK + 0.5 kg Mn + 0.5 kg Zn ha^{-1} and NPK + 1 kg Mn + 1 kg Zn ha^{-1} were the treatment combinations. This was arranged in a randomized complete block design replicated three times. Results shows that stem height, number of branches, leaves, and capsules were not significantly influenced by Mn and Zn. Seed yield was depressed at 1 kg Mn ha^{-1}, 1 kg Mn + 1 kg Zn ha^{-1} and 0.5 kg Mn + 0.5 Zn ha^{-1} by 17.57 and 41% respectively. Number of seed $capsule^{-1}$ was depressed by 9% at 1 kg Mn ha^{-1}. Combined Mn and Zn had dry matter yield disadvantage by 16 and 18% at 0.5 and 1 kg ha^{-1} of Mn and Zn rates, respectively. Shoot N, P, K, Mn, and Zn contents of sesame, N and P uptake were not significantly influenced. Combined Mn and Zn depressed K, Mn and Zn uptake while Mn uptake increased by 57%.

Keywords: Manganese, Zinc, Content, Uptake, N, P, K, Sesame.

INTRODUCTION

Zinc (Zn) and manganese (Mn) are important micronutrients in sesame production. Reduced growth hormone production in Zn deficient plants causes shortening of internodes and short leaves resulting in malformation of fruit with little or no yield (Havlin, 2005). Mn is essential to photosynthesis reactions, enzyme activation and root growth (Mortvedt *et al*., 1999). Therefore, the steady supply of macro nutrients and Zn (Kamel *et al*., 1983) and Mn (Jeyabal *et al*., 1997) was found to increase stem height and nodes for capsule development in sesame.

In Nigeria, sesame is grown mainly between latitude 6° and 10° N by small holder farmers (USAID, 2002) on less productive soils which are characterized by low effective cation exchange capacity and low to medium inherent fertility status (Annon, 2002). Yield increases due to nitrogen and phosphorus application were recorded in Mokwa and Badegi Southern Guinea Savanna of Nigeria (Olowe and Busari, 2000). Mitchell *et al.* (1974) reported increased protein and decreased oil content due to increased levels of nitrogen. Capsule number, seed weight and plant height have been reported to have direct effect on sesame yield in Nigeria (Ogunremi and Ogunbodede, 1986).

These studies have indicated that nitrogen, phosphorus and even potassium, zinc and manganese are the major and minor nutrient elements influencing the growth and yield of sesame. There is however a gap in published information in respect of the dynamics and effects of these nutrient elements on sesame produced on lithosols to reach its maximum potential under Mubi conditions in the Northern Guinea savanna of Nigeria.

MATERIALS AND METHODS

Two years field study were conducted during the 2005 and 2006 rainy seasons at the Food and Agricultural Organisation of the United nations/Tree Crop Programme (FAO/TCP) Teaching and Research farm of the Adamawa State University, Mubi (10^o 11' N : 13^o 19' E, altitude 594 m above sea level) Northern Guinea savanna of Nigeria. The climate of the area is characterized by alternate wet and dry seasons. The rains last from April to October with a mean annual rainfall ranging from 700 mm to 1,050 mm. The rainfall is unimodal, reaching its peak in the month of July and August. The coldest months of the year are November to February whereas the hottest months are March and April (Adebayo, 2004). The Vegetation is of typical Northern Guinea savanna. The soils of the experimental site have been classified as Entisols (SSS, 1975) or lithosols, FAO/UNESCO classification).

Soil Sampling and Analysis

Soil samples were collected at 0-15 cm depths, air dried, crushed and sieved through a two mm screen for analysis prior to the beginning of the experiment. Standard methods were used to analyze the samples as follows: Soil reaction (pH) were determined in the supernatant of 1:2.5 soil-water with a pH meter; Particle size distribution by the hydrometer method (Bouyoucos, 1962); total N by a modified Kjeldahl method (Bremner and Mulvaney 1982); Available P was extracted by Bray P1 method (Bray and Kurtz, 1945) and determined by spectrometry; Exchangeable cations were extracted in 1M NH_4OAc buffered at pH 7 (Page *et al.,* 1982). Calcium and Mg were determined by atomic absorption spectrophotometer, and K and Na by flame photometer. Effective cation exchange capacity was estimated by summation of exchangeable bases (Rhodes, 1982) and exchange acidity by KCl extraction method (Mclean, 1965). Organic carbon was determined by wet oxidation method (Walkley and Black, 1934) while Zn and Mn as described by Lindsay and Norvell (1978).

Parameters measured were stem height, number of leaves, number of branches, number of capsules, number of seed in capsule, seed and dry matter yields. Data collected were subjected to analysis of variance (ANOVA). Duncan's Multiple Range Test (DMRT) was used for mean separation where differences were significant, at 5% level of probability and correlation analysis was also carried out using SAS (2000).

RESULTS

Some Physical and Chemical Properties of the Experimental Soil

Soil of the experimental site was sandy loam in texture and slightly acidic in reaction (pH 6.2). The soil was also characterized by low organic carbon (<1%), total N (<0.1%), available P (<7 mg ka^{-1}), potassium (<0.3 cmol kg^{-1}), Zinc (<2.26 mg ka^{-1}) and Mn (37.83 mg kg^{-1}) as shown in Table 1.

Growth characters of sesame

Stem height and number of branches did not respond significantly (P=0.05) to Mn and Zn fertilizer application. However, significant difference was recorded in the number of leaves between the 0 kg ha^{-1} application and all other treatments.

Seed yield

The effect of Mn and Zn on seed yield of sesame in 2005, 2006 is presented in Table 2. Application of NPK + 0.5 kg Zn ha^{-1} produced the highest seed yield of 591.32 kg ha^{-1} with yield advantage of 5% over NPK. However this is at par with yields recorded from the application of NPK, NPK + 0.5 kg Mn ha^{-1}, NPK + 1 kg Mn ha^{-1} and NPK + 1 kg Zn ha^{-1} (560.5, 573.17, 479.81 and 552.5 kg ha^{-1}). Seed yields recorded from the application of NPK + 0.5 Mn + 0.5 Zn and NPK + 1 Mn + 1 Zn were not significantly different from each other.

Dry matter yield

The effect of Mn and Zn on dry matter yields of sesame is presented in Table 2. Application of NPK + 1 kg Mn ha^{-1} gave the highest dry matter yields of 2003 kg ha^{-1} with 13.2% dry matter yield advantage over NPK. However, this value was not significantly different from the yields produced from the application of NPK (1769), NPK + 0.5 kg Mn (1803), NPK + 0.5 kg Zn (1767) and NPK + 1 kg Zn ha^{-1} (1803 kg ha^{-1}). This shows that Mn increases dry matter yields in sesame at the expense of seeds.

Shoot N, P, K, Mn and Zn content of sesame

Treatments with NPK + 0.5 kg Zn ha^{-1} resulted in the highest shoot N content of 1.44% (Table 3). This was significantly higher than shoot N content (0.71%) produced from the application of NPK + 0.5 kg Mn ha^{-1}. However, the shoot N content (0.71%) produced from the application of NPK + 0.5 kg Mn ha^{-1} was not significantly different from the shoot N content (0.77%) of control plot. Highest shoot P content was recorded from application of

Table 1. Texture and Some selected Chemical Characteristics of Soil of the Experimental Site

Parameter	Value
Sand (g kg^{-1})	536
Silt (g kg^{-1})	302
Clay (g kg^{-1})	162
Textural Class	Sandy loam
pH (1:2.5, H_2O)	6.2
Organic Carbon (g kg^{-1})	6.44
Organic matter (g kg^{-1})	0.75
Total Nitrogen (g kg^{-1})	0.15
Available P (mg kg^{-1})	2.1
Exchangeable K (Cmol kg^{-1})	0.33
Exchangeable Ca (Cmol kg^{-1})	4.8
Exchangeable Mg (Cmol kg^{-1})	2.27
Exchangeable Na (Cmol kg^{-1})	0.98
Available Zn (mg kg^{-1})	2.26
Mn (mg kg^{-1})	37.83

Table 2. Effects of Mn and Zn on growth and yield characters of sesame

	Stem height (cm)	Number of branches	Number of leaves	Number of capsules	Number of seeds in capsule	Seed yield (kg ha^{-1})	Dry matter (kg ha^{-1})
Year							
2005	114.62b	8.95b	561.62	125.95b	80.95	472.83	1636.9
2006	156.81a	12.52a	503.86	228.81a	83.14	530.82	1841.7
SE(±)	8.14	2.64	48.69	34.08	3.04	55.60	190.03
Level of Significance	**	*	ns	**	ns	ns	ns
Fertilizers							
0-0-0	135.17	8.83	208^{b}	99.17^{b}	69.33^{c}	220.65^{d}	682^{c}
NPK	142.5	11.67	596.8^{a}	207.67^{a}	85.00^{ab}	560.50^{a}	1769^{ab}
NPK + 0.5Mn	134.67	12.33	662.7^{a}	197.17^{ab}	79.00^{ab}	573.17^{a}	1803^{ab}
NPK + 0.5Zn	125.67	9.50	431.2^{a}	134.83^{ab}	82.00^{ab}	591.32^{a}	1767^{ab}
NPK + 1Mn	139.33	11.50	440.2^{a}	174.67^{ab}	78.00^{b}	479.81^{ab}	2003^{a}
NPK + 1Zn	138.17	8.83	592.8^{a}	160.17^{ab}	86.00^{a}	552.50^{a}	1803^{ab}
NPK + 0.5Mn + 0.5Zn	132.83	11.17	447.7^{a}	187.17^{ab}	83.33^{ab}	398.40^{bc}	1526^{b}
NPK + 1Mn+ 1Zn	136.83	10.17	535.3^{a}	180.00^{ab}	81.00^{ab}	357.09^{c}	1505^{b}
SE(±)	16.10	2.91	105.04	44.76	3.30	55.46	186.76
Level of Significance	ns	ns	*	*	`*	**	***

†=Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test.

* = Significant at 5% level of probability

** = Significant at 1% level of probability

ns = not significant

NPK + 0.5 kg Zn, NPK + 0.5 kg Mn + 0.5 kg Zn and NPK + 1 kg Mn + 1 kg Zn each which recorded 0.12% P. The shoot P content of all the other fertilizer treatments were at par with the control.

The response of sesame to Mn and Zn fertilizer application to its K content was not significant. Results indicated that the application of Mn and Zn fertilizers did not significantly (P=0.05) influence Mn shoot content of

Table 3. Effect of Mn and Zn fertilizers on shoot N, P K, Mn and Zn contents of sesame

	Shoot content				
Treatment	N (%)	P (%)	K (%)	Mn (mg kg $^{-1}$)	Zn (mg kg $^{-1}$)
Year					
2005	1.04	0.13^{a}	1.20^{b}	238.81^{a}	8.07
2006	1.12	0.09^{b}	1.45^{a}	185.24^{b}	6.83
SE(±)	0.30	0.015	0.12	26.15	1.53
Level of Significance	ns	*	*	**	ns
Fertilizer					
0-0-0	0.77^{b†}	0.07^{b}	1.24	170.83	4.17^{b}
NPK	1.19^{ab}	0.11^{a}	1.43	172.50	7.50^{ab}
NPK + 0.5Mn	0.71^{b}	0.10^{ab}	1.43	195.00	7.00^{ab}
NPK + 0.5Zn	1.24^{ab}	0.12^{a}	1.33	236.67	8.50^{a}
NPK + 1Mn	0.89^{ab}	0.10^{ab}	1.43	235.00	5.83^{ab}
NPK + 1Zn	1.44^{a}	0.09^{ab}	1.25	205.00	8.83^{a}
NPK + 0.5Mn + 0.5Zn	0.92^{ab}	0.12^{a}	1.20	216.67	8.83^{a}
NPK + 1Mn+ 1Zn	1.16^{ab}	0.12^{a}	1.24	0.14^{a}	0.09
SE(±)	0.28	0.02	0.13	0.01	0.02

†=Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test.

* = Significant at 5% level of probability

** = Significant at 1% level of probability

ns = not significant

sesame. Significant effects on Zn shoot content were recorded from the application of Mn and Zn. In the analysis, 8.50 mg kg^{-1} was the highest Zn accumulation obtained from the application of NPK + 0.5 kg Zn ha^{-1}. Results also showed that the accumulation of Zn in shoots were more in treatments that received NPK + 0.5 kg Zn ha^{-1} application and lower in the treatments without Zn application. Combination of Mn and Zn up to 1 kg ha^{-1} each reduced shoot Zn content compared to NPK + 0.5 kg ka^{-1}.

Nitrogen, P, K, Mn and Zn uptake by sesame

The effect of Mn and Zn fertilizer on N uptake is presented in Table 4. Analysis revealed that 25.33 kg ha^{-1} N obtained from the application of NPK + 1 kg Zn ha^{-1} was the highest. The amount of P uptake showed no significant difference between 0 kg ha^{-1}, NPK and NPK +1 kg ha^{-1} each of Mn and Zn with a corresponding P uptake of 0.56, 1.60 and 1.59 kg ha^{-1} respectively. The highest P uptake was recorded when 0.5 kg Zn ha^{-1} was added to NPK where uptake of 2.21 kg ha^{-1} was recorded. While P uptake increased with increase in Mn rate (1.85 to 2.09 kg ha^{-1}), increase in Zn rate decreased P uptake (2.21 to 1.69 kg ha^{-1}). In the analysis, the highest K uptake (28.24 kg ha^{-1}) was recorded where no Mn and Zn were added to NPK.

Treatment NPK + 1 kg Mn ha^{-1} had the highest Mn uptake of 0.47 kg ha^{-1}. Uptake of 0.34, 0.42, and 0.36 kg ha^{-1} from application of NPK + 0.5 kg Mn, NPK + 0.5 kg Zn and NPK + 1 kg Zn ha^{-1} respectively were not significantly different. The lowest Mn uptake (0.12 kg ha^{-1}) was from treatment that did not receive any fertilizer application. Analysis revealed significant responses of Zn uptake to Mn and Zn fertilizer application.

Regression/Correlation

The relationship among yield components and concentration of N, P, K, Mn and Zn is presented in Table 5. A significant positive correlation existed between seed yield and dry matter (r = 0.751) and also between shoot P and Mn (r = 0.380). Application of Mn and Zn increased the uptake of K which gave it a stronger relationship (r^2=0.497) with seed yield than N, and P uptake with corresponding r^2=0.298 and 0.217, respectively (Table 5). Uptake and shoot contents of N, P and K were also positively related significantly.

DISCUSSION

Yield parameters

Results of the two years field study indicated that addition of Mn and Zn to NPK did not significantly influence the number of capsules of sesame. Application of Zn at 1 kg Zn ha^{-1} increased number of seeds in capsules by 1.2

Table 4. Effect of Mn and Zn fertilizers on uptake of N, P K, Mn and Zn by sesame

			Uptake (kg ha^{-1})		
Treatment	N	P	K	Mn	Zn
Year					
2005	16.38	2.06^{a}	20.74^{b}	0.39	0.015
2006	20.53	1.64^{b}	26.61^{a}	0.34	0.013
SE(±)	5.28	0.38	3.62	0.06	0.004
Level of Significance	ns	*	**	ns	ns
Fertilizer					
0-0-0	5.27^{c}	0.49^{b}	8.46^{c}	0.12^{c}	0.003^{c}
NPK	20.83^{ab}	1.72^{a}	28.24^{a}	0.30^{b}	0.013^{ab}
NPK + 0.5Mn	13.15^{ab}	1.85^{a}	26.34^{ab}	0.34^{ab}	0.013^{ab}
NPK + 0.5Zn	21.87^{ab}	2.21^{a}	24.71^{ab}	0.42^{ab}	0.016^{ab}
NPK + 1Mn	17.29^{ab}	2.09^{a}	26.86^{ab}	0.47^{a}	0.012^{a-c}
NPK + 1Zn	25.33^{a}	1.69^{a}	22.69^{ab}	0.36^{ab}	0.016^{ab}
NPK + 0.5Mn + 0.5Zn	13.92^{a-c}	1.76^{a}	18.23^{b}	0.33^{b}	0.021^{a}
NPK + 1Mn+ 1Zn	16.78^{ab}	1.62^{a}	18.64^{b}	0.33^{b}	0.008^{bc}
SE(±)	5.04	0.02	0.13	0.01	0.02

†=Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test.
* = Significant at 5% level of probability
** = Significant at 1% level of probability
ns = not significant

Table 5. Regressed significant correlation coefficients of sesame parameters

Parameters in regression	Regression equation	r^2
dry matter x Seed yield	Y= 2. 391x + 488	0.564
N uptake x seed yield	Y= 8.3663x + 326.1	0.298
P uptake x seed yield	Y=91.979x + 312.3	0.217
K uptake x seed yield	Y=12.436x + 195.96	0.497
Mn uptake x seed yield	Y=544.14x + 285.32	0.248
Zn uptake x seed yield	Y=589.3x + 391.84	0.114
Mn uptake x shoot Mn	Y=287.67x + 111	0.498
N uptake x shoot N	Y=17.227x – 1.1018	0.769
N uptake x K uptake	Y=0.6237x + 3.226	0.294
Shoot P x shoot Mn	Y=643.96x + 139.86	0.144
P uptake x shoot P	Y=16.244x – 0.012	0.498
P uptake x K uptake	Y=0.0379x + 0.8526	0.180
P uptake x Mn uptake	Y=0.1219x + 0.1287	0.455
P uptake x Zn uptake	Y=39.683x + 1.1749	0.201
K uptake x shoot K	Y=23.271x – 8.8751	0.400
Mn uptake x K uptake	Y=0.0079x + 0.1607	0.241
Mn uptake x Zn uptake	Y=6.4329x + 0.2517	0.162
Zn uptake x shoot Zn	Y=263.68x + 3.6962	0.634

and 24% over NPK and control respectively. The lack of significant increase in seed yield from Mn application agrees with the findings of Draycott and Farley (1973). He compared soil application and foliar spray of Mn and reported that soil application of $MnSO_4$ salts did not prevent Mn deficiency. Also Mengel and Kirby (2006) observed that application of Mn salts to the soil in an experiment with barley was of no use. This was attributed to the rapid oxidation of Mn and less suitability of the the method of application compared to foliar spray.

It was observed that application of Mn and Zn at 1 kg ha^{-1} each to NPK yielded an increase of 61.8% in seed yield while the application of Zn alone at 0.5 kg Zn ha^{-1} to NPK increased seed yield by 168% and 5.5% over control and NPK respectively. This concurs with the report of Cakmak *et al.* (1996) that application of Zn at 23 kg Zn ha^{-1} increased seed yield of wheat by 43%. Increase in seed yield may be attributed to the high solubility of $ZnSO_4$ and thus its absorption by the plant.

Application of 1 kg Mn ha^{-1} increased dry matter yield by 194 and 13.2% over control and NPK respectively. Similar result was reported by El-Fouly *et al.* (1992) where increased dry matter weight was observed at higher Mn rates. Application of Mn and Zn at 0.5 and 1 kg ha^{-1} each decreased dry matter yield by 15.9 and 17.5% respectively. This differs from El-Fouly *et al.* (2001) where increase in dry matter was recorded at higher rate of Zn. The interaction of Mn and Zn at these rates might have suppressed the uptake of some secondary nutrients such as Ca and Mg thus altering their functions and subsequently depressing dry matter production.

Effect of Mn and Zn on shoot N, P, K, Mn and Zn content of sesame

The result of the two years field experiment shows that application of Mn at 0.5 kg Mn ha^{-1} reduced shoot N content by 68%. Reduced N content with application of Mn might have occurred as a result of cation competition between NH_4^+ and Mn^{2+} for absorption. Wilkinson *et al.* (1999) reported that N concentration can be reduced in plant as a result of increased concentration of Mn resulting from greater absorption of Mn^{2+} than NH_4^+ - N. This result varies with the findings of Soliman and Farah (1985) that Mn application did not influence the N concentrations in both shoot and seed in an experiment with soybean.

Separate application of Mn and Zn at 1 kg ha^{-1} each, reduced shoot P contents by 9.1 and 18.2% below NPK and 30 and 22% over Zero application, respectively. This result shows that higher concentration of Zn reduces P content in shoot of sesame. This agrees with the findings of Huang *et al.* (2000) that Zn deficiencies increases P content of plant shoot. They found Zn to play specific role in the regulative mechanism of the genes encoding phosphate transporter proteins in the plasma membranes of sugar beet and barley. Thus, controlled uptake of P is lost under low or deficient levels of Zn leading to high concentration of P in plants. Also Parker *et al.* (1992) and Pedler (2000) reported elevated P levels in shoot s as a result of low level of Zn.

Application of Mn and Zn separately and in combination did not influence plant K content of sesame. In addition to the findings of Weis (1983) that application of K fertilizer to sesame is seldom necessary, adding Mn and/Zn could not bring about notable responses to shoot K in sesame.

Application of Mn at 0.5 and 1 kg ha^{-1} increased shoot Mn by 13 and 36% respectively. Increased shoot Mn from increased Mn application was observed by Singh and Steenberg (1974) who reported increase in Mn content of maize and barley plants from Mn fertilizer application. Increase in Mn content was also observed at 0.5 kg Zn ha^{-1}. Increase from 0.5 to 1 kg Zn ha^{-1} depressed Mn concentration by 15.4%. Reduced Mn content of sesame plant due to increased Zn application rate was reported by El-Fouly *et al.* (2001) and Singh and Steenberg (1974). This negative response could be attributed to cation competition during absorption, translocation and distribution into and within the shoot.

Combined NPK fertilization increased sesame shoot Zn content by 79.9% over control. Application of Mn at 0.5 and 1 kg ha^{-1} reduced shoot Zn by 7.1 and 28.6% respectively. Similar result was observed by El-Fouly (2001) where application of 3.30 ppm Mn reduced sunflower Zn content by 74%. It was also observed from this study that increased Zn application rate from 0.5 to 1 kg ha^{-1} increased shoot Zn by 17.7%. Increase in shoot Zn from Zn application was also reported by Paivoke (2003) who studied *Pisum sativum* at different Zn supply levels. Combined Zn and Mn at 0.5 kg ha^{-1} also increased sesame shoot Zn content by 17.7%.

Effect of Mn and Zn on N, P, K, Mn and Zn uptake by sesame

The increase in N uptake by sesame recorded in this study was also observed by Singaravel *et al.* (2002) where 25 kg $ZnSO_4$ ha^{-1} added to recommended NPK increased N uptake by 49% in Vertisols. The non significant response in N uptake from additions of Mn and Zn in this experiment differs with the findings of Singaravel *et al.* (2002) where significant increase (85%) in uptake by sesame by sesame was obtained with 2 kg $ZnSO_4$ + 5 kg $MnSO_4$ ha^{-1}.

There was no marked increase in the uptake of P with Zn and Mn fertilization. This did not agree with the findings of Tiwari *et al.* (1995) who reported increase in P uptake by 122% at 5 kg $MnSO_4$ ha^{-1} added to NPK. The non significant increase in P uptake concurs with Singaravel *et al.* (2002) who reported non significant increase in P uptake both at low and high $MnSO_4$ additions. Similar findings was also reported by Murphy *et al.* (1981) from a comparison of root and shoot concentration for both Zn and P in two varieties of dry bean. They found that Zn concentration did not have effect on P in the shoot, even when P was at high concentration. They also noted high levels of available P in the roots at high Zn concentrations.

Combination of Mn and Zn at 0.5 kg ha^{-1} each and also 1 kg ha^{-1} each depressed K uptake by 54.9 and 51.5% respectively over NPK. This result is at variance with the findings of Singaravel *et al.* (2002) who recorded significant increase in K uptake from additions of Mn and

Zn to NPK on Vertisols. The variance could be attributed to the soils (lithosols) on which this study was conducted.

As regards Mn uptake, Mn at 1 kg ha^{-1} increased Mn uptake by 56.7% while 10% increase was recorded when 0.5 kg Mn and Zn ha^{-1} and 1 kg Mn and Zn ha^{-1} were added to NPK. Increase in Mn uptake from Mn application and Mn and Zn interaction on uptake of Mn was observed by Singh and Steengberg (1974). Manganese uptake in sesame was reduced by 16.7% at 1 kg Zn ha^{-1} application compared to NPK. Similar findings was also reported by El-Fouly *et al.* (1992) where total Mn uptake was reduced by increasing Zn rate in an experiment with sunflower under green house condition. Increase in Mn uptake from Mn application was also observed by El-Fouly *et al.* (2001) where 189% increase was recorded. Manganese in its chemical behaviour shows properties of both the alkali earth cations such as Mg^{2+} and heavy metals (Zn^{2+}). It is therefore not surprising that these ion species can affect uptake and translocation of Mn in the plant. This has been reported by Fox and Guerinot (1998) that Mn has a depressive effect on Fe uptake. Also, addition of Zn separately at lower rates favoured Mn uptake in sesame. El-Fouly *et al.* (2001) reported higher Mn uptake at low Zn rates.

Application of Mn and Zn at 0.5 kg each recorded the highest Zn uptake by 61.5% over NPK. Manganese application both at 0.5 and 1 kg ha^{-1} did not significantly change the uptake of Zn. This concurs with results of Singh and Steegberg (1974) which showed that total Zn uptake and percentage distribution among roots and shoots of maize and barley were not affected by Mn application. Zinc uptake increased by 13.3 and 17.7% from application of 0.5 and 1 kg Zn ha^{-1} rates respectively. This response also agrees with the studies of Singh and Steegberg (1974) who observed significant increase in Zn uptake by roots and shoots of maize and barley plants from Zn application. In a similar work by Schenkano and Berber (1979), it was found that nutrient absorption from the soil by the roots depends on the nutrient concentration in soil solution. Similar results were observed by Brown (1979).

CONCLUSION

Higher concentrations of Mn and Zn depressed seed yield and favoured dry matter accumulation. Concentrations of N, P and K, in the shoot and N and P uptake were not significantly influenced by Mn and Zn as K uptake was depressed.

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REFERENCES

Adebayo AA (2004). Mubi region a geographical synthesis. Paraclete Publishers, Yola, Nigeria. pp 22-31

Anonymous, (2002). Fertilizer use and management practices for crops in Nigeria. Aduayi, E.A., Chude, V. O., Adebusuyi BA, Olayiwola SO (Eds). 3rd edition. Produced by the Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development, Abuja, pp188.

Bouyoucos GJ (1962). Hydrometer method improved for making particle size analysis of soil. *Agron. J.* 54: 564-565.

Bray RH, Kurtz LT (1945). Determination of total, organic and available forms of P in soils. *Soil Science* 59:39-45.

Bremner JM (1982). Inorganic nitrogen *In*: Page, A. L. Miller, R. H and Keeney, D. R. (1982) Methods of soil analysis Part 2. Chemical and mineralogical properties. Agronomy monograph No. 9 ASA-SSSA Madison.

Brown JC (1979). Effects of Zn stress on factors affecting iron uptake in navy bean. *J. Plant Nutr.* 1:171-183

Cakmak I, Sari N, Marschner H, Ekiz H, Kalayi M, Barun HJ (1996). Phytosiderophre release in Bread and Durum Wheat Genotypes Differing in Zn Efficiency. *Plant Soil* 180:183-189.

Draycott AP, Farley RF (1973). Response by sugar to soil dressings and foliar sprays of manganese. *J. Sci. Food Agric.* 24:675-683

El-Fouly MM, Amberger A, Fwazi AFA (1992). Balanced fertilizer use with micronutrients under Egyptain conditions (The Micronutrient Project). *Afr. J. Agric. Sci.* 19:41-61

El-fouly MM, Notal OA, Mobarak ZM (2001). Effects of Soil treatment with Iron, Manganese and Zinc on growth and Micro Nutrient Uptake of Sunflower Plants grown in High – pH soil. *J. Agron. and Crop Sci.* 186: 245 – 257.

Fox TC, Guerinot ML (1998). Molecular biology of cation transport in plants. Annual Review Plant Physiology. *Plant Molecular Biology* 49:669-696

Havlin JL, Beaton JD, Tisdale SL, Nelson WL (2005). Soil fertility and fertility and Fertilizers: An Introduction to Nutrient Management 7th rd. Asoke K-Ghosh, Prentice Hall Publishers. New Delhi, India.

Huang C, Garker SJ, Langridge P, Smith FW, Graham RD (2000). Zinc deficiency up-regulates expression of high affinity phosphate transporter genes in both phosphate sufficient and deficient barley roots. *Plant Physiology* 124:415 – 422.

Jeyabal A, Palaniappan SP, Chelliah S (1997). Integrated nutrient management for higher crop yields. *Agriculture Newsletter* 22(3):2-3.

Kamel MS, Shabana R, Abu-Hagaza NM (1983). Population arrangement and fertility level effects on yields of seed and oil of irrigated sesame (*Sesamum indicum* L.). *Zeitschrift für Acker- und Pflanzenbau* 152:252-259.

Mclean EO (1965). Aluminium. *In*: C.A. Black (ed), methods of soil analysis. Methods of soil analysis Part 2. Chemical and mineralogical properties. Agronomy monograph No. 9 part 2, pp 686-994.

Mengel K, Kirby CA (2006). Principles of Plant Nutrition. 5th edition. Springer publishers India. 849pp.

Mitchell GA, Bingham FT, Yermanos DM (1974). Growth, mineral composition and seed characteristics of sesame as affected by nitrogen, phosphorus and potassium nutrition. *Soil Science Society of America Proceedings*, 38: 925-930.

Mortvedt JJ, Murphy LS, Follett RH (1999). Fertilizer Technology and Application. Meister Publishing, Willoughby, OH.

Murphy LS, Ellis Jr., R, Adriano DC (1981). Phosphorus Micro Nutrient Interaction Effects on Crop Production. *J. Plant Nutr.* 3(1):593-613.

Ogunremi EA, Ogunbodede BA (1986). Path Coefficient Analysis of Seed Yield in Early Sesame (*Sesamum indicum* L.). Ife J. Sci. 127 – 132.

Olowe VIO, Busari L (2000). Response of sesame to N and P applications in the Southern Guinea savanna of Nigeria. *Tropical Oil Seed Journal,* 5: 30-37.

Page AL, Miller RH, Keeney DR (1982). Methods of soil analysis Part 2. Chemical and mineralogical properties. Agronomy monograph No. 9 ASA-SSSA Madison.

Paivoke EAA (2003). Mineral Elements and Phytase Activity in *Psuim Sativum* Grown at Different Zn Supply levels in the green house. *Environmental and Experimental Botany* 49:285-294.

Parker OR, Aguilera JJ, Thomason DN (1992). Zinc-phosphorus interactions in two cultivars of tomato (*Lycopersicum esculentum L.*) grown in chelator-buffered nutrient solutions. *Plant Soil* 143:163-177

Pedler JF, Parker DR, Gowley DE (2000). Zn Dificiency-induced Phytosiderophore release by the Triticacea is not Consistently Expressed in Solution Culture. *Planta* 211:120-126.

Rhodes JA (1982). Methods of soil analysis Part 2. Chemical and mineralogical properties. Agronomy monograph No. 9 ASA-SSSA Madison.

Schenkano MK, Barber SA (1979). Root Characteristics of Corn Genotypes as Related to P Uptake. *Agron. J.* 71:921

Singh BR, Steenberg K (1974). Plant Response to Micronutrients – III. Interaction between Mn and Zn in Maize and barley Plants. *Plants Soil* 40: 655 – 667.

Singaravel R, Imayavaramban V, Thanunathan K, Shanmughapriya V (2002). Effect of micronutrients on yield and nutrient uptake of sesame (*Sesamum indicum* L.) in a Vertisol soil. *Sesame and safflower Newsletter* 17:46-48.

Soil Survey Staff, (1975). Soil taxanomy: Abasic system of Soil Classification for making and interpreting soil surveys. Washington, DC: US. Department of Agriculture, Soil conservation Services, In: Brady, N. C. (1984). The nature and properties of soils, 9th Ed. Macmillan Publishing Co. Inc. 750pp.

Soliman MF, Farah MA (1985). Effect of Phosphorus, Nitrogen fertilization and Foliar Applied Manganese on Yield and Nutrient Concentration of Soyabean. *Communication in Soil Science and Plant Analysis* 16(4): 361 – 374.

Statistical Analysis System (2000). Proprietary Software Release 8.1 (TS1M0) SAS Institute Inc., North Carolina State University-Campuswide-T/R, Site 0027585003. Cary, NC, USA.

Tiwari KP, Namdeo KN, Tomar RKS, Raghu JS (1995). Effect of Macro and Micronutrients in Combination with Organic Manures on the Production of sesame (*Sesamun indicum* L.). *Indian J. Agron.* 40(1):134-136.

USAID (2002). United States Agency for Development. Overview of Nigerian Sesame Industry. Technical Report to the government of the Federal Republic of Nigeria, pp34.

Walkley A, Black CA (1934). An examination of Detjaraff method of determining soil organic matter and proposed modification of the chromic acid/titration method. *Soil Science* 37:29-38.

Weis EA (1983). Sesame *In*: Oil Seed Crops pp283 – 340. Longman, London.

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