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RESEARCH ARTICLE

EFFECT OF SEASONAL VARIATION IN MINERAL COMPOSITION OF LEAVES OF *SENNA OCCIDENTALIS* L. GROWN IN FADAMA AND UPLAND LOCATIONS IN SOKOTO, NIGERIA

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ABSTRACT

This study was undertaken to investigate mineral composition of the leaves of *S. occidentalis* L. used traditionally for nutritional purposes. Hence, leaf samples collected from fadama and upland locations were analyzed using Microkjeldahl method (N), Colorimetry Vanadomolybdate (Yellow) Method (P), Flame Photometry Method (Na and P), EDTA Titration Method (Ca and Mg), Atomic Absorption Spectrophotometery Method (Mn, Cu, Zn, and Fe), and Mohr Titration Method (Cl^-). ANOVA and LSD at 5% level was used to analysed and separate the means for significant results. Results for interaction effect determined were all significant ($P<0.05$) in the leaves of the species studied with the following range of values obtained: N (1.53-2.77%), Na (3.73-5.40ppm), P (2.06-5.53ppm), K (2.43-11.57ppm), Ca (0.67-2.60ppm), Mg (3.27-4.73ppm), Cu (0.10-1.13ppm), Fe (0.20-1.03ppm), Mn (0.20-1.23ppm), Zn (0.02-0.47ppm), and Cl^- (0.05.0-85ppm. Specifically, rainy season, fadama and upland locations, young and matured leaves were the most favourable treatments in the higher concentration of most mineral elements of the species e.g. N, P, Ca, Mg, Cu, Mn, Fe, Zn, and Cl^-. The species is rich in these mineral elements studied, recommended for continued use and further research on anti-nutritional factors to ascertain the active compounds.

INTRODUCTION

Senna occidentalis L. (Septic Weed or Coffee Senna) is part of the numerous important wild plant species growing in the savanna region of Nigeria functioning as primary producer in the ecosystem (Umar and Ahmad, 2014). It leaves, especially when young, are cooked and eaten as vegetable by majority of the rural communities in the zone. The flowers, fruits and seeds are also parts of human food (Bello *et al.,* 2008). The roots, stems, fruits, flowers and leaves are also reported to have medicinal uses; and the dry stalks are source of fire and habitat to micro fauna (Umar and Ahmad, 2014). Literature search revealed that this species of plant have not been domesticated for nutritional reason, but grow in the wild as weeds (Bala, 2006). Tukan *et al*. (1998) have reported that over the last two decades, studies have revealed that wild or semi-wild plants are nutritionally important because of higher vitamins, minerals, essential fatty acids and fibre contents. In another study made by Turan *et al*. (2003) twenty six (26) varieties of wild edible plants were analyzed for micro and macro minerals, among the Apiaceae family, some were found to be high in potassium and phosphorus contents.

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High level of nitrogen, sulphur and copper contents were found in the Polygonaceae family, and high calcium, iron and manganese in the Urticaceae family. Several workers have reported that a large proportion of plants nutrients are found in the foliage of the plants {Humpreys, 1987; Harper, 1989, and Dutta, 2005). Dutta (2005) categorically states that leaf is normally green in colour and is regarded as the most important vegetative organ of the plant since food material is prepared {photosynthesis} in it. Harper (1989) had reported that a leaf is not just an organ of carbon assimilation but also a region of nutrient accumulation and subsequent dissipation. He maintained that leaves function as sites of mineral storage. Humpreys (1987) had reported that matured leaves are less photo-synthetically active than young leaves. Ajakaiye *et al.* (1995) had reported that many of the macro-elements are more directly involved in physiologically mature tissues than in younger ones. Umar *et al.* (2005) had also reported that young leaves had contained more of the mineral elements like (N, K, P, Mg, Ca, Mn, Cu, and Zn) than the matured leaves of Baobab tree (*Adansonia digitata*). It is against this background that the study was designed to investigate the foliar mineral compositions of *S. occidentalis.* This has become necessary to provide additional information on the nutritional potentials of selected wild plant in the study area so as to enhance its conservation and possibly domestication

MATERIALS AND METHODS

The study was conducted at the permanent site, Usmanu Danfodiyo University, Sokoto (05^0 10E - 05^0 12^1E, 13^0 04 0N – 13^0 06 40N) at 308 m above sea level (NMA, 2009). Mean wind speed ranges from 33.92kts to 125.56kts (NMA, 2009). The climate vary into rainy season (May - October) and dry season (November - April), with a relatively cool Harmattan period (November - February) (NMA, 2009, and SARDA, 2009). The pattern of rainfall distribution ranges from 553.43 – 628. 94 mm with relative humidity of about 16 - 55.5% during the dry season but can rise up to 81 % during the rainy season; and the average temperature ranges minimally from 16.3^{oc} during harmattan season but generally 18.6^{oC} to maximally 44.7^{o}C (SARDA, 2009, and NMA, 2009). The fadama land of the area is low – lying relatively flat areas occurring in streamless depression or adjacent to stream or rivers (Adeyeye, 2005). It is also clayey, hydromorphic, most productive, ecologically sensitive and most highly cultivated, both in the wet and dry season (Yakubu *et al.,* 2008). The upland soils of the area are predominantly sandy (>90% sand), hence surface texture for these soils is of fine sand changing in some cases to loamy sand in the subsoil; colours are usually dark to dark-red on the surface horizons and reddish brown in the subsoil's or on the entire profile; the land is therefore very fragile and susceptible to serious soil erosion during both wet and dry season (Noma and Yakubu, 2002; Yakubu *et al.,* 2008).

Treatments and Experimental Design

The treatments were plant species (*S. occidentalis*), experimental sites (fadama and upland areas), season (rainy and dry), and leaf-age. The experiment was laid in a completely randomized design (CRD) with three replications (beds) for each of the study plant species respectively at the experimental sites (Fadama Research Farm and Biological Garden).

Leaf Sample Collection and Sampling Procedure

Samples of fresh leaves of *S. occidentalis* were collected from their seedling stage up to their full stage of maturity based on days after sowing (DAS) at four subseasons (harmattan, dry, early rainy, and late rainy of a year. Eight (8) innermost plants were sampled from the two (2) inner rows excluding the border line rows of each of the beds, making a total of twenty four (24) plants (per 3 beds) per sampling site sampled for the plant species under study from fadama and upland locations (Evans, 1982).. The leaf sample collections was done by handpicking green leaves for all the plants and were put in their respective bag for phytochemical laboratory analysis in accordance with Evans (1982).

Preparation of Sample

The leaf samples collected from fadama and upland were thoroughly separately mixed together, put in to labeled envelopes, oven dried at 100^0 C for 72 hours. The dried samples of each group were pounded separately in a mortar with pestle and sieved in 0.5mm mesh size, and stored for chemical analysis at each subseason (Krishna and Ranjhan, 1980; Evans, 1982; and Udo and Ogunwale, 1986).

Chemical Analysis

The powdered samples were digested with H_2SO_4 and filtered (Udo and Ogunwale, 1986}.Two gram (2g) of the powdered sample was used in the mineral analysis (Udo and Ogunwale, 1986}. Phosphorous was analysed using colorimetry Vanadomolybdate (Yellow) method; Calcium and Magnesium by EDTA titration method; Manganese, Copper, Zinc, and Iron concentrations by atomic absorption spectrophotometery (Udo and Ogunwale, 1986); Sodium and potassium by using flame photometry (AOAC, 1990), while Chloride by Mohr titration (Skoog *et al.* (2004). The values obtained were expressed in parts per million (PPM) except nitrogen which was determined by Mico-kheldhal and expressed in percentage (%).

Data Analysis

Data collected from this study was subjected to analysis of variance (ANOVA), and determined result expressed as mean of triplicate. Where significant differences exist, least significant difference (LSD) was used to separate the means.

RESULTS AND DISCUSSION

Nitrogen (N)

In this finding, some of the values of Nitrogen obtained (1.53 – 2.77 %) for interaction of *S. occidentalis* (Table 1) were within the range and others higher than those reported by Umar *et al.* (2005) in the leaves of *A. digitata* leaves (1.28 % - 1.79 %); Umar *et al.* (2006) in the leaves of *A. indica* and *E. camaldulensis* leaves (0.87 % - 5.05 %). These findings were in agreement with report of Turner and Barkus (2002) that season and leaf age had a greater effect than stage of plant growth on the concentrations of N, P, K, Ca, Mn, Cu and Zn.

Sodium (Na)

The values obtained for Interaction between season, habitat and leaf age significantly ($P<0.05$) effect the content of Sodium in *S. occidentalis* (Table 1) but were lower than those reported by Lintas (1992) for vegetables (2-150 mg/100 g); Faruq *et al.* (2002) in *S. obtusifolia* (45 mg/100 g); Hassan *et al.* (2002) in *C .occidentalis* (0.50 mg). These findings were in consonance with report of Lovelock (2009) that once a species occurred in two habitat types, the processes operating on them in the habitat may affect them differently and that plant communities are more strongly influenced by environmental factors in their habitat. But the low level of Sodium implies that the species could be a good vegetable to the dietary intake of hypertensive patients.

Phosphorus (P)

Interaction effect between season, habitat and leaf age was significant ($P<0.05$) on phosphorus concentration of *S. occidentalis* (Table1). Highest concentrations of P were obtained during dry sub-season at both fadama and upland habitats with matured leaves treatments having the highest contentment of 5.53 ppm in *S. occidentalis.* The values obtained were lower than 0.25 mg in *C. occidentalis* (Hassan *et al.* 2002); 180.00 ± 0.04 mg/100 g in *C. siamea* leaves

Table 1. Mineral Composition of the Leaves of *S. occidentalis* as Influenced by Season, Habitat and Leaf Age

Treatments	Dry Fad Yng	Dry Fad. Mat.	Dry Upl. Yng	Dry Upl. Mat	ER Fad Yng	ER Fad Mat	ER Upl. Yng	ER Upl. Mat.	LR Fad Yng	LR Fad Mat.	LR Upl. Yng	LR Upl. Mat.	Ham. Fad Yng	Ham. Fad. Mat.	Ham. Upl. Yng	Ham. Upl Mat.	Sem	S (5%)
Parameter (ppm)																		
^{x}N	1.67^{fg}	1.77^{e}	2.77^{a}	1.53^{g}	2.50^{b}	2.33^{c}	2.72^{a}	2.31^{c}	1.88^{e}	1.63^{fg}	2.07^{d}	1.74^{ef}	1.94^{de}	1.85^{e}	1.94^{de}	1.85^{e}	0.02	S
Na	4.17^{d}	4.27^{d}	4.27^{d}	3.73^{e}	4.77^{bc}	5.03^{b}	4.53^{cd}	5.33^{a}	4.53^{cd}	5.40^{a}	4.33^{d}	4.47^{cd}	4.73^{c}	5.33^{a}	4.70^{c}	5.13^{qb}	0.05	S
P	2.50^{f}	5.53^{a}	2.73^{e}	2.83^{e}	3.27^{d}	3.17^{d}	3.57^{c}	3.73^{c}	3.17^{d}	2.87^{e}	3.17^{d}	3.91^{b}	2.17^{g}	2.08^{g}	2.45^{f}	2.06^{g}	0.11	S
K	8.57^{cd}	8.93^{c}	8.53^{d}	8.73^{cd}	11.57^{a}	9.53^{b}	3.27^{e}	2.73^{f}	3.63^{e}	2.43^{f}	3.33^{e}	2.53^{f}	8.73^{cd}	8.80^{c}	8.33^{d}	9.07^{c}	0.05	S
Ca	1.33^{g}	1.03^{i}	1.03^{i}	2.03^{d}	0.80^{j}	2.13^{c}	0.67^{k}	1.93^{e}	0.67^{k}	2.20^{b}	0.83^{j}	2.60^{a}	1.33^{g}	1.50^{f}	1.23^{h}	1.33^{g}	0.06	S
Mg	3.73^{d}	3.37^{e}	3.27^{e}	4.27^{bc}	3.53^{de}	4.73^{a}	3.73^{d}	4.13^{c}	3.37^{e}	4.87^{a}	3.60^{d}	4.50^{b}	4.53^{ab}	4.47^{b}	3.27^{e}	3.60^{d}	0.05	S
Cu	0.30^{bc}	0.40^{b}	0.20^{c}	0.30^{bc}	0.40^{b}	0.37^{b}	0.27^{bc}	1.13^{a}	0.10^{c}	0.20^{c}	0.10^{c}	0.20^{c}	0.30^{bc}	0.23^{c}	0.10^{c}	0.10^{c}	0.01	S
Fe	0.43^{c}	0.50^{c}	0.47^{c}	0.50^{c}	0.80^{b}	0.30^{d}	1.03^{a}	0.57^{c}	0.20^{d}	0.30^{d}	0.20^{d}	0.30^{d}	0.70^{b}	030^{d}	0.57^{c}	0.40^{cd}	0.01	S
Mn	0.50^{cd}	0.50^{cd}	0.50^{cd}	0.43^{d}	0.67^{c}	0.37^{d}	1.03^{b}	1.23^{a}	0.20^{e}	0.30^{de}	0.20^{e}	0.20^{e}	0.87^{b}	0.30^{de}	0.40^{d}	0.27^{e}	0.01	S
Zn	0.05^{i}	0.06^{h}	0.03^{j}	0.09^{g}	0.14^{f}	0.06^{h}	0.04^{b}	0.15^{e}	0.20^{d}	0.30^{c}	0.47^{a}	0.40^{b}	0.40^{b}	0.02^{k}	0.03^{j}	0.02^{k}	0.004	S
Cl^{-}	0.22^{j}	0.24^{h}	0.05^{m}	0.25^{g}	0.72^{b}	0.39^{f}	0.19^{l}	0.20^{k}	0.85^{a}	0.62^{a}	0.05^{m}	0.19^{l}	0.61^{d}	0.60^{e}	0.19^{l}	0.23^{i}	0.006	S

With a treatment group, mean in a row with the same latter(s) in subscript are not significantly different using least significance difference (LSD) at 50% level. SEM = Standard Error of Mean; S = Significant; NS = Non Significant. Fad: Fadama; Upl: Upland; Yng: Young; Mat: Matured; ER: Early Rainy; LR: Late Rainy; Ham: Harmattan; X-Note, Nitrogen was measured in %.

(Ngaski, 2006) but within the range (0.20 ppm - 8.50 ppm) reported by Umar (2007). These findings had agreed with report of Agishi (1985) that mineral contents of browses were higher during dry season. In the same vein, Osonubi and Chukwuka (1999) had reported that the amount and number of elements present in many plants also differ from plant to plant and from place to place depending on the habitat and season.

Potassium (K)

Interaction was significant (P<0.05) between season, habitat and leaf age on K concentration of the species (Table 1) with the highest value (11.53 ppm) obtained during the early rainy sub-season, fadama habitat and young leaves treatment in *S. occidentalis* than all the other treatments but all the values obtained were higher than those reported in *A. digitata* young leaves (0.050 %) and 0.057 % in matured leaves (Umar *et al*. 2005) but lower than those reported in *C. occidentalis* (2.25 mg) (Hassan *et al. (*2002); and Umar (2007) range (100.69 ppm - 859.33 ppm). for interaction effect of season and stage of leaf development of four tree species. These findings were in agreement with report of Gent (2002) that differences in nutrient concentrations due to season often occurred in rainy season and this could be due to changes in light and temperature that affect metabolism in leaves and roots of plants together with the rate of chemical transformations of nutrients in the soil.

This finding suggests that potassium concentration needed for the dietary intake of the users could be readily obtained from younger leaves of the fadama stands of the study species during early rainy sub-season than all the other treatments.

Calcium (Ca)

Interaction significantly (P<0.05) effect the calcium concentration in the leaves of the study species between season, habitat and leaf age (Table 1) with the highest concentration obtained during the late rainy sub-season, upland habitat and matured leaves treatment (2.60 ppm) in *S. occidentalis*. But the values obtained were lower than those reported by Hassan *et al.* (2002) in *C. occidentalis* (0.68 mg/100g); Ngaski (2006) in *C. siamea* leaves (17.95 ± 2.00 mg/100 g); and some were lower and others within the range reported by Umar (2007) for interaction effect of season and leaf age of four tree species (0.84 ppm - 520.78 ppm). The findings agreed with report of Gent (2002) that nutrient concentrations in plants due to season often occurred in rainy season. Similar finding was reported by Shelp (1987) in which the concentrations of Ca, B and Mn were more in young leaves than matured leaves (Ajakaiye *et al.,* 1995).

Magnesium (Mg)

Interaction between season, habitat and leaf age had significantly (P<0.05) effect the concentration of Magnesium in *S. occidentalis* (Table 1) with the highest values obtained during rainy and harmattan sub-seasons, fadama location, matured and young leaves treatments (4.87 ppm, 4.73 ppm and 4.53 ppm) than all the other treatments But the values obtained were lower than those reported in *C. occidentalis* (0.58 mg); and in *C. siamea* leaves (400.00 ± 00.00 mg/100 g) ((Hassan *et al.,* 2002; Ngaski, 2006). This finding was in agreement with report of Turner and Barkus (2002) that season was more important for Mg than stage of growth of the plant and that higher concentrations of the less mobile elements Mg, Ca, B and Mn were recorded in the older (matured) leaves compared with the younger leaves, indicating that their movement in to young leaves is relatively slow.

Copper (Cu)

The results for Interaction (Table 1) had revealed that early rainy subseason, upland habitat and matured leaves treatment gave the highest copper concentration (1.13 ppm) in *S. occidentalis* than all the other treatments but the values obtained were within the range of those reported by Umar (2007) for the interaction effect of season and leaf age of four tree species (0.30 ppm - 2.66 ppm). The finding was in agreement with report of Gent (2002) that nutrient concentrations in plants due to season often occurred in rainy season; Turner and Barkus (2002) reported that leaf position had a greater effect than season on the concentrations of N, P, K, Ca, Mn, Cu and Zn.

Iron (Fe)

Interaction revealed that concentration of Iron in *S. occidentalis* (Table 1) was significantly different (P<0.05) with the highest concentration value obtained during early rainy sub season, upland habitat, young leaves treatment (1.03 ppm) than all the other treatments in *S. occidentalis.* But the values obtained were lower than those reported by Hassan *et al.* (2002) in *C. occidentalis* (0.15 mg/100g); Olatunji (2009) in *I. astragalina* leaves (20.95 ± 3.84 mg/100 g); and below or within the range reported by Umar (2007) for interaction effect of micro-nutrients of four tree species (1.32 ppm - 10.64 ppm). The finding of this study was in agreement with report of Lovelock (2009) that plant communities are more strongly influenced by environmental factors in their habitat; and George *et al.* (2002) that leaf concentration of N, P, Cu and Zn decreased with leaf age. This finding was advancement over those reported by Lavanauskas (1958); Gent (2002); and Umar (2007) of non-significant interaction effects of the factors they have considered on micro-nutrients in their separate studies.

Manganese (Mn)

Interaction effect showed that highest concentration of Mn was obtained during early rainy sub-season, upland habitat, and matured leaves treatment (1.23 ppm) than all the other treatments in *S. occidentalis* (Table 1) but some of the values obtained were lower and others higher or within the range reported by Sena *et al.* (1998) in some locally green leafy vegetables (0.98 - 38.0 mg/100 g); and Umar (2007) of interaction effect of season and leaf-age on micro-nutrient concentration of four tree species (0.69 ppm - 2.62 ppm). These findings agreed with report of George *et al.* (2002) that higher concentrations of the less mobile elements (Mg, Ca, B and Mn) were recorded in the older (matured) leaves compared with the younger leaves depending on the season. This finding was advancement over those of interaction effects reported by Lavanauskas (1958); Gent (2002); and Umar (2007) on micro-nutrients concentration of their chosen species and factors in their separate studies.

Zinc (Zn)

Interaction was significant (P<0.05) between season, habitat and leaf age on zinc concentration of the studied species (Table 1) with the highest value recorded during late rainy subseason, upland habitat and young leaves treatment (0.47 ppm) than all the other treatments in *S. occidentalis* but the values obtained were lower than those reported by Hassan *et al.* (2002) in *C. occidentalis* leaves (0.05 mg/100g); Ngaski (2006) in *C. siamea* leaves (6.85 ± 1.00 mg/100 g); and some within the range reported by Umar (2007) on interaction effect of micro nutrients of four tree species (0.07 ppm - 7.29 ppm). Similar finding of significant effect (P<0.05) was reported for Zn concentration in a study of interaction effect by Gent (2002). Harper (1989) had similarly reported that young leaves tends to contained more nutrients than matured leaves because they are born in more exposed positions of the plant canopy and the matured ones are more likely to be shaded by the young for competition to available light, temperature and other climatic factors, hence, matured leaves are less active photosynthetically than young leaves.

Chloride (Cl^-)

Interaction of chloride in *S. occidentalis* (0.85 ppm) significantly (P<0.05) effect the concentration of chloride with the values obtained during late rainy subseason, fadama habitat and young leaves treatment (Table 1) being the highest than all the other treatments. But all the values obtained were within the range (0.22 ppm - 1.08 ppm) reported by Umar (2007) in tree species. These findings were in agreement with reports of Silmary *et al.* (2004); and Osonubi and Chukwuka (1999) that variation in the nutrient concentration of plants may be cause by differences in plants habitat or environment depending on the season; and Umar (2007) that the concentrations of Cu, Fe and Cl^- were significant as influenced by leaf age in the young leaves of all the four tree species studied.

Conclusion

The mineral element concentrations were variedly influenced by the treatment factors (season, habitat and leaf-age) considered in this study. Specifically, rainy season, fadama and upland locations, young and matured leaves were the most favourable treatments in the higher concentration of most mineral elements in the leaves of the study species e.g. Nitrogen, Potassium, Calcium, Magnesium, Copper, Manganese, Iron, Zinc, and Cl^-, From the findings of this research, it can be therefore, concluded that season, habitat and leaf-age are three independent and important factors affecting plant growth and developments, in fact, this research has proved that, hence the foliar nutritional values of the leaves of the study species were generally significant (P<0.05) statistically for all the interaction effects.

Recommendations

On the basis of the findings of this research on mineral elements concentration in the leaves of *S. occidentalis*, the following were recommended:

1. Further study on toxicological evaluation of the leaves of the study species should be carried for proper guidance in the continued use of the leaves of the plant.
2. The wild population of the species studied is seasonal and appear to be threatened. It is therefore, recommended that the species be domesticated and cultivated as garden vegetables.
3. This Senna species is evidently rich in essential minerals and therefore recommended for continued use by both the rural and urban populations.

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