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Effect of Mild Steel Buried in Crude Oil Polluted Soils on the Iron Content of Two Maize (*Zea Mays L.*) Varieties

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Abstract: *Surface soils were collected two weeks before planting and two weeks after harvest and analyzed for some physico-chemical properties. The soil samples were collected from the root area of plants where the leaf samples were obtained. Leaf samples were also taken from two varieties of maize (Zea mays L.) plants during the stem development (at the 9th week of planting) and both were analyzed for Fe content. Correlation analysis between Fe contents of soil before and after planting and Fe contents of leaf during heading was performed to determine the relationship among the variables. The iron contents of the soil samples before planting ranged between 1.27 and 6.50 mg/kg, while the iron contents of soils after harvest ranged between 0.98 and 5.03mg/kg. However, iron contents of the leaf samples ranged from 14.88 to 96.01mg/kg. The correlation between iron contents of soil before planting and after harvest and iron contents of leaves showed a significant effect at the 0.01 level according to statistical analysis. This implies that there was direct relationship between iron contents of leaves and the soil samples analyzed.*

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I. Introduction

Iron is the most abundant micronutrient in surface soils and the most limiting to agricultural production. It is considered a micronutrient because only small amounts are required to aid growth. Plants require a continuous supply of Fe to maintain proper growth since very little accumulated iron is mobilized from older to younger tissues (Fageria*et al.* 2000; Kochian, 2000). Because iron is necessary for several metabolic processes, yet potentially toxic, a plant`s Fe uptake and homeostasis are tightly controlled (Motta et al. 2001).

Iron plays an important role in respiration, photosynthesis and the production of healthy green (chlorophyll) leaves. Plants can suffer iron deficiency with symptoms of chlorosis and stunted growth, and can also take in too much of iron, especially under certain growing conditions (https://homeguides.sfgate.com). The availability of iron to plant roots depends on the pH level of the soil with iron more readily available in soil with a low pH. It should be noted that plants only absorb ferrous iron particles from the soil, and that other types of iron particles will not affect plants. Iron may be harmful to plants at feed concentrations of between 5 and 200ppm (Motta et al. 2001). These cannot be found in nature under normal conditions, when low amount of soil water are present.

Iron toxicity is not common, but some plants secrete acids from the roots, which lowers soil pH, leading to toxicity caused as a result of high absorption of iron. The symptoms of iron toxicity include bronzing and stippling of leaves. Iron toxicity also can occur when chelated iron is added to soil. Chelates help increase nutrient uptake and solubility of metal micronutrients, which in turn makes over-absorption possible. As iron levels continue to rise, the plant`s ability to draw in nutrients from the soil will also be hindered. This means that the plant can no longer draw in essential substances like phosphate or nitrogen, which it needs to function but cannot produce on its own (https://sciencing.com). Weakened on all fronts, the systems of the plant fall from within, causing severe decay of vital tissues in the stem and leaves, which inevitably leads to the plant`s death.

Iron is translocated from roots to shoots as a ferric-citrate chelate form, and this is transported to actively growing shoot regions (Kobayashi and Nishizawa, 2007). Hence the impact of mild steel buried in crude oil polluted soils on soil mineralogy and concentration of iron in leaf of two maize varieties is being assessed.

II. Materials And Methods

The experiment was conducted in Complete Randomized Design (CRD) with three replications for both polluted and control soils. 3.0kg of surface soil samples were collected from each of the three geomorphic zones under study and bagged inside the experimental pot. Mild steel coupons were crushed using a milling machine in the Science workshop, and 300g of it was weighed and buried inside each of the test pots. The soils containing the crushed mild steel were then treated with un-weathered crude oil levels of 0.00, 40.0, and 160.0ml respectively and left under natural condition for six months prior to planting, crude oil being used as a corrodent. Four maize seeds comprising of yellow and white maize varieties which are the early maturing varieties were planted respectively in March, 2017 to approximately 2cm deep in each of the pots six months after crude oil contamination.

The planting pots were perforated at the sides and bottom to allow for aeration and drainage of excess water two weeks before planting. However, this was done after the interval of six months in the aftermath of crude oil contamination when the contaminant had been fully adsorbed unto soil pores (Ayotamuno and Kogbara, 2007). The aim was to ensure adequate aeration necessary for seed germination, and also stimulate conditions of vertical and lateral movement of water that occurs in the soil. The four maize seeds originally germinated in the pots were later thinned to two stands two weeks after planting (2 WAP).

The surface soils were collected two weeks before planting and two weeks after harvest and analyzed for some physico-chemical properties. Soil fertility properties such as texture, moisture content, pH, organic matter, exchangeable cations, cation exchange capacity, total nitrogen, iron content and others were analyzed using the standard methods for soil and plant analysis modified by Eno et al. 2009. To determine the effect of buried mild steel in crude oil polluted soils on the iron content of soils and maize leaves, soil samples were collected from the root area of the maize plants from the pot where it is grown and analyzed for iron content of the soils, while the leaf samples were taken during stem development (heading) at the 9^{th} week and were also, analyzed for the iron content. Iron contents were analyzed using atomic absorption spectrophotometer, after wet digestion of the samples (AOAC, 2009). Well-mixed soil samples of 0.5g each were weighed into 250ml glass beakers and digested with 10ml of aqua regia on a hot plate for 2 hours. After evaporation to near dryness, the samples were diluted with 20ml of de-ionized water, stirred and filtered into another conical flask. The filtrate was used for the analysis of the metals using Buck scientific Atomic Adsorption/ Emission spectrophotometer 205.

III. Results And Discussion

According to the results of soil analyses, the iron content of mild steel in crude oil polluted soils on the growth response of maize plants before planting, after harvest, and during stem development (heading) are presented in Table 1 below. The organic matter contents of the soils before planting were observed between 1.72 and 3.44% (Odagwa and Kaiama), and 1.09 and 3.18% (Odagwa and Kaiama) after harvest, respectively. In the same vein, the pH of the soils before planting ranged from 4.15 at kaiama to 5.61 at Odagwa, and 2.87 (kaiama) to 6.04 (Odagwa) after harvest, respectively. Organic matter and pH before planting and after harvest are also shown in the table. Iron content of soil before planting ranged between 1.27 and 6.50ppm, while iron in soil after harvest ranged from 0.98 to 5.03ppm, respectively with the highest iron content found in Kaiama soil pedon and the lowest recorded at Odagwa site.

Iron content of leaf samples varied between 14.88 and 96.01ppm according to results of chemical analyses. Iron content of all leaf samples appeared to be lower than critical level being 20ppm. The lowest iron content of leaf was found at the control soil of Odagwa site ranging between 14.88 and 17.45ppm for the white and yellow maize varieties, respectively. However, iron content in leaf was higher in Kaiama soils than other soils studied. The distribution of iron contents in the leaves of the maize plants is in the following order: Kaiama>Ahoada>Odagwa. Generally, the iron contentsin the yellow maize were higher than that of the white maize in all the locations studied. The iron content of the soils may be associated with the chemical composition of the parent material hence it has been known that soil parent material has an effect on chemical properties of soil (Irmak et al. 2007).

TABLE 1 Iron Content of Mild steel in Crude Oil Polluted Soils on the Growth of Maize (*Zea maize*) Plants

Sample code	Treatments	OM(%) in soil before planting	OM(%) in soil after harvest	pH in soil before planting	pH in soil after harvest	Fe $_{(ppm)}$ in soil before planting	Fe $_{(ppm)}$ in soil after harvest	Fe $_{(ppm)}$ in leaf before harvesting
ODAGWA	0.00W	1.72	1.09	5.61	6.04	1.27	0.98	14.88
	0.00Y	1.72	1.38	5.61	6.00	1.27	1.07	17.45
	40.0W	2.04	1.44	5.26	5.78	1.30	1.10	24.12
	40.0Y	2.04	1.86	5.26	5.69	1.30	1.08	30.22
	160.0W	2.46	1.80	5.22	5.66	1.32	1.20	40.09
	160.0Y	2.46	1.90	5.22	5.50	1.32	1.06	51.70
AHOADA	0.00W	1.80	1.53	5.50	6.00	3.75	2.28	23.76
	0.00Y	1.80	1.72	5.50	5.72	3.75	2.49	24.71
	40.0W	2.07	1.34	5.81	6.00	4.08	2.89	26.55
	40.0Y	2.07	1.86	5.81	5.84	4.08	3.25	29.80

	160.0W	2.39	1.90	4.94	5.01	4.45	3.77	36.94
	160.0Y	2.39	2.04	4.94	4.98	4.45	3.91	44.55
KAIAMA	0.00W	2.05	1.92	4.44	4.90	4.50	3.87	56.70
	0.00Y	2.05	1.96	4.44	4.74	4.50	3.99	56.38
	40.0W	3.13	2.36	4.24	4.70	5.01	4.14	60.11
	40.0Y	3.13	2.79	4.24	4.30	5.01	4.28	77.50
	160.0W	3.44	2.90	4.15	4.30	6.50	4.96	88.45
	160.0Y	3.44	3.18	4.15	2.87	6.50	5.03	96.01

W = WhiteY = Yellow

Table 2: Regression Analysis Showing the Effect of Iron Content of Soil on the Iron Content of Maize Leaf

Correlations		**Fe (ppm) inSoil**		
Before PlantingAfter HarvestDuring Harvest				
Pearson Correlation	Fe (ppm) in soil before planting	1.000	.979	.729
	Fe (ppm) in soil after harvest	.979	1.000	.767
	Fe (ppm) in leaf during harvest	.729	.767	1.000
Sig. (1-tailed)	Fe (ppm) in soil before planting	.	.000	.000
	Fe (ppm) in soil after harvest	.000	.	.000
	Fe (ppm) in leaf during harvest	.000	.000	.
N	Fe (ppm) in soil before planting	18	18	18
	Fe (ppm) in soil after harvest	18	18	18
	Fe (ppm) in leaf during harvest	18	18	18

IV. Reaction of Iron In Soils Studied

The concentration of iron (Fe) in the soils decreased with increase in soil pH. High pH values may have lead to iron precipitation. Poor soil aeration found in Kaiama soils, or reduced oxygen level caused by flooding or compaction could be the result of the increase or decrease in the iron availability depending on other soil conditions such as microbial activity and root proliferation. In this study, plant oxygen supply limited by crude oil is suspected to have improved by the iron content of the soils which supplies air to the stomata with rising rhizosphere, while transpiration and photosynthesis also increases. This contributes to the green coloration of the leaves (Irmak et al., 2007).

Seed germination, and seedling growth which are very susceptible to oil pollution improved by the absorption of iron. Many properties of the soil which are affected by crude oil spill were improved by the soluble Fe in the soil. Maize growth in the crude oil affected soils would have been difficult without the aid of iron oxides and hydroxides in the soil, unless the crude oil was degraded to tolerable levels. The stimulatory effect is attributed to nitrogen fixation in the soil, or the addition of nutrients from oil killed organisms. This is in agreement with Ogbo, 2009. There was also a large increase in exchangeable ferric ions compared with normal soils, in agreement with Osuji, 2001.In the wetland soils of Kaiama, the concentration of Fe increased with increase in the organic matter content of the soils. This is in agreement with Sahrawat, K. L. (2004). High organic matter improves iron availability in soil, while pH is low. Chelation of iron in soil by organic matter aids the movement of iron to plant roots, but they are neither absorbed to any great extent nor do they raise the activity of Fe^{3+} or Fe^{2+} in the bulk soil solution. To be effective, iron chelates must be stable in soil environments.

V. Conclusion

As seen in the study iron content of the soils have direct effect on the iron content of the leaves. This was established by correlating between the iron content of the soil and iron content of the leaf which showed significant effect. It is therefore recommended that to avoid iron toxicity, the pH balance should be checked and maintainedat pH level of 5.8 or higher when growing plants prone to iron toxicity, and a fertilizer with a balanced ratio of manganese and iron be used, and iron chelates should be used carefully.

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