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EVALUATION OF THE EFFECTS OF RUBBER FACTORY EFFLUENT AND NPK FERTILIZER ON THE PERFORMANCE OF CUCUMBER (*Cucumis sativus* L.)

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ABSTRACT

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Combining inorganic and organic fertilizer is expected to give higher and sustainable crop yields than the sole application of inorganic or organic fertilizer. Nutrients in inorganic fertilizers are readily available for uptake upon application while the organic form of nutrient is slowly available; hence combining the attributes of both types of manure will be beneficial to crops thereby increasing their growth and yield potentials. 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. The objective of the study was to evaluate the effect of rubber effluent and NPK 15:15:15 on the growth and yield potentials of cucumber (var. Poinsett). Five levels of rubber effluent and three levels of fertilizer NPK 15:15:15 (control, 50,000, 100,000, 150,000, 200,000L/ha and 0, 150 and 300kg/ha) respectively were randomly allocated to plots using a randomized complete block design (RCBD) in a factorial scheme 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 Discovery 4 Edition software package. The result of the experiment indicated significant differences ($P < 0.05$) amongst the treated plots and the control. Combining NPK at 150 and 300kg/ha and rubber effluent at 200,000L/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 combined application of rubber effluent at 150,000L/ha and fertilizer at 300kg/ha out yielded the control by 76 percent.

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

INTRODUCTION

Cucumber (*Cucumis sativus* L.) which is one of the thirty-five fruits and vegetable regarded by USDA known to have anti- cancer properties, an ancient vegetable which is relished for its high water and low calories contents. The crop develops rapidly, with a shorter time from planting to harvest than for most crops (Wehner and Guner, 2004). The cultivation of cucumber in Nigeria is however 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. Akanbi *et al.* (2010) reported the use of inorganic fertilizer in combination with organic fertilizer to give the desired higher and sustainable crop yields than sole application of inorganic or organic fertilizer. Nutrients in inorganic fertilizers are readily available for uptake upon application while the organic form of nutrient is slowly available (Leo *et al.*, 2001). Eifediyi and Remison (2010) stated that the application of farm yard manure and inorganic fertilizer enhanced the growth and yield attributes of cucumber. Use of rubber effluent which is a form of organic manure for cultivation is therefore an alternative means to provide additional nutrients to crops at rather low or no costs. 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) have opined 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.* (2005) posited that rubber effluent improves soil fertility and has no apparent adverse effect on the environment and consequently 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.

However, rubber effluent contains both macro and micro nutrient elements and combining it with NPK fertilizer will further increase the nutrient content of the soil and hence increased yield of crops. 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 and inorganic fertilizer on the growth and yield of cucumber.

MATERIALS AND METHODS

The experiment was conducted at the Rubber Research Institute of Nigeria, Iyanomo Benin City, Edo State (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, and minimum 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). Analysis of the rubber effluent indicated that it has a relatively low pH of 4.05, the organic matter and organic carbon contents was high, nitrogen content was moderate, calcium content was moderate. The N, P, K, Ca, Mg in the rubber effluent was higher than that of the soil sample.

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- P_i using ammonium acetate (Olsen and Sommers, 1982), Potassium was determined using flame photometer and calcium and magnesium by EDTA titration method.

The rubber effluent was collected from the Institute's 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 25th of August, 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 and fitted into a factorial scheme. The treatments imposed were five levels of rubber effluent (0, 50,000, 100,000, 150,000 and 200,000 litres per hectare) and three levels of NPK fertilizer application (0, 150 and 300kg/ha⁻¹). The plot size was 3.75 x 3.75 metres with 2- metre pathways. 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 and the fertilizer was applied at three weeks after 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 lamdacyahalothrin as Karate at biweekly intervals for effective insect control. 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 Discovery 4 edition statistical packages for randomised complete block design (RCBD). The means were separated using the least significant differences (LSD) (Steel and Torrie, 1980.).

Table 1: Chemical properties of soil and rubber effluent before and after cropping

Properties	Soil Sample		Rubber effluent
	(Before cropping)	After cropping	
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

Soil analysis

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. The analysed soil also is acidic in nature and had poor nutrients status (Table 1). The nutrient content of the effluent could be utilized by crops for its growth and development. These results agree with the findings of Orhue *et al.*, (2007) Seneviratne, (1997) and Augusthy and Mani (2001) who reported significantly high amounts of total suspended and dissolved solids, phosphates and total nitrogen in rubber effluent. Poon (1982) and Lim *et al.* (1983) had earlier reported similar results. Waizah *et al.*, (2011) has opined that the application of urea and rubber effluent improved the general soil chemical properties and indicated that this change can be attributed to the increase in the soil nutrient level and a more conducive environment for the activities of microorganisms to proliferate thereby increasing the fertility status of the soil.

Growth parameters

The vine length of cucumber increased significantly ($P < 0.01$) with the application of rubber effluent and inorganic fertilizer across the three sampling periods of 4, 6 and 8 weeks after planting (WAP) with significant fertilizer x rubber effluent interaction at each of the three sampling periods. (Table 2). The longest vine length was observed in NPK 300kg/ha⁻¹ + 2000000 l/ha⁻¹ effluent treated plots at the sampling period. However, at 4 WAP, the effects of rubber effluent application increased up to the 150,000l/ha and decreased at the 200,000l/ha application and an increase in fertilizer application resulted to an increase in the vine length of cucumber. The number of leaves was significantly influenced by the application fertilizer, rubber effluent as well as rubber effluent x fertilizer interaction ($P < 0.05$). As the rate of application of the nutrient increased, there was an increase in the number of leaves at 4,6 and 8 WAP (Table 3). The number of branches was significantly enhanced by the nutrient at the three sampling period of 4,6 and 8WAP. As the rates of application increased there was a significant increase in the ($p < 0.05$) rubber effluent, inorganic fertilizer and rubber effluent x fertilizer (Table 4).

Yield and yield components

The fruit length of cucumber was enhanced by the application of rubber effluent and inorganic fertilizer but no significant x inorganic fertilizer interaction (Table5). The longest fruit was recorded with the combination of 200000l/ha + 300kg/ha⁻¹ NPK. However, this was not statistically different from length of fruits at 150000l/ha + 300NPK kg/ha⁻¹. As the rate of application of the nutrient combination increased, the length of the fruit also increased (Table 5). Fruit girth was enhanced by the application of rubber effluent ($P < 0.01$), and fertilizer ($P < 0.01$) but the interactive effect of effluent x NPK was non significant. The broadest cucumber was observed with the combination of 150,000l/ha + 300kg/ha⁻¹ NPK. Fruit weight per plant was significantly enhanced by rubber effluent ($P < 0.05$), NPK ($P < 0.05$) and there was no significant interaction between the rubber effluent and NPK fertilizer. The highest weight was observed with the combination of 150,000l/ha + 300 x NPK fertilizer interaction kg/ha⁻¹ interaction (2.49kg/plant) and the least value was observed in the control.

The cucumber fruit weight per hectare was significantly influenced by the application of rubber effluent ($P < 0.05$), NPK fertilizer but there was no significant rubber effluent x NPK fertilizer interaction. The highest fruit weight per hectare (44,382kg) was observed in the 150,000l/ha + 300kg/ha⁻¹ NPK and the least fruit weight (10,297kg) was observed with the control. The combination of 150, 000l/ha rubber effluent and 300kg/ha⁻¹ gave a yield increase of 331 per cent over the control. Cucumber growth parameters were strongly influenced by the combined application of rubber effluent. The cucumber plant had enough nutrients for rapid growth and development considering the composition of the rubber effluent which was applied to the soil. This increase in the growth

parameters could be attributed to the abundance of nutrients in the soil and the subsequent utilization of these nutrients for growth and development (Banu, 1987). Increase in number of leaves imply increased photosynthetic activity and more assimilate production (Jumbo *et al.*, 2012) and this had direct relationship with the fertilizer applied (Ehigior, 1990). This could be attributed to the nutrients available to the crops and its subsequent uptake and utilization in the form of organic and inorganic fertilizer. This was in agreement with the findings of (Leo, 2001) who posited that nutrients in inorganic fertilizer are readily available for plant uptake after application while the organic form is slowly available. However, the poor growth parameters recorded in the control could be attributed to the dependence of the plants on the inherent fertility of the study area. The combined application of rubber effluent (200000L/ha) and NPK 150 and 300kg/ha¹ gave superior growth characters. Although the application of NPK fertilizer treated plots gave better growth attributes than the sole rubber effluents treated plots. In Nigeria, studies have shown that the use of inorganic fertilizer in combination with organic materials could give the desired sustainable crop yield than the sole use of inorganic fertilizer or animal manure (Lombion *et al.*, 1991). Akanbi *et al.* (2010) also reported the use of inorganic fertilizer in combination with organic fertilizer to give the desired higher and sustainable crop yields than the sole application of inorganic or organic fertilizer. The concentration of nutrients in the rubber effluent is low compared to NPK fertilizer which had higher nutrient composition. This was probably the reason why cucumber performances were superior with NPK fertilizer in comparison with rubber effluent. The cucumber test crop benefited from the addition of rubber effluent and NPK fertilizer either alone or in combination. This was in consonance with the findings of Ayoola and Makinde (2007) who posited that organic fertilizer can be used in combination with inorganic fertilizer to have an increase in maize yield. The yield attributes of cucumber was enhanced by rubber effluent and inorganic fertilizer and in agreement with findings of Eifediyi and Remison (2010) who posited that farmyard manure and inorganic fertilizer increased yield attributes of cucumber. Combining rubber effluent and NPK fertilizer at the rate of 150000L/ha + 300kg/ha of NPK gave the highest fruit weight and this was in agreement with the findings of Titiloye (1982) who reported that the best way to increase maize yield was by the combination of organic waste and inorganic fertilizers. Murwira and Kirchman (1983) who found increased yield of crops through the combination of farmyard manure and inorganic fertilizers. The addition of rubber effluent increased the water holding capacity and reduced the incidence of soil erosion hence, making more nutrients available to crops (Costal *et al.*, 1991).

CONCLUSION

The study revealed that the application of rubber effluent in combination with NPK fertilizer had a positive impact on growth, yield and yield components of cucumber. The rubber effluent improved the soil physical characteristics by increasing the organic matter content of the soil. The application of 150,000L/ha of rubber effluent combined with 300kg/ha¹ of NPK gave the highest vegetative and yield attributes of cucumber. This treatment outyielded the control by about 76 per cent and the study also revealed that rubber effluent could be gainfully harnessed as a soil conditioner in combination with NPK fertilizer.

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Table 2: Effect of rubber effluent and inorganic fertilizer on the vine length of cucumber at 4, 6 and 8 weeks after planting (WAP)

Rubber effluent rates (l ha ⁻¹)	Vine Length (cm)																	
	4WAP					6WAP					8WAP							
Fertilizer rates (kg ha ⁻¹)	0	50,000	100,000	150,000	200,000	Mean	0	50,000	100,000	150,000	200,000	Mean	0	50,000	100,000	150,000	200,000	Mean
0	10.30	12.94	15.35	17.47	14.52	14.12	27.82	31.70	36.63	46.09	42.37	36.92	106.3	121.8	133.2	165.5	152.1	135.8
150	11.21	13.37	15.71	18.65	19.45	15.68	30.69	34.42	37.46	48.61	56.13	41.46	124.2	130.5	139.6	168.5	173.3	147.2
300	12.55	15.42	18.08	18.67	19.77	16.90	31.93	37.00	38.93	49.32	64.16	44.27	124.5	132.1	143.1	171.2	179.3	144.0
Mean	11.35	13.91	16.38	18.26	17.91	30.15	34.37	37.67	48.01	54.22		118.3	128.1	138.6		168.4	168.2	
LSD:0.05Efm. 0.48, fert.0.37, cfm. x fert.0.83 LSD:0.05 Efm. 1.96, fert. 1.52, cfm. x fert.3.40 LSD:0.05Efm. 9.35, fert.7.24, cfm. x fert.16.19																		

Table 3: Effect of rubber effluent and inorganic fertilizer on the number of cucumber leaves at 4, 6 and 8 WAP

Rubber effluent rates (l ha ⁻¹)	No of Leaves																	
	4WAP					6WAP					8WAP							
Fertilizer (kg ha ⁻¹)	0	50,000	100,000	150,000	200,000	Mean	0	50,000	100,000	150,000	200,000	Mean	0	50,000	100,000	150,000	200,000	Mean
0	4.76	4.94	5.49	6.14	5.57	5.38	10.55	11.58	12.81	13.83	12.55	12.26	19.13	22.48	28.78	34.12	28.41	26.58
150	4.67	5.81	6.40	6.35	6.55	5.96	14.13	14.98	16.17	16.68	18.12	16.03	21.20	26.03	31.23	37.47	46.77	32.54
300	5.60	6.19	6.55	6.40	6.55	6.26	14.93	15.67	15.84	17.00	22.74	17.24	23.20	28.37	32.20	44.80	47.53	35.22
Mean	5.01	5.65	6.15	6.30	6.22		13.20	14.08	14.94	15.84	17.80		21.18	25.63	30.74	38.80	40.90	
LSD:0.05 Efm. 0.42, fert.0.32, cfm. x fert.0.72 LSD:0.05Efm. 1.13, fert.0.87, cfm. x fert.1.95 LSD:0.05Efm. 2.14, fert.1.66, cfm. x fert.3.72																		

Table 4: Effect of rubber effluent and inorganic fertilizer on the vine length of cucumber at 4, 6 and 8 WAP

Rubber effluent rates (l ha ⁻¹)	No of Leaves											
	4WAP				6WAP				8WAP			
Fertilizer rates (kg ha ⁻¹)	0	50,000	100,000	150,000	200,000	Mean	0	50,000	100,000	150,000	200,000	Mean
0	0.89	0.95	0.95	1.01	1.27	1.01	2.00	2.69	2.94	3.52	3.05	2.84
150	0.94	1.35	1.65	2.62	3.14	1.94	2.38	3.74	4.34	5.22	7.08	5.55
300	0.95	1.36	1.97	2.87	3.12	2.05	2.81	4.11	4.94	6.71	7.24	5.16
Mean	0.93	1.22	1.52	2.12	2.17	2.40	3.51	4.07	5.15	5.79		5.42
LSD:0.01 Efm. 0.30, fert.0.23, cfm. x fert.0.51 LSD:0.01 Efm. 3.6, fert. 28, cfm. x fert.0.64 LSD:0.01 Efm. 0.87, fert.0.67, cfm. x fert.1.502												

Table 5: Effect of rubber effluent and inorganic fertilizer on the fruit length and fruit girth of cucumber

Fruit Length (cm)	Fruit girth (cm)		Fruit length (cm)									
	Rubber effluent rates (ha ⁻¹)		Rubber effluent rates									
	Fertilizer rates (kg ha ⁻¹)	0	50,000	100,000	150,000	200,000	Mean	0	50,000	100,000	150,000	200,000
0	12.50	14.30	13.93	15.23	14.47	14.09	3.83	4.03	4.47	5.37	4.33	4.41
150	14.97	16.17	17.03	17.67	18.20	16.81	4.30	4.50	5.17	5.87	6.10	5.19
300	15.50	16.60	17.67	18.07	18.30	17.23	4.80	4.60	5.23	6.33	6.03	5.40
Mean	14.32	15.60	16.21	16.77	16.99		4.31	4.38	3.29	5.85	5.48	

LSD:0.01 E.M. 0.96, fert 0.74, efm. x fert ns LSD:0.01 E.M. 0.38, fert 0.296, efm. x fert NS

Table 6: Effect of rubber effluent and inorganic fertilizer on the fruit weight/plant and fruit weight/ha of cucumber

Fertilizer rates (ha ⁻¹)	Fruit weight (kg plant ⁻¹)					Fruit weight (kg ha ⁻¹)						
	Rubber effluent rates (ha ⁻¹)					Rubber effluent						
	0	50,000	100,000	150,000	200,000	Mean	0	50,000	100,000	150,000	200,000	Mean
0	0.58	1.02	0.83	1.54	1.14	1.02	10.297	14.796	18.251	27.317	20.207	18.174
150	0.73	1.50	1.25	2.22	2.22	1.58	14.162	18.133	22.281	39.406	39.702	26.737
300	0.93	1.02	1.61	2.49	2.28	1.67	16.473	26.665	28.545	44.383	40.472	31.308
Mean	0.75	1.18	1.23	2.08	1.88		13.644	19.865	23.026	33.702	33.460	

LSD:0.01 E.M. 0.21, fert 0.16, efm. x fert ns LSD:0.01 E.M. 3872.1fert, 2999.3efm. x fert NS

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