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Soil micronutrient availability as influenced by monosaccharide distribution in cultivated farm land, Nigeria

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ABSTRACT: Soil micronutrient availability as influenced by monosaccharide distribution and its relationship in some cultivated farm lands sown to arable crops in Nigeria were studied, the results indicated that soils in the study area ranged from moderately to slightly acidic (pH 5.63 – 6.83 with a mean value of 6.33) indicating slightly acidic, low in CEC (mean = 5.65 cmol/kg) and exchangeable bases. The available Cu, Mn, Pb and Zn in the soils studied were found to be below the critical ranges except for Fe which was above the range. This means that deficiency symptoms of these plant nutrients on crops grown on these soils are likely. Also, mean values of 1.71 (arabinose), 0.34 (Galatose), 0.07(Glucose), 0.73 (Mannose), 0.46 (Galatose + Mannose/Arabinose), 1.24 (Mannose/Xylose), 1.61 (Xylose/Arabinose), 0.67 (Xylose) were observed. These values decreased with depth and was dominated by arabinose contrary to high concentration of glucose reported in most soils. Variability in monosaccharide distribution in the study area suggests that they could be of different carbohydrate origins. Higher content of arabinose in the soils suggests that the carbohydrate could be of fresh plant tissue origin since it has been noted that arabinose is the dominant sugar in fresh plant tissue origin. The significant relationship between micronutrients and soil properties (clay, pH OC and Cations) in this study ($P < 0.05$) showed the importance of these properties in the availability of micronutrients.

Key words: Arabinose, copper, iron, galactose, lead, mannose, micronutrients, monosaccharides, mannose, soil properties, zinc, xylose

Soil Micronutrient is a major limiting factor in crop productivity and its quality (Kumar *et al.,* 2020), and are the essential elements required by plants in relatively low concentrations. According to Prasad *et al.,* (2006), micronutrients form a coherent group, including eight core elements: iron (Fe), sodium (Na), chlorine (Cl), boron (B), manganese (Mn), zinc (Zn), copper (Cu), and molybdenum (Mo). Their absence can better be explained by the term "hidden hunger" (Nutrient element deficiency with little or no symptom that leads to a significant reduction in crop yield) (Ogeh *et al.*, 2021). The roles of these micronutrients are not limited to plants only but also encompass activities of the micro-organisms and in extension human beings (Atefeh *et al.,* 2010).

The concentration of soil monosaccharides varies and depends on the hydrolysis of the polysaccharides especially cellulose and sucrose. For instance, it has been reported that sucrose readily hydrolyzes to glucose and fructose (Ratnayake *et al.,* 2013, Lahmidi *et al.,* 2016). Soil monosaccharides include glucose, fructose, mannose, galactose, arabinose, xylose, fucose, ribose and rhamnose amongst others (Liu *et al.,* 2019). Quattara *et al*. (2017) reported that five monosaccharides; glucose, mannose, galactose, arabinose and xylose typically represent more than 90% of total hydrolysable carbohydrates. Arabinose, xylose and ribose represent pentoses of plant origin that is not readily synthesized by microbial activities while glucose, galactose and mannose are hexoses that are synthesis products of microorganisms (Apostel *et al.,* 2015). Frutose and rhamnose are deoxysugars of microbial origin that are usually present in small amounts in the soil or sediments (Gunina and Kuzyakov, 2015).

Forms of soil monosaccharides could be useful indicators of the nature, utility and origin of soil carbohydrates. For instance, the ratios of arabinose plus xylose to galactose plus mannose and rhamnose plus fucose to arabinose plus xylose have been noted as important indicators of the origin of soil carbohydrate (Liu *et al*., 2019).

Also, forms of soil monosaccharides and their relationship with mineral nutrients could be useful indicators in providing vita information on the availability or deficiency of the different micronutrient (Ratnayake *et al*., 2013) since carbohydrates supply carbon sources for microbia activities that contribute to mineral nutrient production in soil.

In the humid tropics, particularly in the southern Nigeria, extensive studies have been undertaken on soil organic matter, micronutrients and carbohydrate concentrations (Spaccini *et al*., 2001; Uzoho and Igbojionu, 2014; Uzoho and Okechukwu, 2014), however, there appears to be a dearth of information on monosaccharide distribution and

its relationship with other mineral nutrient especially, the micronutrients of the soils of this region. Hence the need for this study which seek therefore to evaluate soil micronutrients and to ascertain if the impact of soil micronutrient influences the availability of monosaccharide distribution and its relationship in the soils of an arable crop farm land in Benin City, Nigeria.

MATERIALS AND METHODS

Study location and site description

The location of this study is a cultivated farm land in University of Benin, Benin city, Nigeria. The land coordinates are Latitudes 6.404165, 6.404355, 6.404271, 6.404238^{0}N and Longitudes 5.6100631, 5.6100738, 5.610248, 5.610311^{0}E, it has been sown to plantain and banana for a period of about four years and history of the farm showed there has not been application of micronutrient fertilizer for over 3 years.

Sample collection and analysis

Soil auger was used in collecting composite soils samples at depths of 0-15 cm, 15-30 cm and 30 – 45 cm, and were replicated 3 times in a plantain and banana farm land. The composite soil samples were bulk together. The soils collected from each depth were air-dried, crushed and passed through a 2 mm sieve. The sieved samples were analyzed for some physical and chemical properties using standard laboratory procedures.

Laboratory analysis of soil samples

Soil pH was determined using soil: water (1:1) method (Udo *et al.,* 2006). The particle size distribution was determined using hydrometer method (Gee and Or, 2002). Organic carbon was carried out via wet oxidation methods (Walkley and Black, 1934). Organic matter was determined by a multiplication factor of 2.0 (Pribyl, 2010). The exchange acidity was determined using Jackson (1962) method. Exchangeable cations were determined using ammonium acetate solution (1N NH_4OAc) buffered at pH 7.0. Ca and Mg were determined from the extract of 0.01m EDTA (Jackson, 1962), while K and Na were determine using photometer (Jackson, 1962). Total nitrogen and available phosphorous were determined using Bremner and Mulvaney (1982) method. The extractable micronutrients: Fe, Mn, Zn, Cu, Cr, Cd, Pb and Ni, were extracted using 0.1 M HCl solution (Osiname *et al*., 1973) and read using atomic absorption spectrophotometer at a specific wavelength. Monosaccharide contents of the soils were determined using the following procedures: Sub sample of the fine earth soil fraction was weighed (1 g) into a boiling tube and 25 ml of 80% hot ethanol added and shaken on a vortex mixer for 45 minutes. The tube was allowed to settle for 30 minutes and the contents filtered into a beaker using Whatman No. 41 filter paper. The above step was repeated three times to ensure complete extraction. The extracts were then evaporated to dispel all the ethanol and 10 ml de-ionized water added to dissolve the contents before transferring into a 100 ml volumetric flask. The beaker was washed three times and transferred into the 100 ml flask and then made up to mark with de-ionized water. The sugars were subsequently determined as follows:

Glucose content was determined using the Anthrone method (Browne and Zerbon, 1981). In this, about 1ml aliquot of the sugar extract was pipetted into a test tube and 6mls of anthrone-sulphuric acid (Prepared by dissolving 1g of Anthrone in 760 ml of concentrated H_2SO4 and made up to mark using 240 mls of de-ionized water) added and shaken vigorously for 2 minutes on a reciprocating shaker. A blank solution was also prepared as above but using de-ionized water instead of sugar concentration. Standard glucose solution of concentrations10-50µg/ml was prepared. Absorbance of the bluish coloured solutions of sample and the glucose standards were read on a Spectronic 21D Spectrophotometer at a wavelength of 595nm against the blank.

$$\% \text{ Glucose} = \frac{\text{Absorbance of sample x Av. Gradient factor x Dilution factor}}{\text{wt of sample x 10000}} \quad (1)$$

Mannose content was determined using the same method as for the glucose but with the absorbance read at a wavelength of 615nm.

$$\% \text{ Mannose} = \frac{\text{Absorbance of sample x Av. Gradient factor x Dilution factor}}{\text{wt of sample x 10000}} \quad (2)$$

Galactose concentration was determined by reading the absorbance of the standard and raffinose sample at a wavelength of 528 nm on a Spectronic 21D Spectrophotometer.

$$\% \text{ Galactose} = \frac{\text{Absorbance of sample x Av. Gradient factor x Dilution factor}}{\text{wt of sample x 10000}} \quad (3)$$

Arabinose determination was achieved by reading the bluish colour solutions of arabinose standard and sample at a wavelength of 595nm on the 21 D spectrophotometer.

$$\% \text{ Arabinose} = \frac{\text{Absorbance of sample x Av. Gradient factor x Dilution factor}}{\text{wt of sample x 10000}} \quad (4)$$

The Xylose concentration of the sugar extract was determined as the glucose above with the bluish colour solutions of xylose standard and sample read at a wavelength of 595nm.

$$\% \text{ Xylose} = \frac{\text{Absorbance of sample x Av. Gradient factor x Dilution factor}}{\text{wt of sample x 10000}} \quad (5)$$

Data generated for the study were subjected to analysis of variance (ANOVA) and means separated at 5% level of probability, also conducted was correlation analyses. All analyses were executed using the Genstat statistical package (Buysse *et al.,*2004).

RESULTS AND DISCUSSION

Soil Properties

The mean sand, silt and clay fractions ranges from 796.80 – 837.90, 27.33 – 34.77 and 134.8 – 168.4 g/kg respectively (Table 1). The texture across the study area was sandy loam (Table 1). The high sandy nature of the soil is an indication that micronutrients supply availability and uptake by crops may be difficult. This is because soils that are coarse texture (sandy) are more likely to be low in micronutrient since they have low cations binding power (Mckenzie, 2011).

The soil reaction ranged from pH 4.63 – 5.83 with a mean value of 5.33 indicating generally acidic in nature, the pH value varies significantly ($P < 0.05$) between the depth considered, with surface (0-15 cm) pH more acidic than the subsurface (30 - 45 cm). This could be mostly attributed to leaching of basic cations to lower depths (Mustapha and Locks, 2005; Voncir *et al*., 2008), since the study area falls within the rain forest zone of the country or the use of acid–forming fertilizer such as urea for agricultural purposes. The organic matter content falls within the "middel" category (Esu,1991) of fertility classification for Nigeria Savanna soils, the values significantly ($P < 0.05$) ranged from 12.67 to 15.72 g/kg with a mean value of 14.41 g/kg, suggesting that these soils would be prone to leaching of nutrients. Similar low organic matter content values have been reported by Lawal *et al.* (2012) for soils of this region. The low organic carbon contents of the soils are characteristics of the savanna due partly to rapid decomposition and mineralization, leaching of organic matter and somethings to poor management practices (Lawal *et al.,* 2012). Greenland (1995) attributes decline in soil organic matter content to intensification of agricultural activities through clearing and clean cultivation of soils for annual cropping. Thus, there is need to adopt cultural practices that will encourage the return and incorporation of plant/crop residues into these soils in order to beef up the soil organic matter content (Lawal *et al.,* 2012). The exchangeable bases (Ca, Ma, K and Na) significantly ($P < 0.05$) vary across the depths (Table 1). The exchangeable bases in this study are mostly rated low and medium across Sahel and Sudan agro-ecological zone respectively regardless of depth based on Esu (1991) critical limits and micro nutrients fertility ratings, this conforms with the findings of Oyinyola and Chude (2010) in Northern Nigeria which reflects the low and medium CEC of the soils in the study area respectively.

The values of available Cu in the soils ranged from 4.78 to 6.31 mg/kg with a mean value of 5.39 mg/kg in the studied area (Table 2). Based on Esu's (1991) micronutrients fertility rantings, these value falls within the low categories although they are above the values reported by Mulima *et al.* (2015) for soil elsewhere in yobe state, Nigeria. Lombin (1983) reports that the low content of available Cu in soils possess fertility problem to soils. Zinc (Zn) value in the soil ranged from 9.78 – 16.26 mg/kg with a mean value of 12.18 mg/kg. The values obtained were above the critical limit as outlined by Lindsay and Norvell (1978) and Esu (1991). The concentration of Zn had a decreasing trend as the depth increases. Zinc had earlier been reported to be generally of low mobility in soils (Chesworth, 1991) and has a tendency of being adsorbed on clay-sized particles (Alloway, 2008). Its implication here is that plants may not have a Zn stored in the lower surface. This agrees with the findings of Mulima *et al.* (2015). Lead (Pb) value in the soils ranged from 1.60 – 2.67 mg/kg. The values were low when compared to the average critical level of 6.35mg/kg given by Chude and Obigbesan (1980). Manganese (Mn) values in the soil ranged from 8.73 to 10.28 mg/ kg. These values were low when compared to the established critical values of 10.3-15.7mg/kg by Ayanlaja (1983). Iron (Fe) values in the soil ranged from 16.67–22.59 mg/kg with a mean value of 18.99 mg/kg. These values are

Table 1: Physical and Chemical Properties of the soils of experimental site studied

Soil depth(cm)	pH	EC µS/cm	Org.Mat (g/kg)	T.N (g/kg)	Av. P (mg/kg)	Ca	K	Mg	Na	EA	ECEC	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)
						←		(cmol/kg)		→				
0-15	6.83a	28.69a	15.72a	1.27a	16.62a	1.94a	2.93a	1.21a	0.76a	1.18a	9.50a	837.9a	34.77a	134.8b
15-30	6.53b	27.47b	14.85b	1.25b	15.54b	1.87a	2.67b	0.95b	0.62b	0.87b	6.98b	802.7b	30.67b	166.70a
30-45	5.63c	24.47c	12.67c	1.14c	15.17b	0.55b	0.84c	0.37c	0.24c	0.66c	3.18c	796.8c	27.33c	168/4a
Mean	6.33	26.74	14.41	1.22	15.78	1.45	2.14	0.84	0.54	0.9	6.55	812.47	30.92	156.61

Mean value(s) with the same letters(s) in the column are not significantly different from one another at 5% level of probability.

Table 2: Micronutrients content in the top, middle and bottom layer of the soils studied

Soil depth (cm)	Cu	Fe	Mn	Pb	Zn
	←		(mg/kg)		→
0 - 15	6.31a	22.59a	10.28a	2.67a	16.26a
15 - 30	5.09b	16.67c	9.60b	1.86b	10.50b
30 - 45	4.78c	17.73b	8.73c	1.60c	9.78c
Mean	5.39	18.99	9.54	2.05	12.18

Mean value(s) with the same letters(s) in the column are not significantly different from one another at 5% level of probability.

above the values reported by Kparmwang *et al*. (1995). Although available Fe is generally high in the tropical soils, localized deficiencies of Fe are known to occur in these areas (Enwezor *et al*., 1981). High levels of Fe in these soils could be due to the acid conditions of the soils. Although Iron poses no fertility problem in the soils studied.

Monosaccharide forms in the soils studied (Table 3) varied with a mean value of 1.71 (arabinose), 0.34 (Galatose), 0.07(Glucose), 0.73 (Mannose), 0.46 (Galatose + Mannose/Arabinose), 1.24 (Mannose/Xylose), 1.61 (Xylose/Arabinose), 0.67 (Xylose). These various decreased with depth and dominated by arabinose contrary to high concentration of glucose reported in most soils (Ratnayake *et al*., 2013; Lahmidi *et al*., 2016; Liu *et al*., 2019; Apostel *et al.,* 2015). Variability in monosaccharide distribution in the study area suggests that they could be of different carbohydrate origins. Higher content of arabinose in the soils suggests that the carbohydrate could be of fresh plant tissue origin since it has been noted that arabinose is the dominant sugar in fresh plant leaves (Glaser *et al.,* 2000). According to Hu *et al*. (1995), Mannose/xylose ratios of greater than unity have been suggested as a better indicator of the relative contribution of microbially derived sugars to the soil carbohydrate. Furthermore, ratios greater than unity of arabinose /xylose could be useful in the evaluation of the replacement of carbohydrates of forest origin with those of pastures (Ratnayake *et al.,* 2013; Glaser *et al.,* 2000). According to Murayama (1984) xylose/mannose ratio has been used to evaluate the decomposition of plant residues. Therefore, the greater than unity of arabinose/xylose ratio in all horizons of the physiographic positions suggests the existence of a high concentration of fresh forest vegetations (Fujii and Hayakawa, 2021).

Soil pH correlated significantly and negatively ($P \geq 0.05$) with available Cu (r = -0.991*), Fe (-0.913*), Mn (-0.671*), Pb (r = -0.992*) and Zn (r = -0.984*) (Table 4). Oyinlola and Chude (2010) had reported significant correlation between Cu, Fe, Mn, Pb, Zn and pH in Northern

Table 3: Forms of Monosaccharide content and the distribution pattern in top, middle and bottom layer of the studied

Soil depth (cm)	Arabinose	Galactose	Glucose	Mannose	G+M/A	Ara/Xyl	Xyl/Man	Xylose
	←			g/kg				→
0-15	1.89a	0.45a	0.09a	0.72a	0.50a	1.80a	2.68a	0.87a
15-30	1.78a	0.35b	0.07b	0.83a	0.46a	1.44ab	0.87b	0.733b
30-45	1.47b	0.22c	0.04b	0.64a	0.40a	1.21b	0.55b	0.40c
Mean	1.71	0.344	0.07	0.73	0.46	1.48	1.37	0.67

Mean value(s) with the same letters(s) in the column are not significantly different from one another at 5% level of probability. Ara = Arabinose, Xyl = Xylose, Man = Mannose, G = Galactose, M = Mannose, and A = Arabinose

Table 4: Correlation coefficient showing the relationship between some soil properties and Micronutrients in the soils studied

	Cu	Fe	Mn	Pb	Zn
pH	-0.991*	-0.913*	-0.671*	-0.992*	-0.984*
Sand	0.993*	-0.949*	0.742*	0.990*	0.993*
Silt	-0.913*	-0.719*	0.742*	0.921*	-0.875*
Clay	-0.981*	-0.967*	-0.792*	-0.975*	-0.988*
Ca	-0.984*	-0.976*	-0.964*	-0.984*	-0.997*
Mg	-0.993*	-0.888*	0.909*	-0.924*	0.963*
Na	-0.993*	-0.958*	-0.641*	-0.970*	-0.960*
K	-0.993*	-0.958*	-0.756*	-0.993*	-0.998*
Av.P	0.046	0.358	0.680*	0.020	0.128
T.N	-0.992*	-0.941*	-0.725*	-0.995*	-0.993*
Org.Matt	-0.985*	-0.895*	-0.632*	-0.997*	-0.977*

*Significantly correlated at 5% level of probability.

Table 5: Correlation coeffiecient showing the relationship between micronutrients and forms of monosaccharides in soils studied

Soil micronutrients	Galatose	Glucose	Mannose	Arabinose	Xylose	G+M/A	Ara/Xyl	Xyl/Man
Cu	-0.096	-0.405*	0.364	-0.273	-0.015	0.412*	0.155	-0.359
Fe	-0.449*	-0.317	-0.224	-0.431*	-0.382	-0.032	0.165	0.042
Mn	-0.042	-0.294	-0.049	-0.055	0.011	-0.033	0.003	0.034
Pb	-0.037	-0.350	-0.302	-0.246	0.047	0.348	0.074	-0.287
Zn	-0.059	-0.375	0.284	-0.239	0.016	-0.376	0.103	-0.276

*Significantly correlated at 5% level of probability.
Ara = Arabinose, Xyl = Xylose, Man = Mannose, G = Galactose, Mannose, X = Xylose and A = Arabinose.

Nigeria soils. Sims and Johnson (1991) had reported that the availability of these micronutrients in the soils are affected by pH and soil texture. Sand correlated positively and significantly ($P \geq 0.05$) with all the micronutrients except for Fe which was a negative correlation: Cu (r = 0.993*), Fe (-0.949*), Mn (0.742*), Pb (r = 0.990*) and Zn (r = 0.993*) Silt also correlated significantly ($P \geq 0.05$) with Cu (r = -0.913*), Fe (-0.719*), Mn (r=0.742*), Pb (r = 0.921*) and Zn (r = -0.875*). Clay correlated negatively ($P \geq 0.05$) with Cu, Fe, Mn, Pb and Zn (r = -0.985*, -0.970*, 0.805*, 0.977*, and -0.991*respectively (Table 4). The significant relationships between clay and the micronutrients signify the importance of clay in the availability of these micronutrients. Similar findings have been reported by Ibrahim *et al.* (2011) in their studies.
The cations (Ca, Mg, Na and K) correlated negatively with the soil micronutrients (Cu, Fe, Mn, Pb and Zn). These results obtained from the study conformed to the report of Debs and Sakal (2002) and Tisdale *et al.* (2003) that the availability of most micronutrients in soils depend on soil pH, OC content, cations and adsorptive surfaces.

Correlation coefficient between micronutrient and forms of monosaccharides in the soils studied (table 5) indicate a negative significant relationship $P \geq 1$ between Cu and Glucose (r = -0.405*), Cu and Galactose/Mannose/ Arabinose (0.412*), Fe and Galatose (r = -0.405*).

CONCLUSION

The results of the present study have indicated that soils in the study area ranged from moderately to slightly acidic (pH 5.63 – 6.83 with a mean value of 6.33) indicating slightly acidic, low in CEC (mean = 5.65 cmol/kg) and exchangeable bases. The available Cu, Mn, Pb and Zn in the soils studied were found to be a below the critical ranges except for Fe which was above the range. This means that deficiency symptoms of these plant nutrients on crops grown on these soils are likely. Also, the significant relationship between micronutrients and soil properties shows the importance of these soil properties (clay, pH OC and Cations) in the availability of micronutrients. Variability in monosaccharide distribution in the study area suggests that they could be of different carbohydrate origins. Higher content of arabinose in the soils suggests that the carbohydrate could be of fresh plant tissue origin since it has been noted that arabinose is the dominant sugar in fresh plant leaves. The importance of organic matter in the supply of micronutrients was also observed in this study.

REFERENCES

Alloway B, J. (2008). Zinc in soils and crop nutrition. International Fertilizer Industry Association and International Zinc Association, Brussels, Belgium and Paris, 135p.

Apostel C, M Dippold, and Y Kuzyakov (2015) Biochemistry of hexose and pentose transformations in soil analyzed by position-specific labeling and 13C-PLFA. *Soil Biology and Biochemistry*, 80: 199-208.

Atefeh R., Campbell C. D., Dahlin S., Hillier S., and Öborn I. (2010) Relation of soil mineralogy and microbial communities based on micronutrient status 19thWorld Congress of Soil Science, Soil Solutions for a Changing World, 27: 1 – 6.

Ayanlaja S. A. (1983) Soil and Agro meteological Studies on Cocoa, Cocoa Research Institute of Nigeria Annual Report.

Bremner J. M. and Mulvaney C. S. (1982) Nitrogen-total. In: Methods of soil analysis. Part 2. Chemical and microbiological properties, Page AL, Miller RH, Keeney DR, Eds. American Society of Agronomy, Soil Science Society of America, Madison, Wisconsin, Pp 595-624.

Browne C.A and Zerbon, F.W (1981). Physical and chemical methods of sugar analysis. 3rd edition. New York.

Buysse W., Stern R. and Coe R (2004). Genstat Discovery Edition for everyday use. ICRAF Nairobi, Kenya, 114 p.

Chesworth W. (1991) Geochemistry of micronutrients. In: Mortvedt, J.J.Cox, F.R. Shuman, L.M. and Welch R.M. (eds). Micronutrients in Agriculture, 2nd edition. Soil Science Society America. Inc. Madison Wisconsin, Pp 427–476.

Chude V. O. and Obigbesan G.O (1980) Federal Ministry of Agriculture and Natural Resources (FMANR). (1990) Literature Review on Soil Fertility. Investigation in Nigeria, Pp. 170-173.

Debs D. L. and Sakal, R. (2002). Micronutrients. In: Indian Society of Soil Science. Indian Research Institute, New Delhi, Pp. 391-403.

Esu I. E. (1991). Detailed soil survey of NIHORT farm at Bunkure, Kano State, Nigeria. Institute of Agricultural Research, Zaria, 72p.

Enwezor W. O., Udo E.J. and Sobulo R.A (1981). Fertility status and productivity of the acid sands, In Udo E.J. and Sobulo R.A Acid Sands of Southeastern Nigeria. *Soil Science Society of Nigeria*, Special Pub. Monograph No 1 pp 56-73.

Fujii K. and Hayakawa C. (2021) Root exudation and biodegradation of organic acids in a tropical forest soil under dipterocarp and pioneer trees, *Plant and Soil,* 469 (1):213-226.

Gee G. W., and Or D. (2002) Method of Soil analysis: Part 4, *Physical Methods,* 5:255-293.

Gunina A. and Kuzyakov Y. (2015). Sugars in soil and sweets for microorganisms: Review of origin, content, composition and fate. *Soil Biology and Biochemistry,* 90: 87-100.

Glaser, B, Turrion, M. Solomon, D. Ni, A and Zech, W (2000). Soil organic matter quantity and quality in mountain soils of the Alay Range, Kyrgyzia, affected by land use change. *Biology & Fertility of Soils*, 31:407–413

Greenland, D. J. (1995) Long-term cropping experiments in developing countries: the need, the history, and future. In J. C. Waterlow, D. G. Armstrong, L. Fowden and R. Riley (eds.). *Feeding the world population of more than eight billion people: a challenge to science.* Oxford: University Press.

Ibrahim, Usman, Abubaka, Aminu (2011) Extractable micronutrient status in relation to other soil properties in Billiri local Govetnment Area. Journal of soil science and environmental management. https://www.semanticscholar.org/paper/Extractable-micronutrients-status-in-relation-to-in-Ibrahim-Usman/3e1a89b9dd7cbb6ef4b232faaaef2b850f68cf52

Hu S, Coleman D. C., Beare M. H. and Hendrix, P. F. (1995). Soil carbohydrate in aggrading and degrading ecosystem: influences of fungi and aggregates. *Agriculture, Ecosystem and Environment*, 54:77-88.

Jackson M. L. (1962) Soil chemical analysis. Prentice Hall, New York.;263–268.

Kparmwang. T., Esu, I. E. and Chude. V.O. (1995). Available and total forms of copper and zinc in basaltic soils of the Nigerian savanna. *Communications Soil Science Plant Analysis*, 29: 2235 – 2245.

Kumar D., Patel K. P., Ramani V. P., A. K. Shukla and R. S. Meena (2020) Management of Micronutrients in Soil for the Nutritional Security, nutrient dynamics for sustainable crop production, Pp130-134.

Liu C. Z., Jia J., Ma T., and Feng X. J. (2019) Origin and distribution of neutral sugars in soils. *Chinese Journal of Plant Ecology*, 43(4): 284-295

Lahmidi N. A., Courty P., Chatagnier O., Arnould A., Doidy J., Berta G., Lingua G., Wipf D., and Bonneau L. (2016). Sugar exchanges in arbuscular mycorrhiza: RiMST5 and RiMST6, two novel Rhizophagus irregularis monosaccharide transporters, are involved in both sugar uptake from the soil and from the plant partner, *Plant Physiology and Biochemistry,* 107: 363.

Lawal B. A., Odofin A. J., Adeboye M. K. A. and Ezenwa M. I. S. (2012). Evaluation of selected Fadama soils in Katcha local Government Area of Niger State for arable cropping. *Nigerian Journal of Soil Science,* 2: 22.

Lindsay W. L and Norvell W. A. (1978) Development of DPTA soil test for Zinc, Iron, Manganese and Copper, Soil. *Sci. Soc. American. Journal*, 42:421-428.

Lombin, G. (1983). Evaluating the micronutrients fertility of Nigeria's semi-arid savanna soils. Copper and manganese. *Soil Science,* 135, 377 – 384.

McKenzie R. H. (2011). Micronutrient requirements of crops. Alberta Agriculture and Rural developmenthttp://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex713.Acessed on 21 July 2011.

Mulima I. M, Ismaila M, Benisheikh KM and Saminu I. (2015). Assessment of micronutrients status of soils under millet cultivation in geidam local government Yobe state, Nigeria. *Asian Journal of Basic and Applied Sciences,* 2(2): 32-41.

Murayama S. (1984). Decomposition kinetics of straw saccharides and synthesis of microbial saccharides under field conditions. *Journal of Soil Science,* 35: 231-242.

Mustapha, S. and Locks, N. A. (2005). Distribution of available zinc, copper, iron and manganese in the Fadama soils from two distinct agro-ecological zones in Bauchi State, Nigeria. *Journal of Environmental Science,* 9(2): 22-28.

Ogeh J.S., Imogie, A.E. and Maduakor C.S. (2021). The micronutrient status of some soils supporting oil palm plantation in NIFOR, Benin, City, Benin. *Bayero Journal of Pure and Applied Sciences*, 14(1):95-99

Osiname O. A., Schulls B. T. and Corey R. B. (1973). Soil test for available copper and zinc in soils of western Nigeria. *Journal of Soil food and Agriculture*, 24:1341-1349 Published by John Wiley and Sons.

Ouattara B., Sermé I., Ouattara K., Sédogo M. P. and Nacro H. B., (2017). Cropping System Effects on Soil Monosaccharides in Western Burkina Faso. *Journal of Agricultural Studies*, 5 (4): 97-109.

Oyinlola E. Y. and Chude V. O. (2010). Status of available micronutrients of the basement complex rock – derived Alfisols in northern Nigeria savanna. *Tropical and Subtropical Agro-ecosystems,* 12: 229 – 237.

Pribyl D. W. (2010). A Critical review of the conventional SOC to SOM conversion factor. *Geoderma,* 156 (3-4): 75-83.

Ratnayake R. R., Seneviratne G. and Kulasooriya A. S. (2013) Effect of soil carbohydrate on nutrient availability in natural forests and cultivated lands in Sri Lanka. *Eurasian Soil Science*, 46(5): 579-586.

Sims, J.T. and Johnson. G.V. 1991. Micronutrient soil test. In: J.J. Mortvedt, F.R., Cox, L.M. Micronutrient in Agriculture, 4:427-476.

Spaccini, A. Zena, C, Igwe, A, Mbagwu, J.S.C. and Piccolo, A. (2001). Carbohydrates in water stable aggregates and particle size fractions of forested and cultivated soils in two contrasting tropical ecosystems. Biogeochemistry 53:1-22.

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

Udo E. J., Ibia T. O., Ogunwale J. A, Ano A. O., Esu I. E., Udoh B. T., Ndaeya N. U., Harold K. O. (2006). Fertility status and variability of some soils developed from parent material in the humid region of Nigeria. Proceedings of the 31st Annual Conference of Soil Science of Nigeria (SSSN), 13th – 17th November, 2006, Ahmadu Bello University, Zaria. 2006;79 – 85.

Uzoho B.U. and Okechukwu T.V. (2014) Soil Organic Matter Distribution of Contrasting Landscapes in Egbema, Southeastern Nigeria. *Journal of Biology, Agriculture and Healthcare*, 4(7):104-112.

Uzoho, B. U. and Igbojionu G. U. (2014). Carbohydrate Distribution of Particle Size Fractions of Soils in Relation to Land-use Types in Mbaise, Southeastern. *Nigeria Journal of Biology, Agriculture and Healthcare*, 4(2): 27-36.

Voncir N., Mustapha S., Tenebe V. A., Kumo A. L. and Kushwaha S. (2008). Content and profile distribution of extractable zinc (Zn) and some physicochemical properties of soil along a toposequence at Bauchi, Northern Guinea Savanna of Nigeria. *International Journal Soil Science,* 3: 62-68.

Walkley A. and Black I. A. (1934). An examination of the different methods for determining soil organic matter and the proposed modification of the chromic acid wet titration method. Soil Science of America Journal. 1934; 37:29–38.

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