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Growth of *Dialium guineense* Willd Seedlings and Changes in Some Chemical Properties in Soil Amended with Brewery Effluent

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Abstract: A 20 week greenhouse study was carried out at Faculty of Agriculture, University of Benin, Benin City, Nigeria to investigate the influence of brewery effluent on some chemical properties of soil and on the growth of *Dialium guineense* seedlings in a completely randomized design with three replicates. Five rates of brewery effluent were used: 0, 25,000 50,000 75,000 and 100,000 L ha^{-1}. Effluent application increased soil pH and soil N, P, K, Na, organic matter content, but soil Ca and Mg and exchangeable acidity were reduced. Effluent application increased plant nutrient uptake and leaf production, but did not affect soil texture or a range of plant growth parameters. No nodule formation was observed.

Key words: Brewery effluent, rate, *Dialium guineense*

INTRODUCTION

Brewery effluent is the rinsate produced from washing beer wort filters, fermenters and the bottles. It contains a range of dissolved and suspended organic compounds, including sugars, soluble starch, ethanol, proteins, volatile fatty acids, spent grains and waste yeast. Effluent quality is affected by several brewing processes, including raw material handling, wort preparation, fermentation and filtration (Driessen and Vereijken, 2003). A typically effluent contains 30-100 mg N, 10-30 mg P and 10-60 mg of suspended solids per litre (World Bank, 1997). Typical biological and chemical oxygen demand ranges are 1.0-1.5 and 1.8-2.0 g L^{-1}, respectively (World Bank, 1997).

Land applications of various organic industrial effluents can alter soil properties. Effluent from palm oil milling and sugar processing increase soil organic matter content (Poon, 1982; Lim and P'ng, 1983; Lim *et al*., 1983; Valdes *et al*., 1996). Tannery, palm oil and cassava mill effluents can increase soil nutrient levels (Poon, 1982; Lim and P'ng, 1983; Lim *et al*., 1983; Vieites and Brinkoli, 1993; Karunyal *et al*., 1993). Effluent from rubber production improves soil water retention (Yeow and Zin, 1981).

The influence of effluents on plant growth has also been reported. The germination of *Oryza sativa*, *Acacia holisevices* and *Leucaena leucocephala* were hindered by tannery effluent (Karunyal *et al*., 1993). Paper mill effluent applications did not affect the germination and early growth of pigeon pea, *Cajanus caja* (L.) Millsp. (Karande and Ghanvat 1994). Vegetative growth of wheat, *Triticum aestivum* (L.) increased in soil treated with sugar mill effluent (Rajesh and Bahargara, 1998).

Dialium guineense Wild is an important legume plant that is widely distributed in the tropics. Its fruit is consumed raw, fermented to produce alcoholic beverage. The wood is a good source of charcoal (Okafor, 1975). Utilization of effluents as soil amendment is a recent development in agriculture in Nigeria. Thus, it is therefore important to study the properties of brewery effluent vis a vis it effect on crop production rather than the indiscriminate discharge in the environment. The purpose of this study therefore was to evaluate the effect of brewery effluent on some soil chemical properties as well as the growth of *Dialium guineense* seedlings.

MATERIALS AND METHODS

The study was conducted in a greenhouse on the experimental grounds of the Faculty of Agriculture, University of Benin, Benin City, Nigeria. The brewery effluent was obtained from Bendel brewery Nigeria PLC, Benin City while *Dialium guineense* seeds were bought from a local market in Benin City, Nigeria. The soil used was collected from top 15 cm of an uncultivated field left to fallow for two years after seven years of continuous maize, *Zea mays* (L.) production. The soil was bulked, mixed thoroughly, air dried and then sieved to remove debris. Thereafter, 2 kg of the composite was weighed and put into polythene bags 20×21.5 cm. The experiment was

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laid out in a Completely Randomized Design with three replicates. Each replicate had 25 polythene bags (5 per treatment) making up a total of 75 bags. The brewery effluent was applied at the following rates of 0, 25,000, 50,000, 75,000 and 100,000 L ha^{-1}. The effluent applied was thoroughly mixed with the soil and left for 2 weeks to allow for adequate mineralization before transplanting.

Dialium guineense seeds, purchased from local market, were extracted from matured pods and scarified using the method of Aghatise and Egharevba (1994). The scarified seeds were planted in a germination box containing the same soil as that of the polythene bags but no effluent was applied. The seeds were left in the nursery to germinate and grow for 3 weeks before they were transplanted to the polythene bags, one plant per bag. The plants were watered every other day with deionized water. Growth parameters were observed and measured every 2 weeks starting from the second week after seedlings transplant. This was continued for 20 weeks, after which the seedlings were harvested and oven dried at 70°C for 48 h.

Soil analysis was carried out before and after the experiment. Brewery effluent analysis was done before application. The soil pH was determined in a soil water ratio of 1:1 using a glass electrode pH meter whereas the pH of the effluent was read directly from the pH meter. Particle size analysis was determined by hydrometer method of Bouyoucus (1951) as modified by Day (1965). The organic carbon content of both soil and the effluent was determined by the chromic acid wet oxidation procedure, as described by Jackson (1962). The nitrogen was determined by micro kjeldahl method as described by Jackson (1962). Available phosphorus was determined using Bray and Kurtz (1945). The exchangeable bases were determined by the methods of Black (1965). Exchangeable acidity was determined by the KCl extraction and NaOH titration methods of Maclean (1965). The total dissolved and suspended solids were analyzed according to Ademoroti (1996). Alkalinity was determined by Larson and Henley (1955) methods. The electrical conductivity was determined using the 230HT Corning conductivity meter. Biological and chemical oxygen demands were measured using the method of Ademoroti (1996). Plant nutrient uptake was determined using the method of Pal (1991).

RESULTS AND DISCUSSION

Properties of brewery effluent used: The brewery effluent used in this study is acidic with suspended particles. Analysis of the effluent revealed that it contained N, P, K, Mg, Ca, Na. The BOD, COD and the electrical conductivity were high. The presence of suspended solids in the effluent agrees with the report of Grolsch Brewery (2000) that not all the organic material is dissolved in brewery effluent but some organic materials remain as particulates (Table 1).

Influence of brewery effluent on some soil chemical properties: The soil used in this trial is an ultisol as shown by its low percent base saturation (<35%), which differentiated it from an alfisol (Buol *et al*., 1973). The pH is relatively low (5.30) and the particle size analysis showed that the soil is loamy sand. The soil particle size analysis showed no change in soil texture with brewery effluent application. The soil pH rose from 5.30 to 6.76 at 100000 L ha^{-1} treatment. The rise in soil pH may be due to the presence of Ca and Mg in the effluent. Similar results have earlier been obtained by Lim *et al*. (1983), Lim and P'ng (1983) and Orhue *et al*. (2005) who reported a rise in pH with rubber effluent due to the presence of Ca and Mg. The organic carbon content rose from 1.27% in control to 1.73% in 100000 L ha^{-1} treatment but with a decline at control after the experiment. The increased organic matter content may be attributed to the presence of abundance of both suspended and dissolved solids that are converted by biological activies into organic carbon in the soil. This result agreed with the findings of Poon (1982) and Valdes *et al*. (1996). The total N rose from 0.11 to 0.20% in 100000 L ha^{-1} treatments with a decline at control initially before rising. The C/N ratio was lowest in 100000 L ha^{-1} treatment compared to control. The C/N ratio rose from 11.54 to 15.42 in control and then declined at 100000 L ha^{-1} treatment. The present state of C/N ratios according to Orhue *et al.* (2005) suggests that a lot of biological activities may have occurred in the treated soil and that also, the microorgamisms utilized the soil N for metabolic activity. Vieities and Brinkoli (1983) reported an increased in soil nitrate with manioc (cassava) effluent application. The available P rose from 21.59 to 29.80 mg kg^{-1} in 100000 L ha^{-1} effluent treatment. The exchangeable

Table 1: Properties of brewery effluent used in the trial

Parameter	Value
pH	4.34
Total nitrogen (mg L^{-1})	13.62
Available P (ppm)	5.46
Potassium (mg L^{-1})	40.16
Magnesium (mg L^{-1})	6.56
Calcium (mg L^{-1})	182.09
Sodium (mg L^{-1})	15.12
Biochemical Oxygen Demand (BOD) (mg L^{-1})	1069.00
Chemical Oxygen Demand (COD) (mg L^{-1})	1296.00
Electrical Conductivity (μs)	780.00
Alkalinity (mg L^{-1})	1290.00
Suspended Solids (SS) (mg L^{-1})	996.00
Total Dissolved Solids (TDS) (mg L^{-1})	420.00
Ammonium Nitrogen (NH_4-N) (mg L^{-1})	1.04

Ca decreased from 0.48 Cmol kg^{-1} in control to 0.10 Cmol kg^{-1} in 100000 L ha^{-1} treatment while the Mg content was however reduced from 0.16 to a value of 0.01 Cmol kg^{-1} in 50,000, 75,000 and 100,000 L ha^{-1} treatment. The exchangeable K rose from 0.39 to 0.62 Cmol kg^{-1} in 100000 L ha^{-1} treatment, whereas the exchangeable acidity declined from 0.42 to 0.02 Cmol kg^{-1} in 50000 L ha^{-1} treatment. The Na content increased from 0.39 to 0.62 Cmol kg^{-1} in 50000 and 100000 L ha^{-1} treatment. The increased in Na is shown in the increase in pH towards alkalinity. Increased in Na poses the danger of Na toxicity to plant (Sanchez, 1996; Brady, 1984) (Table 2).

Influence of brewery effluent on the growth of *Dialium guineense* seedlings: The results showed that there was no significant difference in collar girth (Table 3), number of nodes (Table 5), number of branches (Table 6) as well as plant height and leaf area (Table 7 and 8) among treatments throughout the period of the study. In number of leaves (Table 4), the 50000 L ha^{-1} effluent concentration treatment was significantly different ($p<0.05$) from the control at 2 WAT but did not differ significantly from other treatments. At 10 WAT however, the 25000 L ha^{-1} effluent treatment was significantly different ($p<0.05$) from the control but did not differ significantly from other treatments. No nodules formation was observed in this study nor has it been reported on *D. guineese* elsewhere (Orhue, 2001; Orhue *et al*., 2005).

Effect of brewery effluent on *Dialium guineense* nutrients uptake: The highest N uptake (Table 9) was at 50000 L ha^{-1} effluent concentration treatment and was significantly ($p<0.05$) better than other treatments including control, whereas the P uptake at treatments 0, 50000, 75000 and 100000 L ha^{-1} effluent treatments were not significantly different from one another but better than 25000 L ha^{-1} effluent concentration. The highest P uptake however occurred at 50000 L ha^{-1} effluent concentration treatment. Brady and Weil (1999) have earlier reported that as a general rule in mineral soil P fixation is at its lowest and its availability to plant is highest when the soil pH is maintained in the range between 6 and 7 as shown in this study.

The cations uptake by *Dialium guineense* seedlings was also influenced by brewery effluent. The K uptake at various treatments was not significantly different from one another but higher K uptake was recorded at 50000 L ha^{-1} effluent concentration treatment. There was however symptoms of K deficiency in especially the older leaves generally among the treatments inspite of high K content of the brewery effluent used. This can be attributed to K fixation caused by the interaction with other nutrient elements which may have resulted to antagonism. According to Remison (1997), the supply of one element can increase, decrease or maintain their percentage in dry matter in leaves. Ca uptake in 75000 and 100000 L ha^{-1} effluent was better than 0, 25000 and 50000 L ha^{-1}. The highest Ca uptake was recorded in 100000 L ha^{-1} effluent. This may be attributed to the high Ca content of the effluent used. Mg uptake at 75000 L ha^{-1} effluent concentration was significantly ($p<0.05$) better than 25000, 50000 and 100000 L ha^{-1} effluent concentration including control, whereas Na uptake at 25000, 50000, 75000 and 100000 L ha^{-1} effluent concentration though not significantly different from one another, were better than control. The Na uptake was however higher at 50000 L ha^{-1} effluent concentration treatment. Generally, no definite pattern of nutrient uptake in this investigation was recorded. The N, P, K and Na uptake was higher in 50000 L ha^{-1} effluent concentration, whereas Ca and Mg were higher in 100000 and 75000 L ha^{-1} effluent concentration respectively. This higher nutrient uptake with brewery effluent is similar to the report of Bahara *et al.* (1995), Chidaunbalam *et al.* (1996) and Orhue *et al.* (2005) using chloro-alkli, tannery and rubber effluent respectively. Orhue *et al.* (2005) reported that certain factors such as temperature, aeration, plant age, concentration of competing ions, alteration of soil pH as well as nutrient elements may influence variation in nutrient uptake. According to Drewes and Blume (1997), the reduce nutrient uptake in the presence

Table 2: Soil chemical properties before and after the experiment

	Treatment ($L\ ha^{-1}$ Conc.)	Particle size analysis: Sand (%)	Silt (%)	Clay (%)	pH (H_2O) (1:1)	Organic carbon (%)	Total nitrogen (%)	C/N	Available phosphorus ($mg\ kg^{-1}$)	Exchangeable bases: Ca	Mg	K	Na	Exch. acidity
Before Effluent application		89	2	9	5.30	1.27	0.11	11.64	21.59	0.48	0.16	0.18	0.39	0.42
After the Experiment	0	90	1	9	5.58	1.08	0.07	15.42	18.90	0.06	0.03	0.13	0.06	0.06
	25000	91	1	8	5.98	1.57	0.14	13.08	23.63	0.06	0.03	0.14	0.29	0.03
	50000	91	1	8	6.06	1.31	0.12	9.35	26.95	0.07	0.01	0.28	0.62	0.02
	75000	91	1	8	6.76	1.66	0.16	10.37	2.63	0.11	0.01	0.23	0.49	0.03
	100000	91	2	8	6.75	1.73	0.20	8.65	29.80	0.10	0.01	0.28	0.62	0.03

Table 3: Effect of Brewery effluent on the Collar girth (cm) in *Dialium guineense* seedlings

Treatment concentration (L ha^{-1})	Weeks after transplanting									
	2	4	6	8	10	12	14	16	18	20
0	0.608^{a}	0.707^{a}	0.725^{a}	0.742^{a}	0.792^{a}	0.833^{a}	0.908^{a}	0.967^{a}	1.000^{a}	1.142^{a}
25000	0.633^{a}	0.658^{a}	0.708^{a}	0.758^{a}	0.808^{a}	0.933^{a}	1.000^{a}	1.117^{a}	1.242^{a}	1.392^{a}
50000	0.642^{a}	0.658^{a}	0.675^{a}	0.725^{a}	0.817^{a}	0.900^{a}	0.983^{a}	1.100^{a}	1.183^{a}	1.333^{a}
75000	0.667^{a}	0.673^{a}	0.692^{a}	0.792^{a}	0.833^{a}	0.908^{a}	0.955^{a}	1.050^{a}	1.158^{a}	1.275^{a}
100000	0.672^{a}	0.687^{a}	0.717^{a}	0.767^{a}	0.850^{a}	0.917^{a}	1.000^{a}	1.092^{a}	1.142^{a}	1.275^{a}
SEM	0.037	0.040	0.047	0.075	0.082	0.088	0.093	0.119	0.133	0.157

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

Table 4: Effect of Brewery effluent on the number of leaves in *Dialium guineense* seedlings

Treatment concentration (L ha^{-1})	Weeks after transplanting									
	2	4	6	8	10	12	14	16	18	20
0	3.167^{b}	4.333^{a}	5.200^{a}	6.200^{a}	6.400^{b}	7.800^{a}	7.333^{a}	9.167^{a}	12.000^{a}	14.933^{a}
25000	4.000^{a}	5.500^{a}	6.667^{a}	7.833^{a}	8.833^{a}	9.500^{a}	11.167^{a}	13.833^{a}	14.333^{a}	18.500^{a}
50000	4.500^{a}	5.333^{a}	5.833^{a}	6.667^{a}	8.600^{a}	8.800^{a}	10.833^{a}	11.667^{a}	13.833^{a}	18.167^{a}
75000	4.000^{a}	5.333^{a}	6.167^{a}	7.167^{a}	7.667^{a}	8.667^{a}	10.167^{a}	10.833^{a}	13.833^{a}	14.833^{a}
100000	4.000^{a}	5.333^{a}	6.333^{a}	7.500^{a}	7.833^{a}	9.167^{a}	9.500^{a}	9.500^{a}	14.000^{a}	14.833^{a}
SEM	0.459	0.843	0.047	1.101	1.135	1.472	1.636	2.226	3.469	3.985

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

Table 5: Effect of Brewery effluent on the number of branches in *Dialium guineense* seedlings

Treatment concentration (L ha^{-1})	Weeks after transplanting									
	2	4	6	8	10	12	14	16	18	20
0	Nil	Nil	Nil	Nil	Nil	Nil	0.167^{a}	0.333^{a}	0.333^{a}	0.333^{a}
25000	Nil	0.167^{a}	0.167^{a}	0.167^{a}	0.167^{a}	0.167^{a}	11.167^{a}	0.333^{a}	0.333^{a}	0.333^{a}
50000	Nil	Nil	Nil	Nil	Nil	Nil	Nil	1.167^{a}	1.167^{a}	1.167^{a}
75000	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
100000	Nil	Nil	0.167^{a}	0.167^{a}	0.167^{a}	0.167^{a}	0.167^{a}	0.500	0.500	0.500
SEM	-	0.105	10.149	0.149	0.149	0.258	0.258	0.316	0.316	0.316

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

Table 6: Effect of Brewery effluent on the number of nodes in *Dialium guineense* seedlings

Treatment concentration (L ha^{-1})	Weeks after transplanting									
	2	4	6	8	10	12	14	16	18	20
0	2.167a	3.833^{a}	4.167^{a}	5.167^{a}	5.333^{b}	6.833^{a}	7.167^{a}	8.000^{a}	9.333^{a}	10.167^{a}
25000	2.000^{a}	3.667^{a}	4.833^{a}	6.000^{a}	7.000^{a}	7.833^{a}	9.167^{a}	11.167^{a}	11.833^{a}	13.333^{a}
50000	2.500^{a}	3.333^{a}	4.167^{a}	5.167^{a}	7.333^{a}	7.500^{a}	8.833^{a}	9.500^{a}	9.500^{a}	12.000^{a}
75000	2.000^{a}	3.500^{a}	4.333^{a}	5.333^{a}	5.667^{a}	6.667^{a}	7.833^{a}	8.667^{a}	8.667^{a}	11.333^{a}
100000	2.000^{a}	3.833^{a}	4.500^{a}	5.667^{a}	5.833^{a}	7.167^{a}	8.000^{a}	8.333^{a}	10.833^{a}	10.667^{a}
SEM	0.211	0.494	0.715	0.823	0.843	1.006	0.101	1.378	1.378	1.616

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

Table 7: Effect of Brewery effluent on the plant height (cm) in *Dialium guineense* Seedlings

Treatment concentration (L ha^{-1})	Weeks after transplanting									
	2	4	6	8	10	12	14	16	18	20
0	4.083^{a}	6.433^{a}	7.167^{a}	8.550^{a}	9.400^{a}	10.150^{a}	12.080^{a}	13.933^{a}	16.200^{a}	17.833^{a}
25000	4.86^{a}	6.933^{a}	8.183^{a}	9.350^{a}	10.200^{a}	12.000^{a}	13.730^{a}	17.467^{a}	19.750^{a}	23.533^{a}
50000	5.033^{a}	6.333^{a}	7.450^{a}	8.733^{a}	10.433^{a}	11.367^{a}	13.783^{a}	16.617^{a}	19.567^{a}	23.533^{a}
75000	4.667^{a}	6.733^{a}	7.950^{a}	9.317^{a}	10.000^{a}	11.417^{a}	13.100^{a}	15.300^{a}	18.373^{a}	21.683^{a}
100000	4.400^{a}	6.900^{a}	7.983^{a}	9.250^{a}	9.717^{a}	11.583^{a}	12.400^{a}	15.450^{a}	16.600^{a}	19.317^{a}
SEM	0.851	0.044	1.262	1.425	1.379	1.748	1.991	2.506	3.272	3.260

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

Table 8: Effect of Brewery effluent on the leaf area (cm^{2}) in *Dialium guineense* Seedlings

Treatment concentration (L ha^{-1})	Weeks after transplanting									
	2	4	6	8	10	12	14	16	18	20
0	2.554^{a}	5.140^{a}	6.899^{a}	11.247^{a}	13.412^{a}	20.295^{a}	22.052^{a}	24.453^{a}	24.303^{a}	27.017^{a}
25000	2.686^{a}	6.117^{a}	8.638^{a}	10.415^{a}	12.081^{a}	13.735^{a}	20.282^{a}	28.430^{a}	34.179^{a}	33.581^{a}
50000	2.938^{a}	6.613^{a}	9.770^{a}	12.776^{a}	17.484^{a}	19.763^{a}	29.151^{a}	34.673^{a}	36.337^{a}	36.441^{a}
75000	2.394^{a}	6.801^{a}	9.508^{a}	10.611^{a}	13.170^{a}	15.605^{a}	20.151^{a}	26.265^{a}	31.472^{a}	32.727^{a}
100000	2.840^{a}	6.839^{a}	10.470^{a}	13.550^{a}	15.833^{a}	16.605^{a}	26.017^{a}	29.647^{a}	31.769^{a}	38.739^{a}
SEM	0.814	0.044	1.262	1.425	1.379	1.748	1.991	2.506	3.272	3.260

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

Table 9: Effect of Brewery effluent on nutrient uptake of *Dialium guineense* seedlings

	Nutrient uptake (mg g^{-1})					
Treatment concentration (L ha^{-1})	N	P	K	Ca	Mg	Na
0	34.06^{d}	1.70^{a}	17.03^{a}	120.63^{b}	467.79^{c}	19.22^{b}
25000	54.78^{c}	0.99^{b}	19.92^{a}	120.10^{b}	526.00^{b}	26.01^{a}
50000	74.73^{a}	2.18^{a}	21.82^{a}	122.53^{b}	562.52^{b}	27.77^{a}
75000	68.71^{b}	2.10^{a}	20.20^{a}	795.33^{a}	771.98^{a}	25.40^{a}
100000	67.79^{b}	1.33^{c}	19.57^{a}	887.10^{a}	580.28^{b}	26.25^{a}

Values with the same superscript in the column are not significantly different from one another at 5% level of probability

of effluent would also occur due to strong adsorption or degradation in the soil and that the extent of adsorption or degradation does not only depend on the properties of the site, soil types, kind of soil organism and climatic conditions.

CONCLUSIONS

The results showed that soil pH, organic carbon, N, P, K and Na increased with application of brewery effluent whereas Ca, Mg and exchangeable acidity declined. On the average, the highest residual soil nutrient level was at 100000 L ha^{-1} effluent concentration treatment. The nutrient uptake was increased with various brewery effluent applications when compared with control. The growth of *Dialium guineense* seedlings was also enhanced with the application of the effluent as a result of the influence of some soil chemical properties, which may have affected the rate of uptake, synthesis as well as the translocation of vital nutrients in the *Dialium* plant. Thus, it may be concluded that brewery effluent has some plant nutrients needed by *Dialium guineense* plant. Therefore, in order to be sure of the fertilizer potential of this effluent, more trial both in the greenhouse and field should be carried out.

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