Sulphur Status Of Some Soils In Edo State, Nigeria

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Abstract: Sulphur status of some soils in Edo Central, Nigeria was evaluated in five different locations; Ekpoma, Irrua, Uromi, Ubiaja and Agbede. The area lies within the derived savanna-forest transitional zone. Surface soil samples (0 – 15 cm) collected from the five localities wasanalyzed for their physico-chemical properties, inorganic, organic and total sulphur contents. Results showed that inorganic, organic and total sulphur ranged from 0.10 to 0.37, 0.79 to 2.75 and 6.30 to 16.41 mg/kg respectively. Inorganic sulphur content of all the locations was generally below the critical level of 8.50 mg/kg and therefore generally deficient in inorganic sulphur. Inorganic sulphur correlated significantly with available phosphorus but was negative and non-significant with organic carbon, pH, nitrogen, ECEC, clay and silt contents. Application of sulphur fertilizer is recommended for adequate crop yield in the agro-ecological zone.

Key words; inorganic sulphur, organic sulphur,sulphur, physico-chemical properties, total sulphur

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1 INTRODUCTION

Sulphur is an element that occurs naturally in the environment and it is the sixteen most abundant in the earth crust, averaging 0.06 to 0.10%.Sulphur deficiency has become a major constraint in crop production in coarse textured soils [1]. Introduction of higher yielding crop varieties, intensive and the decreased use of farmyard manures seem to have led to a wild occurrence of sulphur deficiency and diverted the attention of the researchers towards this hither to neglected element. The results of earlier studies in Nigeria indicated that sulphur deficiency exists in some Nigeria soil [2], [3]). The deficiency of sulphur in the savanna soils of West Africa has been attributed to annual burning of grassland vegetation, low organic matter contact and the relatively insignificant accretion from precipitation [2]. Raji [4] studied profile distribution of total available sulphur and boron in sandy soils of Nigeria semi-arid savanna and reported that they were deficient in available sulphur except for soils derived from illela sand dune, which were marginally sufficient. Osemwota and Aghimien[5] reported that 66% of Edo state soil was deficient in available S. The deficient soils were predominantly from the derived savanna ecological zone of the state. .Deficiency of sulphur is becoming wild spread due to continuous use of sulphur free fertilizers, high yielding crop varieties intensive multiple cropping system and high sulphur requiring crops.

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Cowpea production in Nigeria could be limited in the Nigeria savanna due to S deficiency [6]. They found that sulphur deficiency was observed to be most in acute in soil from guinea savannah, followed by those derived from savannah and least acute in soil from the rainforest zone. Insufficient availability of sulphur to crop plants not only declines their growth and yield but can also deteriorate nutritional quality of the [7]. In soils with low organic matter contents (mostly < 1%) and little or no recycling of crop residues [8] the amount of S mineralized from organic sources may not be appreciable [9]. Soil characteristics particularly the texture, clay minerals, pH, and organic matter may influence the contents of plant available S by controlling the retention and leaching characteristics of highly mobile SO_4^{2-} -S in soils [10]. Ogeh *et al* [11] studied the distribution of Sulphur in soils formed from different parent materials in southern Nigeria; extracted sulphur in Akure, the values recorded were lower than the critical level of 8.50 mg/kg as established by [3] except at Sapele, where the values were above 8.50 mg/kg in the top soil. Khalid *et al* [12] obtained significant positive relationships between plant available S ($CaCl_2$ extractable $SO4^{-2}$-S) and the total S, organic S and organic C contents in soils of Pakistan. Organic S formed the largest fraction of total S in the soils and also had significant positive relationship with total S and organic C contents in the soils. This was in agreement with the findings of [13], this indicates a strong link between soil organic matter and different S fractions in the rain-fed soils. Slow mineralization of indigenous soil organic S seems to contribute to plant available S in these soils [13]. There exists a negative correlation of plant available S with soil pH and CaCO3 contents. According to [10], SO_4^{-2} retention capacity of sulphur in soils decreases with increasing soil pH and becomes almost negligible at pH values above6.5 [13]. Thus under high soil pH conditions, SO_4^{-2} retention in soils is minimum which favors its leaching losses. The objective of the experiment therefore is to evaluate the sulphur status of some soils of Edo Central, Edo State, Nigeria.

Materials and Methods

The study area includes: Irrua, Uromi, Ekpoma, Ubiaja and Agbede in Edo State. Edo State is located between latitudes 5^0 4^1 and 7^0 38^1 North and longitudes 5^0 4^1 and 611^1 East of equator. The state has tropical climate characterized by rainy season between April and October and dry season lasting from November to March. The state has a mean rainfall of about 1300 to 2300 mm [14]. The State has mean daily temperature of about 26.7 ^{o}C. Relative humidity is fairly high and about 70 % [15]. The area lies within the northern belt of derived savanna-forest transition and is further degraded intensively as a result of cultivation. Crops such as maize, grain legumes root and other crops (yams, cassava, cocoyam and sweet potatoes), horticultural crops such as pineapple, plantain and bananas are also common [16].

Soil Samples Collection

Surface soil samples (0-15cm) from the five different locations were collected using probe anger. Soil samples collected were air – dried at room temperature, ground, sieved using a 2mm mesh sieve and bagged using polyethylene bag in readiness for laboratory analysis.

Laboratory Studies

Soil samples were taken to Nigerian Institution for Oil Palm Research (NIFOR), Benin City for routine soil analysis and forms of Sulphur. Soil pH was determined in a 1.1 soil water suspension using a pH meter [17], organic carbon was determined according to Walkley – Black method modified by [18]. Total N was determined by the Micro – Kjeldehl method of [19]. Available P was extracted with bray P solution measured by the molybdenum blue method on the technicon auto analyzer. Exchangeable Ca, Mg, Na and K were extracted with in NH_4OAc. pH 7.0 (Ammonium acetate) [20]. Potassium and Na were determined with atomic absorption Spectrophotometer [21]. Effective cation exchange capacity (ECEC) was determine by summation of exchangeable bases (Ca Mg Na and K) and exchangeable acidity ($A1^{3+}$ and H^{+}).

Statistical Analysis

Data obtained was statistically analyzed by determining the coefficient of variability and correlation at 5 % probability level.

Results

Table 1 shows the physico-chemical properties of the soil samples collected. From particle size analysis and using the textural triangle all the location soils were sand texture. The pH of the soils ranged from 6.30 to 6.80 with a mean of 6.98. The range is slightly acidic and is therefore favourable for nutrient availability and release. Organic carbon ranged from 10.9 to 29.6 g/kg with a mean of 21.08 g/kg. Organic carbon was sufficient in soils of Ekpoma, Irrua and Ubiaja but the highest content was observed in soil of Irrua and the lowest content was observed in soils of Agbede. Total Nitrogen ranged from 0.83 to 2.33 g/kg with a mean of 1.55 g/kg. With a critical level of 1.5 g/kg, total nitrogen is high in soils of Ekpoma and Irrua and low in soils of Ubiaja, Uromi and Agbede. Available phosphorus ranged from 7.16 to 38.02 mg/kg with a mean of 25.32 mg/kg. Available phosphorus was highest in soils of Agbede and lowest in soils of Ubiaja. With a critical level of 15 mg/kg, it shows that available phosphorus was high in soils of Agbede, Ekpoma, Uromi and Irrua and low in soils of Ubiaja. Calcium, sodium and potassium ranged from 2.11 to 2.85 cmol/kg, 0.20 to 0.34 cmol/kg and 0.05 to 0.19 cmol/kg with means of 2.14, 0.29 and 0.10 cmol/kg respectively. With critical level of 3.8, 10 and 0.24cmol/kg for calcium, sodium and potassium respectively, it shows that all the locations were below the critical level and are therefore low in calcium, sodium and potassium in all the locations. Magnesium ranged from 0.32 to 2.08 g/kg with a mean of 0.82 cmol/kg. With critical level of 2.00 cmol/kg, Irrua soil had sufficient magnesium content but was deficient in other locations. Inorganic sulphur content of the locations ranged from 0.10 to 0.37 mg/kg with a mean of 0.26 mg/kg (Table 2). The values were highest in soils of Agbede followed by soils of Uromi but were least in Ubiaja. When compared with the mean for all the areas, Ubiaja had the lowest mean value. Organic sulphur content of the locations ranged from 0.79 to 2.75 mg/kg with mean of 1.44 mg/kg. The values were highest in soils of Irrua followed by soils of Agbede; but were least in Uromi, when compared with the mean for all the areas. Ekpoma had the lowest organic sulphur content. Total sulphur content ranged from 6.30 to 16.41 mg/kg with a mean of 11.87 mg/kg. The value was highest in soils of Irrua followed by the soils of Ubiaja, least in Agbede. Soils of Ekpoma and Agbede had the lowest mean values that were below the general mean for the area.

Table 1 Soil properties of the study areas

Locations	pH	OC	N	P	Ca	Mg	Na	K	H^+	Al^{3+}	ECEC	Clay	Silt	Sand
	← g/kg →		mg/kg	←			cmol/kg			→	←	g/kg	→	
Agbede	6.30	10.90	0.83	38.02	2.32	0.32	0.30	0.06	0.40	-	3.40	35	17	948
Ekpoma	6.80	27.80	2.13	30.76	2.20	0.48	0.20	0.05	0.10	-	3.00	60	27	913
Irrua	6.40	29.60	2.33	16.96	2.85	2.08	0.34	0.19	0.30	-	5.72	50	27	923
Uromi	6.40	15.00	1.15	33.68	2.11	0.56	0.33	0.07	0.10	-	3.29	50	32	918
Ubiaja	6.50	22.10	1.33	7.16	2.56	0.64	0.26	0.10	0.20	-	3.73	40	27	933
Mean	7.00	21.08	1.55	25.32	2.41	0.82	0.29	0.06	0.22	-	3.83	47	26	927
SD	0.70	8.05	0.65	12.85	2.75	0.72	0.06	2.29	0.13	-	1.08	9.75	5.48	13.87
CV %	9.8	38.20	41.41	50.75	12.4	87.4	19.8	62.3	9.27	-	28.30	20.7	21.17	1.50

Table 2: Forms of sulphur in soils of the areas

Locations	Total S	Inorganic S	Organic S
←	mg/kg		→
Agbede	0.37	0.83	6.30
Ekpoma	0.26	0.79	10.99
Irrua	0.28	2.75	16.41
Uromi	0.31	1.26	11.51
Ubiaja	0.10	1.55	14.13
Mean	0.26	1.44	11.87
SD	0.10	0.80	3.80
CV %	38.71	55.50	31.99

The correlation between chemical properties and forms of sulphur are shown in Table 3. Phosphorus correlation matrix between inorganic sulphur, total sulphur and soil physico correlated significantly with inorganic sulphur; inorganic sulphur had a non-significant negative correlation with organic carbon, pH, nitrogen, calcium, magnesium, ECEC, clay and silt but was positive with sand and potassium.

Discussion

The organic carbon content, total N and available P of the soils of the different locations are moderately variable. This will affect sulphur availability and its relationship with the above soil parameters. Wainweight et al [22] reported higher sulphate contents of the soil after amending soil with pressed sugar beet pulp (organic matter source). Lower organic carbon resulted in low sulphur forms in these soils. With 8.50 mg/kg critical level as given by Kang and Osiname [3] the soils of all the locations are deficient in inorganic sulphur. Oke [23], [5] earlier reported low content of sulphur in Nigerian soils. The positive correlation of total S with organic carbon and total N and that of inorganic S with P and clay suggests the influences of the above parameters on soil inorganic and total S contents. Khalid *et al [12]* obtained significant positive relationships between plant available S ($CaCl_2$ extractable $SO4^{-2}$-S) and the total S, organic S and organic C contents in soils of Pakistan. Organic S formed the largest fraction of total S in the soils and also had significant positive relationship with total S and organic C contents in the soils. This was in agreement with the findings of Srinivasarao et al [13], and indicates a strong link between soil organic matter and different S fractions in the rain-fed soils (like Nigerian soils). Donahue et al [24] proposed the sulphur availability index; a soil containing SO4 - S content just above the critical limit and low in organic matter cannot be considered as sufficient in available sulphur, since there is less organic matter to support to inorganic fraction in case of any depletion. In soil sulphur is continuously cycled between inorganic sulphur and organic forms of sulphur [25]. Similarly, the organic sulphur is also in equilibrium with inorganic counterpart and if there is any decline in inorganic SO4-S level by means of crop uptake or leaching loss, it will be adequately replenished by the organic fraction. However, with the low organic S of these soils, inorganic S will remain low except there is buildup of the organic matter or supplementary application of sulphur to the soils.

Conclusion

The study revealed very low sulphur forms in the areas. The need for supplementary application of sulphur through fertilization is therefore suggested in the intensively cultivated soils of the areas. The problem of sulphur availability is further exacerbated due to the low organic sulphur contents of the soils; this could be improved further by avoiding the current bush burning in the area and manure application.

Table 3 Correlation matrix of physico-chemical properties, total and inorganic sulphur of the areas

Pearson Correlation Coefficients, N=5
Prob>|r| under Ho: Rho=0

	pH	OC	N	P	Ca	Mg	K	H	Inor S	ECEC	Clay	Silt	Sand	Total S
pH	1.00000	0.61284	0.56376	-0.09188	-0.25709	-0.18576	-0.42982	-0.67783	-0.36932	-0.34609	-0.29433	0.33221	-0.66509	0.13317
OC	0.61284	1.00000	0.97746	-0.52107	0.52810	0.65649	-0.02328	-0.29310	-0.38730	0.52802	-0.47450	0.39999	-0.64395	0.74870
N	0.56376	0.97746	1.00000	-0.35690	0.48230	0.69596	0.05789	-0.25034	-0.18628	0.55584	-0.61444	0.36857	-0.67121	0.67872
P	-0.09188	-0.52107	-0.35690	1.00000	-0.72782	-0.47899	0.03101	0.04841	0.88022	-0.50824	-0.30806	-0.30271	0.05578	-0.81114
Ca	-0.25709	0.52810	0.48230	-0.72782	1.00000	0.84154	0.06222	0.49460	-0.33248	0.91359	0.12466	-0.09303	0.17400	0.70329
Mg	-0.81576	0.65649	0.69596	-0.47899	0.84154	1.00000	0.45982	0.23123	-0.04826	0.97456	-0.41660	0.23445	-0.23943	0.78954
K	-0.42982	-0.02328	0.05786	0.03101	0.06222	0.45982	1.00000	-0.22779	0.23208	0.39261	-0.58326	0.63750	-0.38473	0.41412
H	-0.67783	-0.29310	-0.25034	0.04841	0.49460	0.23123	-0.22779	1.00000	0.35434	0.41858	0.46545	-0.84017	0.84300	-0.25055
Inor S	-0.36932	-0.38730	-0.18628	0.88022	-0.33248	-0.04826	0.23208	0.35434	1.00000	-0.04717	-0.40144	-0.37640	0.14680	-0.58587
ECEC	-0.34609	0.52802	0.55884	-0.50824	0.91359	0.97456	0.39261	0.41858	-0.04717	1.00000	-0.22706	0.06823	-0.01879	0.72057
Clay	-0.29433	-0.47450	-0.61444	-0.30806	0.12466	-0.41660	-0.58326	0.46545	-0.40144	-0.22706	1.00000	-0.57259	0.81610	-0.28968
Silt	0.33221	0.39999	0.36857	-0.30271	-0.09303	0.23445	0.63750	-0.84017	-0.37640	0.06823	-0.57259	1.00000	-0.83889	0.63369
Sand	-0.66509	-0.64395	-0.67121	0.05578	0.17400	-023943	-038473	0.84300	0.14680	-0.01879	0.81610	-0.83889	1.00000	-0.48728
Total S	0.13317	0.74870	0.67872	-0.81114	0.70329	0.78954	0.41412	-0.25055	-0.58587	0.72057	0.28968	0.63369	-0.48728	1.00000

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