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THE EFFECT OF RUBBER EFFLUENT ON SOME CHEMICAL PROPERTIES OF SOIL AND EARLY GROWTH OF MAIZE (*ZEA MAYS* L)

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ABSTRACT
A preliminary pot trial was conducted in a greenhouse to determine the effects of rubber effluent on some soil chemical properties as well as early growth and nutrient uptake by maize plant. The levels of rubber effluent used were 0, 50, 100, 150, 200, 250 ml per 2 kg soil. The trial was arranged in a completely randomized design and replicated three times. Results showed that the soil pH, organic carbon, N, P, K, Mg, Ca Na, ECEC, Fe, Mn and Zn were significantly higher (P<0.05) in rubber effluent treated soils than the control, while the control was significantly higher in exchangeable acidity. Except Zn, the N, P, K, Mg, Ca, Na, Fe, Mn content and their uptake by the plant were significantly higher (P<0.05) in rubber effluent treated plant than the control. The plant height, leaf area and number of leaves were also significantly higher in effluent treated plants than the control. The N, P, K, Mg, Ca, Na content and their uptake and the growth parameters however declined at 200 ml treatment while in Fe, Mn and Zn content and their uptake, there was no definite pattern of increase with increasing effluent levels. Conclusively, rubber effluent contained vital plant nutrients which may be favorable to soil fertility improvement and maize growth at the application rates.
Keywords: Rubber effluent, maize, nutrient uptake, soil, greenhouse

INTRODUCTION

Rubber is important because its latex is a valuable source of raw materials for numerous items. In addition to being one of the major economic crops in Nigeria, it strengthens the forest cover there by contributing towards continuity of ecological balance. The latex of rubber plant consists of colloidal suspension of rubber particles in an aqueous serum. Thus, natural rubber is an amorphous hydrocarbon, poly-isoprene, which has the property of being highly extensible. The latex also contains many non-rubber constituents such as protein, resins, sugars, glycosides, tannin, alkaloids and mineral salts (Onwueme and Sinha, 1999). The serum phase of the latex according to Seneviratne (1997) is known to constitute 70% of the total volume and contains large amount of major nutrients required for plant growth. Seneviratne (1997) further reported that the rubber effluent mostly contains an approximate percentage of non-rubber constituents such as carbohydrate (methyl inositol (2.5%)), protein (1%), free amino acid (0.018%) and other organo nitrogenous bases (chlorine, methyl amine(0.08%)), inorganic anion (Po_4^{3-} , Co_3^{2-}), metallic ions (K^+, Mg^{2+}, Na^+, Cu^{2+}) and formic acid (0.12%) used for latex coagulation.

The processing of the latex poses a lot of impacts on the environment. The most suspected noticeable effect is caused by factory effluent which contains a large amount of non-rubber substances in addition to traces of various processing chemicals. The amount of rubber effluent produced in Nigeria has been increasing steadily during the past few years with increase in the number of several processing factories in the country.

The practice of indiscriminate discharge of large volumes of these effluents onto soil and water courses as a means of disposal is wasteful in terms of resource utilization and contradicts the present day agricultural technical development. Also, the abundance of the effluent and the suspected adverse effects on the environment due to the offensive odor pose challenges to agronomist to seek valuable and positive uses for it.

The controlled applications of effluent on land have been reported to cause changes in soil as well as growth of some plants. Yeow and Zin (1981) recorded improved water retention of soil when rubber effluent was used. Poon (1982), Lim and P'ng (1983), Lim *et al* (1983) reported an increased pH, K, Ca, Mg and organic matter content when rubber effluent was applied. Seneviratne (1997) also observed an increase in soil N, P, K, Na, Mg and Ca in an estate, which had been exposed to rubber effluent for 20 years, while a reduced organic carbon and Mg was reported for rubber effluent affected soil (Orhue, *et al*., 2005). Yeow and Yeop (1983) described rubber effluent as excellent soil conditioner.

Effluents have also been reported to have varying effect on plants. The application of block rubber effluent was reported to increase oil palm yield and there was no adverse effects on growth and nutritional status (Lim *et al*., 1983). The growth of Nupier grass (Tan *et al*., 1975) and *Dialium guineense* seedlings (Orhue *et al*., 2005) were enhanced significantly with rubber effluent. Orhue *et al.* (2005) reported increased uptake of N, P, Mg, Na as well as decreased K uptake by *Dialium guineense* seedlings with the application of rubber effluent.

The aim of this trial was to examine the influence of rubber effluent on some soil chemical properties and early growth of maize (*Zea mays* L).

MATERIALS AND METHODS

The trial was conducted in a greenhouse at the experimental site of the Faculty of Agriculture, University of Benin, Benin City, Nigeria. The rubber effluent was obtained from Odia rubber factory, while the Suwan 1 maize variety was obtained from Agricultural Development Project (ADP) both in Benin City. The top soil used was collected from the floor of *Gmelina arborea* plantation with spade at a depth of 0 – 15 cm. The soil was bulked, mixed thoroughly and a composite sample was made, air-dried and then sieved to remove debris. Thereafter, 2 Kg of the composite soil sample was weighed and put in each of the polythene bags. A total of 36 polythene bags were used. Each replicate had 12 polythene pots. The rubber effluent was applied at the rates of 0, 50, 100, 150, 200 and 250 ml per 2 Kg soil. The rubber effluent was thoroughly mixed with the soil and then left for 2 weeks to allow for equilibration. The experiment was arranged in a Completely Randomized Design and replicated 3 times. On the day before sowing, the soil was moistened with water. Four seeds of maize were initially sowed and later thinned to one plant per pot at 2 weeks after emergence. Thereafter, the plants were watered every other day with water. Data collection on plant height, number of leaves and leaf area were carried out at 8 weeks after planting. Thereafter the plants were harvested, dried in ventilated oven at 72^0C for 48 hours to a constant dry weight used in computing nutrient uptake. The nutrient uptake was determined using the product of dry weight (g) of the plant and the nutrient content (%)

Soil analysis:

Soil analysis was carried out before and after harvesting of maize plant. The rubber effluent was analyzed before applying it on the soil, while the plant analysis was done at the end of the experiment. Particle size analysis was determined by method of Gee and Or (2002), while the soil pH was determined at a soil to water ratio of 1:1 using a glass electrode pH meter. The pH of the rubber effluent was read directly from the pH meter. The electrical conductivity of soil was determined also at a soil to water ratio of 1:1 using the CIBA-CORNING conductivity meter whereas the rubber effluent conductivity was read directly from the CIBA-CORNING meter.

The organic carbon content of both soil and rubber effluent was determined by using the chromic acid wet oxidation procedure described by Jackson (1962). The total nitrogen, available phosphorus, exchangeable bases as well as exchangeable acidity were determined using methods of Udo *et al.* (2009). The effective cation exchange capacity was calculated as the sum of exchangeable bases and exchangeable acidity. The zinc, iron and manganese were determined by methods of Udo *et al.* (2009).

Plant analysis:

The plant materials were digested with a mixture of HNO_3, H_2SO_4 and $HClO_4$ acids. The Na, K, Ca, Mg, Fe, Mn and Zn were determined by the use of atomic absorption spectrophotometer. For P content (AOAC, 1990) perchloric acid digestion (wet oxidation) method was used while the micro-kjeldal method of Jackson (1962) was used for N determination. The data obtained were analysed by Genstat statistical version 6. 1. 0 234. Data collected were subjected to analysis variance (ANOVA). Duncan Multiple Range Test was used in separating the means at 5% level of probability

RESULTS AND DISCUSSION

Properties of rubber effluent:

The physico-chemical properties of rubber effluent in Table 1 indicated that the effluent was slightly acidic, colorless and contained several elements. The result of the effluent analysis when compared to that of Seneviratne (1997) indicated that most of the parameters are not dependent on the sources of the effluent. The fact is that whatever stage of processing (creep, crumb and concentrate latex) the effluent obtained contains the same basic plant nutrients.

Pre-trial properties of soil used:

The properties of soil used in the trial were shown in Table 2. The soil was moderately acidic and classified as Ultisol and Benin fasc, grey in color and texturally sandy. Apart from Mg, the N, P, K and Ca were below the critical values of 1.5-2.0 gkg^{-1} (Sobulo and Osiname, 1981), 10-16 $mgkg^{-1}$ (Adeoye and Agboola, 1985), 0.16-0.25 $cmolkg^{-1}$ (Akinrinde and Obigbesan, 2000) and 2.50 $cmolkg^{-1}$ (Akinrinde and Obigbesan, 2000) respectively. The properties of the soil used indicated that the soil is low in fertility, which is typical of an ultisol as reported earlier by Agboola and Ogunkunle (1993).

Post-trial chemical properties of soil:

The post-trial properties of the soil are shown in Table 2. The soil pH, organic carbon, N, P, K, Mg, Ca, Na and ECEC increased significantly ($P < 0.05$), with increasing levels of rubber effluent while Fe, Mn, Zn and exchangeable acidity increase were not consistent with increasing rubber effluent treatments but significantly higher than the control treatments. The increase in soil pH, N, P, K, Mg, Ca, Na, ECEC, Fe, Mn, Zn and organic carbon is attributed to the serum properties of the effluent. This increase in soil nutrient content further confirms that applying effluent alone is not problematic especially when the rate of application is geared to supply nutrients at a level corresponding to those in inorganic fertilizers normally applied to promote satisfactory crop performance and that controlled application of effluent causes no detrimental changes in soil, rather it improves soil fertility and has no apparent adverse effect on the environment.

Thus, the beneficial properties of rubber effluent as excellent soil conditioner, makes it a good source of fertilizer. The increased soil organic carbon content is similar to the finding of Lim *et al.* (1983) and Seneviratne (1997).

The inconsistent increase in Fe, Mn and Zn content may be attributed to antagonism or nutrient interactions, as earlier reported by O' Conner and Anderson (1974), Loose *et al.* (1979), Clinton and William (1981), Drewes and Blume (1977) and Remison (1997). The increase in soil pH, N, P, K, Ca, Mg, ECEC and Na is however similar to the reports of Poon (1982), Lim and P'ng (1983) and Lim *et al.* (1983).

Effect of rubber effluent on nutrient content and uptake by maize plant

The nutrient content of maize in relation to various levels of rubber effluent is shown in Table 3. The N, P, K, Mg, Ca, Mn and Fe content of the rubber effluent treated plants were significantly higher than the control. The trend however was that the N, P, K, Mg and Ca increased with increasing rubber effluent levels up to 150 ml and then declined. Non-significant differences were however recorded among the various treatments in Zn component of the plant. The uptake of nutrient by maize was shown in Table 4. Except Zn, the N, P, K, Mg Fe, Mn and Ca uptake were significantly higher ($P < 0.05$) than the control in maize plants treated with rubber effluent. The uptake of N, P, K, Mg and Ca however increased with increasing effluent up to 150 ml whereas there was no definite pattern of Fe, Mn, and Zn uptake.

The increase in nutrient content and uptake by the plant may be attributed to the applied rubber effluent which has higher content of serum. The rubber latex serum phase is known to constitute 70% of total volume and contains large amount of micro and major nutrients needed for plant growth as earlier reported by Seneviratne (1997). This result is however similar to the findings of Orhue *et al.* (2005).

Influence of rubber effluent on height, number of leaves and leaf area of maize:

Table 5 shows the influence of rubber effluent of the growth parameters. The height, number of leaves and leaf area of rubber effluent treated maize were significantly higher ($P<0.05$) than the control treatment. A decline in these growth parameters was however recorded in 200 ml and 250 ml rubber effluent treatments. The increase in plant height, leaf area and number of leaves is attributed to presence of high soil nutrient content provided by the rubber effluent applied. This increase in growth parameters is similar to earlier reports of Lim *et al.* (1983) in oil palm, Tan *et al.* (1975) in Nappier grass and Orhue *et al.* (2005) in *Dialium guineense* seedlings.

Table 1: Properties of the rubber effluent used in the trial

Effluent property	Mean value
pH	5.00
Conductivity $S cm^{-1}$	58.00
Total Nitrogen %	2.10
Phosphorus mg/l	5.26
Organic carbon %	0.14
Potassium mg/l	12.25
Calcium mg/l	8.82
Sodium mg/l	1.54
Magnesium mg/l	2.92
Iron mg/l	0.04
Manganese mg/l	0.02
Zinc mg/l	0.91

Table 2: Chemical properties of soil prior and after the trial

Treat. ml/2kg soil	pH	Org carbon gkg^{-1}	Total N gkg^{-1}	P $mgkg^{-1}$	K	Mg	Ca $cmolkg^{-1}$	Na	Exch acidity	ECEC	Fe	Zn $mgkg^{-1}$	Mn
	Before	Planting											
	5.10	13.20	0.5	4.71	0.04	1.39	0.01	0.08	2.08	3.52	0.01	0.09	0.05
	After	Harvesting											
0	5.14d	10.04f	0.04b	1.91d	0.04b	1.31b	0.01b	0.05d	2.08a	3.49d	0.01c	0.07b	0.03b
50	6.46c	13.61e	8.60a	2.48c	2.10a	4.37a	5.61a	1.01c	1.40b	14.49c	0.84b	0.98a	0.30a
100	6.50bc	14.68d	8.70a	2.50c	2.18a	4.37a	6.41a	1.05b	1.60b	15.61bc	0.97a	0.99a	0.31a
150	6.56bc	15.71c	8.80a	2.85b	2.94a	4.84a	6.41a	1.07ab	1.60b	15.86b	0.92a	1.02a	0.31a
200	6.60b	16.85b	9.80a	2.85b	3.03a	4.84a	6.41a	1.09a	1.40b	16.77b	0.79b	0.90b	0.30a
250	6.70a	18.19a	10.22a	2.99a	3.29a	5.86a	7.21a	1.09a	1.60b	19.05a	0.82b	0.98a	0.30a

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

Table 3: Effect of rubber effluent on the nutrient content of maize plant (%)

Treatments ml/2 kg soil	N	P	K	Mg	Ca	Fe	Mn	Zn
0	1.03d	0.03b	1.01d	0.04e	0.02e	0.05d	0.04b	0.06a
50	1.88c	0.08a	1.40c	0.10de	0.07cd	0.11c	0.09a	0.07a
100	2.06b	0.08a	1.54b	0.14cd	0.07cd	0.18a	0.11a	0.08a
150	2.27a	0.09a	1.70a	0.64a	0.11a	0.14b	0.13a	0.11a
200	2.26a	0.08a	1.62ab	0.25b	0.10abc	0.11c	0.10a	0.08a
250	2.20a	0.08a	1.57b	0.19bc	0.08bcd	0.15b	0.12a	0.09a

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

Table 4: Influence of rubber effluent on Nutrient uptake by maize plant ($mgkg^{-1}$)

Treatments ml/2 kg soil	N	P	K	Mg	Ca	Fe	Mn	Zn
0	26.37f	8.33d	8.73e	11.56e	9.66c	8.67b	6.33c	12.00a
50	37.72e	13.19c	12.73d	21.77d	14.74b	17.67a	13.67a	14.00a
100	47.33b	16.47bc	23.78c	28.98c	15.01b	16.67a	14.33a	12.00a
150	59.65a	25.58a	30.89a	56.25a	27.33a	14.67a	11.33b	14.00a
200	43.92c	18.73b	26.32b	43.02b	23.91a	18.00a	11.67b	11.33a
250	40.91d	18.57b	23.50c	31.40c	15.69b	20.65a	15.00a	12.00a

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

Table 5: Effect of rubber effluent on maize height, number of leaves and leaf area

Treatments ml/ 2 kg soil	Plant height (cm)	Leaf area(cm^2)	Number of leaves
0	15.69f	61.30f	4.00f
50	43.50e	80.30e	6.69e
100	60.50d	91.30d	8.55d
150	84.04a	145.90a	12.67a
200	75.30b	136.20b	10.74b
250	69.32c	99.80c	8.85c

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

CONCLUSION

The physiological and nutritional implications of rubber effluent on maize as well as soil chemical properties studied revealed that rubber effluent contained vital plant nutrients which may be favorable to soil fertility improvement and maize growth at the application rates. Therefore, it could be concluded that rubber effluent has a potential value as fertilizer for maize.

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