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EVALUATION OF THE EFFECTS OF RUBBER FACTORY EFFLUENT ON SOIL NUTRIENTS, GROWTH AND YIELD OF CUCUMBER (*Cucumis sativus* L.)

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ABSTRACT

Rubber effluent contains high concentration of organic matter, suspended solids and various plant growth substances such as nitrogen, phosphorus, potassium, calcium and magnesium. But attention has not been paid to its usefulness as a soil conditioner probably because of its odour. A field experiment was conducted at the Rubber Research Institute of Nigeria (RRIN), Iyanomo Benin City, Latitude 6° 00' and 7° 00' North and Longitude 5° 00' and 6° 00' East in a humid forest zone of Nigeria during the wet season of 2011 to evaluate the effect of rubber effluent on the growth and yield of cucumber (var. Poinsett). Five levels of rubber effluent: control, 50,000, 100,000, 150,000 and 200,000L/ha were randomly allocated to plots using a randomized complete block design (RCBD) with three replicates. Data were collected on growth parameters – vine length, number of branches and number of leaves and yield characters – fruit length and girth, number of fruits per plant, weight of fruits per plant and total yield per hectare. Analyses of variance (ANOVA) for all measurements were performed using Genstat version 12 software package. The result of the experiment indicated significant differences ($p < 0.05$) between the treated plots and the control. Rubber effluent at 150,000L/ha gave the highest vegetative traits- vine length, number of branches and number of leaves and yield characters – number of fruits per plant, weight of fruits per plant, fruit length and fruit girth and total yield per hectare of cucumber. The 150,000L/ha out yielded the control by about sixty-two percent.

Keywords: Rubber effluent, soil fertility restoration, growth attributes, yield of cucumber

1. INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an important fruit vegetable eaten in accompaniment with other vegetables as salad. It is a popular delicacy for people who are trying to lose weight. The cultivation of cucumber in Nigeria is constrained by low soil fertility. Cucumber requires fertile soil as infertile soil results in bitter taste and misshapen fruits that are often rejected by consumers. Although bush fallowing is an efficient and effective way of soil fertility restoration in the tropics (Ayoola and Adeniran, 2006), increase in population has decreased the fallowing periods from ten to three years and this has had an adverse effect on fertility restoration leading to poor yields of crops. Furthermore, there is a growing concern

on health hazards posed by frequent addition of chemical fertilizers into the soil. Consequently, there is now a concerted effort to review the use of chemical fertilizers and to place more emphasis on the use of organic fertilizers (Ahmad, 2001) such as green manure, compost manure, farm yard manure and rubber effluent among others.

Many rivers in urban and semi-urban areas are polluted due to the disposal of both untreated solid waste and waste water (Arimoro, 2009). This high pollution status threatens and in many cases has altered the ecological status of most rivers in Nigeria (Ogbogu and Olajide, 2002, Arimoro and Ikomi, 2008). When the effluent is disposed into public water bodies, it

gives rise to serious depletion of dissolved oxygen, thus affecting the normal environment supplying the aquatic biota (Atagana *et al.*, 1999) and when discharged continuously into land will increase the soil pH. Also the odour emanating from rubber processing factories is offensive. However, this waste water contains high concentrations of organic matter, suspended solids and nitrogen (Kumlanghan *et al.*, 2008) which are beneficial to crop plants. Many studies have shown that the application of organic wastes such as effluents, compost and sewage sludge to soil increases plant growth (Osemwonta, 2010). Organic wastes contain considerable amounts of plant nutrients including micronutrients whose benefits to plant growth have been documented (Kaldivo and Nelson, 1979). The use of rubber effluent has been reported to cause changes in soil properties and improved water retention on soils. Rubber effluent is a liquid leftover which arises during latex processing. These effluents are improperly disposed continuously into soils, rivers and streams in developing countries especially Nigeria thereby causing serious environmental pollution. The most important effect is caused by factory effluents which contains large amount of non-rubber substances in addition to traces of various processing chemicals (Seveviratne, 1997).

These untreated effluents consist mainly of small amounts of uncoagulated latex and latex serum. However, these effluents contain various plant growth substances including a number of elements such as N, K, P, Ca and Mg, (Peries and Fernando, 1983). Mohd and Abu (1989) reported that rubber effluent contains substantial amount of plant nutrients particularly N and K and these nutrients have potential as fertilizer for crops such as oil palm (*Elaeis guineensis*) and rubber (*Hevea brasiliensis*). Consequently, the use of effluent from rubber sheet factory for cultivating economic crops could give a match between the pollution control purpose at virtually no additional cost and the need of farmers for beneficial utilization of the available nutrients contained in the effluent. The use of rubber effluent has been reported to cause changes in soil properties and improved water retention on soils (Yeow and Zin, 1981). Peries and Fernando (1983), has recommended the use of rubber effluent serum as fertilizers particularly

for grasses and leafy vegetables while napier grass production have been observed to increase significantly with rubber effluent application (Tan *et al.*, 1976). Orhue *et al.* (2007), posited that rubber effluent improves soil fertility and has no apparent adverse effect on the environment and that the gains and beneficial properties of rubber effluent as an excellent soil conditioner make it a good source of fertilizer.

Apart from rubber effluent being used as a soil conditioner, the growth of maize has also been reported to be influenced by brewery effluent (Orhue *et al.*, 2005). Karunyal *et al.* (1983) reported that soils treated with tannery effluent were rich in Mg, Mn, Fe, Na and K ions. Yeop and Poop (1983) observed that the application of palm oil mill effluent improves soil fertility and has no adverse effect on the environment. Sugar factory effluent applied to crops in Cuba increased the soil organic matter content by 1% (Valdes *et al.*, 1996), while cassava effluent applied to soil increased the nitrate content (Vieties and Brinkoli, 1983). Karunyal *et al.* (1983), reported tannery effluent caused an increase in leaf area, biomass, chlorophyll content and total protein of *Gossypium hirsutum*, *Vigna mungo*, *Vigna unguiculata* and *Lycopersicum esculentum* over control.

People living in areas where rubber-processing factories are located complain often about their discomfort because of this odour. However, rubber effluent contains some nutrient elements which can be used by crops in significant amounts. There is a need therefore to utilize this material in the form of soil amendment because of the presence of vital elements. The objective of this study was to investigate the effect of rubber effluent on the growth and yield of cucumber.

MATERIALS AND METHODS:

Study location

The experiment was conducted at the Rubber Research Institute of Nigeria, Iyanomo Benin City, Edo State on Latitude 6° 00' and 7° 00' North and Longitude 5° 00' and 6° 00' East in a humid forest zone of Nigeria. The area is characterised by a bimodal rainfall pattern with a long rainy season that starts in early March and the short rainy period extends from

September to late October after a dry spell in August. The rainfall for the year 2011 was 2557.5mm, the average rainfall for the period of the experiment was 1071.1mm, the maximum temperature for the year was 30.1°C and the maximum temperature for the period 32°C. The soil order is an Ultisol and the site is classified locally as kulfo series with a pH range of 4.0 – 5.5. The soil has been described as acid sands derived from unconsolidated grits and sand stones containing clay peds of varying proportions (Vine, 1956).

The site was left fallow for three years after it was cropped to maize, yam and cassava for two years prior to the establishment of the experiment. A composite soil sample was collected from 0-30 cm depth prior to planting before the rubber effluent was applied to determine the pH and the nutrient status of the soil. Soil pH was analysed by 1:2 in H₂O, organic matter was determined by wet oxidation method through chronic acid digestion, total N content was determined by Kjeldahl method (Bremner, 1965); available phosphorus was analysed using the Bray- P1 using ammonium acetate (Olsen and Sommers, 1982), Potassium was determined using flame photometer and calcium and magnesium by EDTA titration method.

Effluent Application and Study Duration

The rubber effluent was collected from the Institutes` rubber collection depot, Iyanomo - Benin City, left to ferment for 28 days before the effluent was analysed for N, P, K Mg and Ca following the methods outlined by AOAC (1980).

The experiment commenced on the 5th of July, 2011 with the planting of two seeds of Poinsett variety of cucumber at a spacing of 75cm by 75cm which was later thinned after two weeks to one seedling per stand to give a population of 17,777 plants per hectare. The experiment

was laid out in a randomised complete block design with three replicates. The plot size was 3.75 x 3.75 metres with 2- metre pathways. The treatments imposed were five levels of rubber effluent: 0, 50,000, 100,000, 150,000 and 200,000 litres per hectare. The rubber effluent was passed through a 2mm sieve to remove suspended particles of various sizes before they were uniformly spread on the plots using a knapsack sprayer a week before planting. A total of 20 plants were planted per plot and data were collected from five (5) tagged plants in the net plot in respect of growth and yield parameters. Hoe weeding was carried out at 3, 5 and 7 weeks after planting. Insect pests were controlled with lamda cyhalothrin as Karate at biweekly intervals for effective insect control. The experiment was terminated on the 25th of November, 2011.

Monitoring of Plant Growth, Yield and Statistical Analysis of Data

Data on growth parameters (vine length, number of branches, and number of leaves) were collected at 4, 6 and 8 weeks after planting (WAP) while yield parameters (fruit length and fruit girth) were assessed by using a digital calliper at every harvest, number of fruits per plant were visually counted and weight of fruits per plant was assessed by using a 10kg scale and fruit weight per hectare was extrapolated from the weight of fruits per plant. Harvesting was done every four days and a total of ten harvests were carried out and the cumulative weights of the entire harvests were summed up for data analysis.

Analysis of variance (ANOVA) for all measurements was performed using Genstat software version 12 statistical packages for randomised complete block design (RCBD). The means were separated using the least significant differences (LSD) (Steel and Torres, 1980.).

Table 1: Chemical Properties of Soil and Rubber Effluent

Properties	Soil sample (Before cropping)	Soil sample After cropping	Rubber effluent
pH (in 2: 1 water)	5.15	5.02	4.05
Organic matter content g/kg	24.14	27.43	35.88
Organic carbon g/kg	14	15.91	20.81
Nitrogen g/kg	1.29	1.59	2.23
Calcium mg/kg	7.8	5.69	6.08
Magnesium cmol/kg	2.85	3.21	3.87
Available P mg/kg	29.33	42.4	33.51
Exchangeable K cmol/kg	1.29	1.01	1.27

RESULTS AND DISCUSSION

Physio-chemical Properties of soil and rubber effluent

The analysis of the rubber effluent used for the study revealed that it is acidic. It contained organic carbon, N, P, K, Mg and Ca (Table 1). The chemical composition of the effluent showed that it is rich in N, P, K Mg, and Ca, (Table 1) which could be utilized by crops. These results are similar to those reported by Orhue *et al.*, (2007) and Seneviratne, (1997) and in agreement with the findings of Augusthy and Mani (2001) who reported high amounts of total suspended and dissolved solids, phosphates and total nitrogen in significant amounts. Poon (1982) and Lim *et al.* (1983) have earlier reported similar results. The increase in the above nutrients further confirms that applying effluent especially when the rate is geared towards supplying nutrients at levels corresponding to those in inorganic fertilizer normally applied to promote satisfactory crop performance and that controlled application of effluent causes no detrimental effects in the soil properties (Orhue *et al.* 2005).

Growth Characters

The vine length was enhanced by the rubber effluent application at each of the three sampling periods and there was a significant difference among the treatments (Table 2). The

application of 150,000L/ha of rubber effluent however resulted in a superior vine length than in the other treatments. The presence of plant nutrients in the rubber effluent helped to boost an early growth and subsequent yield of cucumber. This was in agreement with the findings of Augusthy and Mani (2001), who reported that diluted rubber effluent favoured seedling growth of mung bean (*Vigna radiata*). Srivastava and Sanhai (1987), also reported that early seedling growth of cowpea was promoted by distillery effluent. The increase in the vine length of the cucumber at 150,000 L/ha could therefore be attributed to plant nutrients being made available to the cucumber crops. Orhue *et al.* (2007), also reported an improved growth and nutrient uptake when rubber effluent was used on *Dialium guineensis* and maize (*Zea mays*) plants. Ajmal and Khan (1983) observed increased plant height in kidney beans (*Phaseolus vulgaris*) and pearl millet (*Pennisetum glaucum*) when dairy effluent was applied.

The application of rubber effluent to the cucumber plant had no significant effect on the number of branches at 4 WAP but at 6 and 8 WAP similar to results obtained in respect of vine length. The application of rubber effluent at 150,000L/ha also had the highest number of branches and the control had the least number of branches.

Mean number of leaves was significantly enhanced at each of the three sampling periods. The 150,000L/ha treatment consistently had superior number of leaves than the other treatments and the differences were significant ($P < 0.05$). The least number of leaves was observed in the control at the three sampling periods. The increase in vine length, number of leaves, and number of branches may be attributed to the nutrient status of the rubber effluent applied. This was in consonance with the findings of Ammar *et al.* (1999) who posited that industrial effluent had positive effect on plant stem girth and those of Yeop and Poop (1983) who observed that the application of palm oil mill effluent improved soil fertility and plant growth. Orhue *et al.* (2005) also reported positive growth response of maize following the application of brewery effluent amendment. The reduced cucumber growth parameters in the control could be attributed to the poor nutrient status of the soil while results obtained at 200000 L/ha could be attributed to toxicity of the effluent at higher concentration (Kumlanghan *et al.* 2008).

Yield characters of cucumber

Although the 150,000L/ha treatment produced the longest fruits, the effect of rubber effluent on the mean fruit length was not significant ($P > 0.05$). The 150,000 L/ha produced fruits with the highest girth which was significantly different from the other treatments ($P < 0.05$). The 150,000L/ha treatment produced the highest number of fruits per plant which however was not statistically different from the 100,000L/ha and 50,000L/ha.

Fruit weight per plant was also enhanced by the application of rubber effluent most especially at 150,000L/ha where fruit weight was significantly higher than the other treatments while the control produced the least fruit weight per plant.

Cucumber yield increased with increase in level of rubber effluent up to 150,000 L/ha. The differences between yield per hectare at this level and other levels were 17,007.49kg, 13503.50 kg, 9,126.55kg and 7,111.53kg for 0, 50000, 100000 and 200000 L/ha respectively. It was clear that the enhanced yield was a direct effect of rubber effluent application and good agronomic practices carried out. Zhou *et al.* (2000), reported yield increases in crops following fermented wastewater application. It was apparent that all rubber effluent treated plots had an elevated cucumber yield which was clearly demonstrated in the number of fruits per plant, fruit weight per plant, fruit size (fruit length and girth) and total yield per plant. This result is in agreement with the findings of Chaiprapat and Sdoodee (2007) that had similar results in Thailand. It was apparent that the rubber effluent treated plots had a superior plant growth and yield attributes. The highest effluent plot out yielded the control by about sixty two percent.

CONCLUSION

Our study revealed that the application of rubber effluent had a positive impact on the growth and yield characters of cucumber. The rubber effluent improved the soil physical characteristics by increasing the organic matter content of the soil and the nutrient status. The application of 150,000L/ha of rubber effluent gave the highest vegetative and yield attributes of cucumber. However applying rubber effluent above 150,000L/ha, led to decrease in the growth and yield parameters of cucumber. The study also revealed that rubber effluent could be gainfully harnessed as a soil conditioner.

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Table 2. Effect of rubber effluent on the vegetative traits of cucumber at 4, 6 and 8 weeks after planting.

Treatments L/ha	Vine length (cm)			No of branches/plant			No of leaves/plant		
	WAP 4	6	8	WAP 4	6	8	WAP 4	6	8
Control	10.30	27.80	106.33	0.89	2.00	4.74	4.75	10.55	19.12
50,000	12.94	31.69	121.82	0.68	2.69	5.34	4.94	11.57	22.48
100,000	15.34	32.63	133.16	0.94	2.93	5.79	5.49	12.81	28.78
150,000	17.47	46.09	165.51	1.27	3.52	9.84	6.13	13.83	34.11
200,000	14.52	42.02	157.09	1.01	3.05	5.94	5.57	12.85	28.40
Mean	14.11	36.06	136.78	0.95	2.84	6.33	5.38	12.32	26.58
LSD (0.05)	0.59	2.91	17.24	NS	0.48	1.25	0.73	2.15	4.09

WAP= Weeks after planting

Table 3 . Yield and yield components of cucumber as affected by rubber effluent.

Treatments	No.of fruits/plant	Fruit length (cm)	Fruit girth (cm)	Wt of fruits/plant (kg)	Yield (kg/ha)
Control	2.73	12.90	3.83	0.58	10,311.11
50,000	3.90	14.03	4.03	0.83	14,815.07
100,000	4.35	13.90	4.46	1.03	18,192.05
150,000	4.66	15.20	5.36	1.54	27318.60
200,000	3.36	14.40	4.33	1.14	20207.01
Mean	3.80	17.07	4.40	1.02	18168.77
LSD (0.05)	0.88	NS	0.79	0.16	2940.70

Wt = weight

No = number

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