

THE EFFECT OF MANGANESE ON EARLY GROWTH OF FLUTED PUMPKIN (*Telfairia occidentalis* HOOK F) IN AN ULTISOL

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ABSTRACT

The trials were conducted at the experimental site of University of Benin Teaching and Research Farm to determine the influence of Mn on early growth, nutrient content and uptake by *Telfairia occidentalis* using six levels of Mn treatment. The greenhouse treatment levels were 0, 50, 100, 150, 200, 250 mgMn per 5 kg soil while in the field trial, 0, 20, 40, 60, 80, 100 kgMnha⁻¹ levels were used. In the greenhouse, completely randomized design (CRD) was used while randomized complete block design (RCBD) was used in the field trial. Results indicated that there were no pronounced variations in the soil chemical components after the trial except for the Mn component the of soil which however increased with increasing levels of Mn treatment. The N, P, K, Mg, Ca, Na, Zn, Cu contents of the plant increased with increasing levels of Mn treatments in both trials. The N content of the plant in the field trial was however, not consistent with increasing levels of Mn treatment. The Fe content of the plant consistently declined in both trials with increasing levels of Mn application indicating antagonistic influence of Mn on Fe uptake. The Mn content and uptake by the plant in the trials increased consistently with increasing levels of Mn treatment. The Mn content and uptake by the plant in the control treatment was however low. Synergistic influence of Mn on Cu and Zn uptake by the plant was recorded while the Mn had no effect on the uptake of N, P, K, Ca and Na. The Mn treatments significantly increased the growth parameters and shoot dry matter yield up to 50 mgMn per 5 kg soil and 20 kgMnha⁻¹ and declined at various Mn treatment levels indicating the levels of accommodation of Mn by the plant. Correlation coefficient (r) between soil pH, organic matter, available P, Fe and Mn uptake by the plant indicated non-significant negative correlation (P > 0.05).

Keywords: Manganese, Nutrient interaction, fluted pumpkin, *Telfairia occidentalis*.

INTRODUCTION

Manganese (Mn) is a micro-nutrient element required by crops in trace amount for amino acid synthesis, several enzyme activation processes, oxidation-reduction and chlorophyll formation and its deficiency symptom is chlorosis (McLaughlin *et al.*, 1999). High concentration of Mn in plants brings about necrotic brown spotting on the leaves, petioles, and stem (Wu, 1994), brown colourless roots (Foy *et al.*, 1995) and sometimes cracked coloured roots. However, the effect of Mn on plants depends on the species and the type of soil. Certain soil factors such as soil pH, organic matter, available P and Fe have been identified to influence the availability of Mn to plants (Tisdale *et al.*, 1985). Mn applications have been reported by Fageria (2002) to significantly increase corn and

common bean plant shoot dry matter yield. The application of chelated Mn reduced the effects of high soil salinity on sugarcane growth and nutrition (Hagihara and Bosshert, 1983) and yields of cotton had been reported to have been reduced by the application of 0.7mg Mn. The Mn treatment significantly improved uptake of Mg and Zn but decreased Ca and Fe in corn while in common bean, Mn had a synergistic effect on the uptake of K and Zn and antagonistic effect on uptake of P and Cu (Fageria, 2002). Remison (1997) reported that Mn when present in excessive amount decreases Fe solubility to such an extent as to cause a deficiency resulting in chlorotic plants.

The test crop, fluted pumpkin is commonly grown and consumed in Nigeria because of its high nutritive value. It is cultivated in home gardens and abandoned dumpsites in the urban areas without screening for the presence of Mn and the level of

interaction between Mn and other essential nutrient elements. This study was therefore initiated to determine the influence of Mn on the uptake of essential nutrient elements and as a corollary establish its effects on the growth and nutrient uptake by fluted pumpkin.

MATERIALS AND METHODS

Soil samples used in the greenhouse investigation was obtained from 0 – 30 cm depth in a plot left fallow for 2 years at the University of Benin Teaching and Research Farm. The soil samples were air-dried, sieved and thereafter, 5 kg weighed into each experimental pot. The trial was laid out in a Completely Randomized Design in three replicates. Each replicate had 18 pots with 3 pots per treatment level.

The field experiment was set up on the plot where the soil sample was taken. The experimental design for the field experiment was RCBD with three replicates. Each replicate had six beds. Each bed size of 2.5m X 2.5m represented a treatment level and the treatments, were separated from one another by 50cm alley. The replicates were separated from one another by 1m alley.

In the greenhouse trial, the $MnSO_4 \cdot 4H_2O$ rates of 0, 50, 100, 150, 200, 250 mgMn per 5 kg soil were applied, mixed thoroughly and left for 2 weeks before transplanting one seedling into each pot. Similarly, $MnSO_4 \cdot 4H_2O$ equivalent to greenhouse trial rates of 0, 20, 40, 60, 80, 100 kgMnha⁻¹ were used in the field trial. Four (4) seedlings per bed were transplanted at a spacing of 60 cm x 60 cm.

In both trials, basal dressing of NPK fertilizer at 10 kg ha⁻¹ was applied as urea, single super phosphate and muriate of potash. Watering and weeding were carried out regularly and both trials lasted for 56 days. Before harvesting, the plant height, number of leaves, number of branches and stem girth were determined. Thereafter, the shoots were separated from the roots and oven dried at 78°C for 48 hours to constant weight. This was for the determination of nutrient uptake by the plant.

Soil analysis

Soil samples were collected, air-dried and analysed using standard laboratory methods. Particle size distribution was determined by hydrometer method as modified by Day (1965). Soil pH was measured by using the pH meter at 1:1 soil to water ratio. The organic carbon was determined by chromic acid wet methods of Black (1965) while the organic matter was obtained by multiplying the value of organic carbon by the factor, 1.724.

The total nitrogen was determined by the micro-kjeldahl technique as described by Jackson (1962). The available P was extracted and the P in the extract assayed colorimetrically by molybdenum blue colour method of Murphy and Riley (1962). Exchangeable bases were extracted by ammonia acetate solution as described by Jackson (1962). The Ca and Mg were determined by atomic absorption spectrophotometer (AAS) while K and Na were determined by flame emission photometry. The exchangeable acidity was determined using McLean (1965). The effective cation exchange capacity (ECEC) was obtained by adding the exchangeable acidity and the exchangeable bases. The Fe, Mn, Cu and Zn were determined by the methods of Soon and Abboud (1993).

Plant analysis

Representative oven-dried plant sample (1g) was digested with a mixture of HCl₄, HNO₃ and H₂SO₄ acids (IITA, 1979). The Na, Cu, Mg, Fe, Mn, Cu and Zn contents were determined by atomic absorption spectrophotometer (AAS UNICAM 969) while P content was determined by AOAC (1970) perchloric acid digestion (wet oxidation) method. The N content was determined by method of Jackson (1962). The data generated were analysed by the Genstat Statistical System (Payne 2002).

RESULTS AND DISCUSSION

Pre-trial soil properties

The soil properties of both trials are shown in Table 1. The soils were moderately acidic, texturally, sandy loam and low in fertility. The N, P, K and organic matter for instance were below the critical levels of 1.5 gkg⁻¹, 10-16 mgkg⁻¹, 0.18-20 cmolkg⁻¹ and 20-30 gkg⁻¹, respectively (Enwezor, *et al.*, 1979). The Mn content of the soil was less than the critical level of 0.3 mgkg⁻¹ (WHO, 1984).

Post trial soil chemical properties

There were variations in some chemical properties of the soil after both trials (Table 2). In the greenhouse trial, the exchangeable acidity, K, Na, soil pH, Cu, effective cation exchange capacity and Zn increased inconsistently with increasing levels of Mn treatment. Significant differences were however not recorded among the various levels of Mn treatment in K, Na, soil pH and ECEC. The organic carbon, organic matter, N, available P, Mg, Ca and Fe, on the other hand, declined inconsistently with significant differences (P<0.05) also recorded among the various Mn treatment levels.

With the exception of N, P and Cu, which declined, all the other soil components determined increased inconsistently with no

significant differences ($P > 0.05$) recorded in soil pH, Na, Fe and Cu among various levels of Mn treatment in the field trial. However, the Mn levels of the soil increased significantly ($P < 0.05$) in both trials with increasing Mn application. The changes in some of these nutrient components may be attributed to uptake by the plant and mineralization of the ploughed-in organic matter especially in the field trial. Similar results have earlier been reported by Orhue *et al* (2010).

The nutrient content of *Telfairia occidentalis* as influenced by Mn application

The nutrient content of the plant in both trials is shown in Table 3. As the Mn treatment levels increased, the N, P, K, Mg, Ca, Na, Zn and Cu contents of the plants increased consistently with significant differences ($P < 0.05$) recorded among the various Mn levels in the greenhouse trial. With the exception of N, significant increase in Ca, Cu, Mg, P, Na, Zn with increasing Mn levels occurred in the field trial. Significant differences ($P < 0.05$) among the Mn levels were also recorded. The Fe content of the plant significantly decreased consistently with increasing Mn levels in both trials

Table 1: Physico-chemical properties of the soil used in the trials

PROPERTIES	GREENHOUSE VALUE	FIELD VALUE
pH(1:1) soil: water	4.99	5.00
Organic carbon (gkg^{-1})	0.86	0.97
Organic matter (gkg^{-1})	1.49	1.68
Total N (gkg^{-1})	0.88	0.88
Av P (mgkg^{-1})	3.25	4.94
Ca	0.90	0.89
Mg	0.38	0.36
K	0.11	0.04
Na	0.04	0.03
Exchangeable acidity	0.30	0.23
Ecec	1.73	1.55
Cu	0.02	0.09
Fe	0.07	0.02
Mn	0.04	0.07
Zn	0.24	0.26
Sand	931	920
Silt	27	28
Clay	42	52
Textural class	Sandy loam	Sandy loam

Effect of Mn on the uptake of nutrients by *Telfairia occidentalis*

The uptake of some mineral nutrients is shown in Table 4. In both trials, the uptake of Cu and Zn significantly ($P < 0.05$) appreciated with increasing Mn levels while the changes in N, P, K, Mg, Ca and Na were not consistent with increasing levels of Mn application. Significant differences were however recorded in Ca uptake by the plant among the Mn levels except in the field trial.

The uptake of Fe in the trials recorded significant decrease with increasing Mn levels. This finding is similar to earlier report of Chinnery and Harding (1980) who reported that the antagonistic effect of Mn on the uptake of Fe is vice versa and that the decrease in Fe uptake with increase in the levels of Mn treatment may be due probably to oxidation of Fe in the presence Mn. Chinnery and Harding (1980) reported further that the antagonistic interaction between Fe and Mn have some practical implications. Fe toxicity in soils can be reduced by Mn application and Mn toxicity in acid soils can be minimized by Fe application.

Mn content and uptake by *Telfairia occidentalis*

Table 5 reveals the Mn content and the level of uptake by *Telfairia occidentalis*. The Mn content and uptake by the plant in the entire trial increased with increasing Mn levels. The highest levels of Mn treatment in each trial (250 mgMn and 100 kg Mn ha^{-1} for greenhouse and field trials, respectively) were significantly higher than the other treatments including the control. The control treatment had the lowest Mn content in the trials and it is less than the WHO/EU (1993) permissible limit of 0.2 mgkg^{-1} . The presence of these Mn values in the control treatments explains why it is within the tolerable limits for human consumption while others treated with Mn had values greater than this permissible level. The plants with high values of Mn may lead to adverse health situation when regularly consumed. These findings are in agreement with the report of Fageria (2002) and Abdulahi *et al.*, (2008).

Influence of Mn on plant height, number of leaves, number of branches, and shoot dry matter of *Telfairia occidentalis*

The application of Mn up to 50 mgMn for the greenhouse trial and 20 kgMn ha^{-1} for the field trial significantly increased the entire growth parameters and shoot dry weight (Table 6). The values declined at higher Mn levels in the trials. The decline in growth parameters and shoot dry matter yield at higher Mn levels is a clear indication that the Mn concentration in the plant rose beyond the tolerable limit of the plant for the element. Significant increase in growth parameters and shoot dry matter yield at lower Mn levels has earlier been reported by Novais *et al.* (1989) and Fageria (2002) in rice and common bean.

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Table 2: Some chemical properties of the soil used after the greenhouse and field trials

Trace metals	Rate	pH(H ₂ O 1:1)	Org C gkg ⁻¹	Org matter gkg ⁻¹	Av P mgkg ⁻¹	Total N gkg ⁻¹	Ca	Mg	K	Na	Exch acidity	Ecec	Fe	Mn	Zn	Cu
Greenhouse							Field Trial									
Mn	0	5.30ab	0.81a	1.40a	1.30c	0.52d	0.17d	0.34a	0.12a	0.06a	2.21b	2.90a	0.02b	0.03f	0.20c	0.04a
	50	5.70a	0.16e	0.14f	1.83a	0.58cd	0.55b	0.24e	0.12a	0.06a	2.18b	3.18a	0.04a	60.40e	0.40ab	0.04a
	100	5.40ab	0.13de	0.22ef	1.90a	0.61bc	0.64a	0.26cd	0.13a	0.06a	2.31ab	3.40a	0.04a	64.90d	0.44a	0.04a
	150	5.30ab	0.21d	0.36e	1.10d	0.63bc	0.19d	0.27c	0.12a	0.06a	2.41a	3.05a	0.05a	72.65c	0.28b	0.05a
	200	5.20b	0.38c	0.66c	1.43b	0.68ab	0.30c	0.25de	0.12a	0.05a	2.31ab	3.03a	0.05a	83.63b	0.38ab	0.04a
	250	5.20b	0.48b	0.83b	1.82a	0.71a	0.20d	0.30b	0.13a	0.05a	2.28ab	2.99a	0.04a	86.68a	0.42ab	0.04a
Mn	0	5.35a	1.32d	2.28d	3.81ab	0.57abc	1.01c	0.80b	0.27c	0.04c	2.23a	4.35b	0.03b	0.05e	0.42bc	.05a
	20	5.44a	1.62c	2.80c	3.30ab	0.46b	1.06c	0.85b	0.36bc	0.17a	2.25a	4.69ab	0.06a	32.49d	0.33c	0.07a
	40	5.32a	1.90bc	3.29bc	3.93a	0.54bc	1.25b	0.98a	0.39b	0.17a	2.32a	5.11a	0.07a	43.28c	0.46abc	0.07a
	60	5.43a	1.92abc	3.32abc	3.10b	0.54bc	1.71a	0.58c	0.43ab	0.18a	2.43a	5.33a	0.06a	55.79b	0.53ab	0.08a
	80	5.30a	1.99ab	3.44ab	3.38ab	0.67ab	1.10c	0.98a	0.47ab	0.12b	2.45a	5.12a	0.07a	58.10b	0.59a	0.06a
	100	5.28a	2.23a	3.86a	3.60a	0.69a	1.26b	0.83b	0.51a	0.13b	2.50a	5.23a	0.06a	65.46a	0.60a	0.06a

Mean values with the same letter in the column are not significantly different from one another at $P < 0.05$.

Table 3: Shoot mineral content as influenced by various levels of manganese in the greenhouse and field trials (%)

Trace metal	N	P	K	Mg	Ca	Na	Fe	Cu	Zn	
										Greenhouse
Mn	0	0.51e	0.05d	0.38c	0.53d	0.99e	0.07c	1.37a	0.02d	0.04e
	50	0.63d	0.08cd	0.41c	0.61c	1.20d	0.09bc	1.23b	0.04d	0.10d
	100	0.70cd	0.08cd	0.50bc	0.65c	1.27c	0.09bc	1.10c	0.11c	0.22c
	150	0.77bc	0.11bc	0.53bc	0.71b	1.32c	0.09bc	0.96d	0.12c	0.26c
	200	0.81b	0.13ab	0.60ab	0.74b	1.40b	0.12bc	0.84e	0.19b	0.38b
	250	0.98a	0.16a	0.71a	0.81a	1.61a	0.19a	0.70f	0.26a	0.51a
Mn	0	0.33cd	0.05c	0.27e	0.46e	0.86f	0.06b	0.93a	0.007e	.02d
	20	0.42a	0.09b	0.32d	0.54d	1.04e	0.08b	0.53b	0.007e	.03cd
	40	0.38b	0.10b	0.41c	0.60c	1.10d	0.11a	0.41c	0.05d	0.05bc
	60	0.36bc	0.10b	0.41c	0.63c	1.22c	0.11a	0.35d	0.07c	0.07ab
	80	0.32d	0.12a	0.50b	0.71b	1.28b	0.12a	0.26e	0.09b	0.08ab
	100	0.32d	0.12a	0.55a	0.76a	1.48a	0.12a	0.18f	0.13a	0.10a

Mean values with the same letter in the column are not significantly different from one another at $P < 0.05$.

Table 4: Shoot mineral uptake as influenced by various levels of manganese in the greenhouse and field trials (mgkg⁻¹)

Trace Metal		N	P	K	Mg	Ca	Na	Fe	Cu	Zn	
		Greenhouse					Trial				
Mn	0	39.88ab	3.91cd	29.72ab	41.45b	77.42b	5.48bc	107.14a	1.56e	3.13e	
	50	46.23a	6.25ab	32.04a	47.66a	93.76a	7.03ab	96.11b	3.13d	7.81d	
	100	28.86c	3.29d	29.42ab	26.81e	52.36f	3.48c	45.35c	4.40cd	9.07cd	
	150	32.41c	4.63bcd	21.05c	29.89de	55.57e	3.79c	40.42cd	5.05c	10.95c	
	200	34.10bc	5.47abc	22.31bc	31.16d	58.94d	5.06bc	35.36de	5.13b	16.00b	
	250	45.11a	7.37a	27.62abc	37.26c	73.92c	8.76a	32.19e	11.97a	23.63a	
Mn	0	145.30bc	22.13c	119.10d	202.30d	378.10a	26.53b	410.70a	3.14e	8.94d	
	20	274.40a	58.69a	209.50a	352.80a	672.80a	52.44a	343.90b	4.48e	14.52cd	
	40	154.80b	40.71b	167.00bc	244.30c	781.40a	44.83a	167.00c	20.34d	22.31bc	
	60	137.00bc	38.23b	156.80c	241.00c	466.70a	42.09a	133.10d	26.76c	24.83bc	
	80	124.40c	48.28b	195.40ab	278.00bc	501.90a	46.74a	102.20d	34.98b	28.52ab	
	100	123.00c	47.85b	212.00a	293.00b	573.30a	46.69a	69.90e	50.17a	37.57a	

Mean values with the same letter in the column are not significantly different from one another at $P < 0.05$

Table 5: Manganese content (%) and uptake (mgkg⁻¹) by *Telfaira occidentalis* in the greenhouse and field trials

Trace Metal	Rate	SHOOT Mn CONTENT		SHOOT Mn UPTAKE
		Greenhouse	Trial	
Mn	0	0.05f		3.90f
	50	0.21e		16.41e
	100	0.65d		26.66d
	150	0.75c		31.53c
	200	0.84b		35.36b
	250	0.93a		42.94a
Mn	0	0.06f		26.47c
	20	0.11e		71.83b
	40	0.18d		73.90b
	60	0.20c		80.79b
	80	0.25b		97.68a
	100	0.28a		108.29a

Mean values with the same letter in the column are not significantly different from one another at $P < 0.05$

Table 6: Effect of manganese on plant height, number of leaves, number of branches and shoot dry matter yield of *Telfaira occidentalis* in greenhouse and field trials

Trace Metal		Plant height (cm)	Number of branches	Number of leaves	Shoot dry weight (g)
		Greenhouse		Trial	
Mn	0	58.10b	1.67c	21.00b	7.80a
	50	76.17a	4.30a	27.30a	7.82a
	100	21.83f	1.87c	6.70e	4.12d
	150	33.30e	2.67b	14.33c	4.21c
	200	43.30d	2.00c	11.30d	4.21c
	250	46.17c	2.00c	11.00d	4.60b
Mn	0	82.27b	6.60a	67.10d	44.00b
	20	106.60a	6.60a	86.47a	65.37a
	40	70.20b	5.20b	75.62b	40.73bc
	60	70.40b	3.77c	51.87f	38.25c
	80	61.78c	5.20b	65.10e	39.19bc
	100	65.45bc	4.70b	70.35c	38.75bc

Mean values with the same letter in the column are not significantly different from one another $P < 0.05$

Correlation coefficient (r) between some soil factors and Mn uptake by *Telfairia occidentalis*

The negative correlation coefficient (r) between Mn uptake and soil pH (r = -0.433), P (r = -0.103), Fe (r = -0.029) and organic matter (r = -0.367) are not significant. Higher soil pH increased the precipitation of Mn and then decreased the uptake of Mn. The negative correlation of organic matter and Mn uptake may be due to the chelation of numerous organic matter fractions with Mn²⁺. This chelation restricts the availability of Mn to the plant. The negative correlation of soil pH and organic matter further supports earlier report of Tisdale *et al.* (1985). The negative correlation between Fe and Mn uptake is as a result of Mn oxidation actions on Fe as earlier reported by Chinnery and Harding (1980). The interaction between P and Mn uptake is complex. The negative correlation between P and Mn uptake may be due to the precipitation of the Mn ions. Similar result was reported by Blaylock and Huang (1999) and Chaney *et al.*, (2000). Chaney *et al.* (2000) reported that the addition of P fertilizer can lead to metal precipitation as pyromorphite and chloropyromorphite.

CONCLUSION

The Mn treatments had no pronounced influence on the soil chemical properties but had impact on the nutrient content and uptake by the plant. The Mn content and uptake however increased with increase in Mn application. The Mn content of the control plants were however below the permissible level of WHO/EU (1993) of 0.2mgkg⁻¹ making it free for consumption. Those treated with Mn however had higher Mn content above the 0.2 mgkg⁻¹ (WHO/EU 1993) permissible levels thereby making it hazardous to health when regularly consumed. However, the uptake of Mn by *Telfairia occidentalis* negatively correlated with pH, organic matter, Fe and available P components of the soil which means that increasing these soil factors could interfere with the uptake of Mn by the plant. It is therefore reasonable to conclude that soil laden with high amount of Mn should not be recommended for the cultivation of *Telfairia occidentalis*.

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