SJIF IMPACT FACTOR (2015): 5.79 CRDEEP Journals
International Journal of Life Sciences Okundia et. al., Vol. 5 No. 4 ISSN: 2277-193x
International Journal of Life Sciences. Vol. 5 No. 4. 2016. Pp. 203-209

Full Length Research Paper

Rubber Effluent Effects on Soil Chemical Properties and Growth of *Telfairia occidentalis* in a humid area of Southern Nigeria

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Article history
Received: 15-11-2016
Revised: 24-11-2016
Accepted: 08-12-2016

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Abstract
The study was conducted during 2011 and 2012 rainy and dry seasons at the Rubber Research Institute of Nigeria, Iyanomo, Edo state to determine the effects of rubber effluent on soil chemical properties, growth and yield of fluted pumpkin. Four treatments involving different rates of rubber effluent at 0, 2,380, 4,761 and 7,142l/ha were used for this experiment, fitted into a Randomised Complete Block Design (RCBD) and replicated three times. Data were collected on growth parameters such as leaf area, leaf number and biomass yield. Soil samples were collected prior to and after treatment application. All data collected were subjected to analysis of variance (ANOVA) using GENSTAT (2008). The vegetative traits such as leaf area, and leaf number were significantly increased by the applications of amendment (rubber effluent). The result showed that the application of 7,142L/ha of rubber effluent produced the highest leaf area, leaf number and biomass yield of Telfairia but was not significantly different from the application of 4,761/ha as they were at par at 5% level probability. Annual application of rubber effluent irrespective of their rate, consistently resulted in a significant improvement in the soils available P, exchangeable Ca and Mg and micro nutrients (Fe, Zn and Cu), while the org. C was reduced compared to their respective values before treatment application in each season. Therefore this study recommends the application of 4761L/ha of rubber effluent for environmentally friendly production of fluted pumpkin in Iyanomo area of Edo state and southern Nigeria.

***Keyword**: Soil chemical properties, Rubber effluent, sandy loam, humid environment*

Introduction

Fluted pumpkin (*Telfairia occidentalis* Hook F), Ugu (Ibo), Ubong (Efik), Umwenkhen Edo), Iroko (Yoruba) is eaten in different parts of southern Nigeria. It is a curcubit and it belongs to the family Curcubitacea. It is believed to be indigenous to Eastern Central and West Africa, between latitude 07^{o}S and 05^{o}N and Longitude 02^o E and 38^o W (Akoroda., 1990). Fluted pumpkin is named after Charles Telfair (1778-1833), and Irish botanist who died in Mauritius.

It is a perennial woody climber grown for its leaves and seeds which are very nutritious (Sanni 1982). Green leafy vegetables are important sources of vitamins where manufactured vitamins are too expensive for the poor. It has also been revealed that leaf vegetable are cheap sources of minerals, proteins, and vitamins (Abaelu., 1999 Oyenuga., 1968).The staple diets of most Nigerians are low in building materials like proteins, vitamins and minerals. It is therefore essential that minerals and vitamins lacking in such diets be supplied by other food stuffs. *Telfairia* and other leafy vegetables are therefore regarded as nutritional compliment to conventional cereals and grains.

In Nigeria most crop growing soils are predominantly sandy to sandy-loam, textured in the surface layer and therefore susceptible to leaching, erosion and nutrient loss. The principal method of overcoming the problems posed by inadequate nutrients in the soil is the judicious use of fertilizer. Fertilizer if used properly enhances the growth and productivity of crops. Inorganic fertilizers are one of the important inputs for increased food production. However, there is a growing concern on health hazards caused by the consumption of food crops produced by frequent application of chemical fertilizers. 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 such as green manure, compost manure, farmyard manure and rubber effluent amongst others (Kihande., 1996 and Ahmad., 2001). This will offset the nutrient removed by the crops and by recycling part of the nutrient through crop residue decomposition in the field will offset soil organic matter losses.

Rubber effluent is a liquid left over which arises during Natural Rubber latex processing. The 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). However, these effluents contain various plant growth substances including a number of elements such as N, P, Ca, Mg (Peries and Fernando., 1983).

In recent times, the recycling of organic residues (rubber effluent) in order to re-utilize them as an alternative source for the production of fertilizers is a strategic measure from environmental stand point and is convenient as it is economically feasible thus this necessitate the need for an alternative source of nutrients that are readily available, relatively cheap, and environmentally friendly. Waizah *et al.*, (2010) reported a significant increase in the growth parameters of rubber in the nursery with the application of rubber effluent. In the same vein, Eifediyi *et al.,* (2012) revealed that the application of rubber effluent had a positive impact on the growth and yield of cucumber.

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 soil physical and chemical properties, growth and yield of fluted pumpkin in south south Nigeria,

Materials and Methods

Study area

This study was carried out at the Agronomy Division experimental plot of the Rubber Research Institute of Nigeria (RRIN), Iyanomo, near Benin City, Edo state. The study area falls between latitude 6^{o}00' and 7^{o}00' north of the equator and longitude 5^{o}00' and 6^{o}00' east of the meridian. The soil of the area is derived from coastal plain sands with humid tropical climate characterised by deep, porous sandy to loamy sand at the surface, overlying sandy loam to sandy clay sub soil. Soil reaction usually ranges from strongly to very strong acid. The rainfall pattern is bimodal with the peaks in the months of June with short dry spell in August. This location is characterised by a moderately high temperature with 30.1^{o}C as the mean temperature and 32^{o}C as maximum, mean annual rainfall of 1800-2300mm and relative humidity of 75% (Department of Meteorological service RRIN 2011)

Site of trial

The field experiment were carried out in two cropping seasons (Rainy season of 2011 and dry season of 2012 respectively) at the same location but different experimental plots of the Agronomy Division, Rubber Research Institute of Nigeria Iyanomo, Benin City, Edo State.

Experimental Design

The experiment was laid out in a Randomised Complete Block design (RCBD) with three replicates. Replicates and beds were separated from each other by 1m strip of land and furrows 0.5m respectively. Each replicate had a total of 4plots giving a total of 12 plots. Each plot was measured 2m by 2m containing fifteen plants at a spacing of 50cm by 50cm .The factor whose effect was determined are was rubber effluent at the rates of 0, 2,380l/ha, 4,761.9l/ha and 7,142l/ha.

One seed of *Telfairia* per hole was planted at a spacing of 0.5m by 0.5m and this gave rise to a plant population of 20,000 plants per hectare. During the plant growth, agronomic practices such as weeding and trailing of the fluted pumpkin vines to a stake were carried out.

Data Collection

Data collected on growth parameters were leaf area, leaf number, biomass fresh weight.

Data Analysis

Statistical analysis was done by the analysis of variance (ANOVA) using GENSTAT and the significant effects were separated using Duncan Multiple Range Test (DMRT) at 5% probability level.

Results and Discussion

Pre-cropping Physico-chemical properties of the soil used for the experiment

The physico-chemical properties of the experimental site before the experiments are shown in Table 1. The soils fall within the type described as the coastal plain sands that is partly marine, estuarine and deltaic or fluviolacustine in origin (Kogbe, 1975). The pre-experimental values of the soils physiochemical properties for the two cropping seasons of 2011 and 2012 indicates that the soil texture was sandy loam. Soil reaction was strongly acidic, low in ECEC and moderate in total nitrogen and available P respectively. The basic cation contents and percentage base saturation were low. The extractible micro nutrient element content were somewhat high especially Fe and Mn . The acidic nature of the pre-treated soil may be attributed to erosion and leaching as the highly mobile basic cations are generally washed away leaving the sesquioxides to occupy the exchange sites of soil colloids (Donahue, 1983).

Chemical Properties of Rubber effluent used in the experiment

The chemical properties of rubber effluent used in the experiment for both 2011 and 2012 showed that it is moderately acidic, colourless and contained N, P, K, Ca, Mg, Fe, Mn, Zn and organic carbon as indicated in Table 2.

Table 1: Physico-chemical properties of the soil used for the experiment

	Values Obtained	Values Obtained
Soil Properties	**2011**	**2012**
Sand (%)	82.84	83.84
Silt (%)	1.12	0.12
Clay (%)	16.04	16 .04
Textural Class	Sandy Loam	Sandy Loam
pH	5.14	5.2
Organic c (%)	1.60	1.50
Total N (%)	0.168	0.17
Available P (mg/kg)	8.61	8.8
Exchg.bases , Cation (Cmol kg^{-1})		
Ca2+	1.42	1.47
Mg^{2+}	0.56	0.54
Na^{+}	0.52	0.59
K^{+}	0.14	0.10
$Al^{3+} + H^{+}$	1.60	1.65
ECEC	4.24	4.35
Base saturation (%)	62.26	62.07
Mn (mg/kg)	60.5	62.3
Fe (mg//kg)	64.2	63.4
Cu (mg/kg)	6.9	6.5
Zn (mg/kg)	17.32	18.10

Table 2: Analysis of the chemical properties of rubber effluent used in the experiment

Parameters	Values obtained	Values obtained
	2011	**2012**
pH	5.7	5.8
Nitrogen (%)	2.10	2.1
Phosphorous (ppm)	5.26	5.1
Organic carbon (%)	0.14	0.14
Potassium (mg/l)	12.25	12.33
Calcium (mg/l)	8.68	8.8
Sodium (mg/l)	1.54	1.51
Magnesium (mg/l)	2.25	2.4
Iron (mg/l)	0.04	0.04
Manganese (mg/l)	0.02	0.02
Zinc (mg/l)	0.91	0.93
Manganese (mg/l)	0.02	0.03
Zinc (mg/l)	0.91	0.93

Effect of rubber effluent on leaf area (cm^2) of fluted pumpkin

The response of leaf area of fluted pumpkin to the application of rubber effluent fertilizer is shown in table 3. From results observed, there was significant differences in leaf area in both years (2011 and 2012) except at the 4WAP (in 2011) where all treatment levels of effluent were similar (P>0.05). The effect of effluent was consistent as increasing effluent levels increased leaf area at 4, 8, and 12WAP for both seasons. The highest mean values of 186.6cm and 177.0cm at 4WAP, 369.4cm and 355.8cm at 8WAP and 426.6cm and 405.9 at 12WAP for both 2011 and 2012 respectively was observed from the application of 7,142l/ha but was not significantly different from the plant treated with 4,761l/ha which had mean values of 178.3cm and 175.5cm at 4WAP, 330.8cm and 349.0cm at 8WAP and 402.1 and 402.2cm at 12WAP. There was also no significant difference (p>0.05) between the untreated plot (control) and the application of 2380l/ha as the lowest mean values of leaf area was recorded from the control plot.

Table 3: Effect of rubber effluent on leaf area (cm^2) of fluted pumpkin

	← Weeks After Planting →					
Level of urea and rubber effluent	4		8		12	
Effluent (l/ha)	2011	2012	2011	2012	2011	2012
0	168.9	156.7	316.1	311.5	387.9	370.6
2,380	176.8	166.5	325.8	327.8	386.9	382.4
4,761	178.3	175.5*	330.8	349.0*	402.1*	402.2*
7,142	186.6	177.0*	369.4*	369.4*	426.6 *	405.9*
Mean	177.6	168.9	335.5	335.5	401.0	390.3
LSD (0.05)	NS	4.849	25.39	20.4	28.81	12.2

NS = Not significant and means with the same asterisks in the column are not significantly different from one another at 5% level of probability

Effect of rubber effluent on number of leaf of fluted pumpkin

The response of number of leaves to rubber effluent application is shown in Table 4. Application of rubber effluent showed significant effect for both seasons. At 4WAP during the 2011 season , there was no significant (P>0.05) difference amongst treatments while at the 8 and 12WAP, *telfairia* leaf showed significant effect as the highest number of leaf was observed from the application of 7142l/ha with its mean value at 31.88 and 34.48 respectively for both weeks but however it was similar with the application of 4,761l/ha which had the mean values of 29.77 and 31.83 respectively while in the second season (2012), the application of 4,761l/ha had the highest leaf number of 17.55 in the 4WAP but was similar with the application of 7,142l/ha and 2,380l/ha while at 8WAP, treatment of 7142l/ha again produced the highest mean value of 29.38cm which was similar with the results obtained from the application of 4,761l/ha and 2,380l/ha except the control. During the final week (12WAP), the application of 4761l/ha of effluent produced the highest number of leaf (39.38) but was statistically the same with the result obtained from the application of 7,142l/ha (38.35). The lowest mean value of 34.25 was obtained from the controlled plot. This agrees with the findings of Olaniyi and Odedere, (2009) who stated that the use of organic manure alone would be sufficient to produce vigorous, healthy and high yielding plant

Table 4: Effect rubber effluent on numbers of leaf of fluted pumpkin

	← Weeks After Planting →					
Level of rubber effluent	**4**		**8**		**12**	
Effluent (l/ha)	**2011**	**2102**	**2011**	**2012**	**2011**	**2012**
0	16.20	15.12	28.96	26.29	32.27	34.25
2,380	16.17	16.13	28.10	27.56*	31.27	36.19
4,761	16.55	17.55*	29.77*	28.98*	32.83*	39.38*
7,142	17.77	16.81*	31.88*	29.38*	34.48*	38.35*
Mean	16.70	16.40	29.68	28.05	32.46	37.04
LSD (0.05)	NS	1.83	2.166	2.086	2.060	2.41

NS = Not significant and means with the same asterisks in the column are not significantly different from one another at 5% level of probability

Effect rubber effluent on fresh leaf weight (tons/ha) of fluted pumpkin

The fresh leaf weight as influenced by rubber effluent application is presented in table 5. From the result obtained in 2011, the treatment of rubber effluent at 7,142l/ha produced the highest fresh weight value of 11.90tons/ha and was also similar at 5% level probability with the application of 4,761l/ha having 11.48tons/ha. The lowest fresh weight value was obtained from the control plot. In 2012, the application of rubber effluent at 4,761l/ha had the highest value of 10.37tons/ha but was not different significantly from other levels of effluent treatment except the untreated plot (control) which had the least fresh weight mean value of 8.49tons/ha. This results agrees with the report of ,Akanbi (2002) who demonstrated that the application of organic waste alone enhanced and improved vegetative growth of *telfairia* plant.

Table 5: Effects of rubber effluent on fresh weight of fluted pumpkin

Level of rubber effluent	**Fresh Weight (tons/ha)**	
Effluent (L/ha)	**2011**	**2012**
0	10.25	8.49
2,380	10.38	9.97
4,761	11.48*	10.37*
7,142	11.90*	10.22*
Mean	11.00	9.76
LSD (0.05)	1.22	0.71

NS = Not significant and means with the same asterisks in the column are not significantly different from one another at 5% level of probability

Effects of rubber effluent on soil chemical properties after cropping

Table 6 shows the effect of rubber effluent on some soil chemical properties after cropping in both 2011 and 2012 seasons. The results of the chemical analysis shows that there was a general decrease in pH mean value in the pre cropping of 2011 (i.e. 5.7) and 2012 (5.2) seasons. Soil pH decreased in the first season from 5.7 to 4.67 while in 2012 while in the second season (2012), there was also a decrease from the pre cropping of 5.2 to a mean of 4.56. The decline in soil pH values is attributable to the removal of the vegetation cover that subjects the soil to erosion and leaching due to high rainfall in the area (Uni Uyo Consult, 2003). Organic carbon was reduced in the pre cropping value of 1.60% (2011) and 1.50% (2012) to the mean of 0.37% and 0.40% respectively. Total nitrogen (N) was reduced from the pre cropping of 0.17% to a mean value of 0.034%.This could be because of leaching and volatilization caused by high precipitation in the area, as reported by waizah, *et. al.,* (2010) who reported the loss of nutrient element through the incidence of leaching and high level of precipitation. This also agrees with the findings of Defoer, *et. al.,* (2000).Available P rose from the pre cropping value of 8.61mg/kg (2011) and 8.8mg/kg (2012) to the value of 12.37mg/kg and 11.30mg/kg respectively.

Table 6: Effect of rubber effluent application on some soil chemical characteristics after cropping.

Levels of rubber effluent(L/ha)	pH(H_2O)		Org C %		N%		P (mg/kg)	
Effluent(l/ha)	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
0	4.70	4.56	0.37	0.40	0.032	0.045	9.45	9.59
2380	4.67	4.60	0.42	0.43	0.036	0.046	10.93	9.83
4761	4.67	4.62*	0.45	0.44	0.043	0.054*	11.50	11.30
7142	4.68	4.61*	0.45	0.43	0.045	0.050	12.37	10.90
Mean	4.68	4.60	0.42	0.42	0.039	0.049	11.06	10.40
LSD(0.05)	NS	0.03	0.051	NS	0.003	0.0002	0.31	0.147

NS = Not significant and means with the same asterisks in the column are not significantly different from one another at 5% level of probability

Effect of rubber effluent on some soil exchangeable bases after cropping

The results of the influence of rubber effluent application on soil exchangeable bases (Ca, Mg and K) are presented in Table 6.2. With exception of K^+, the result showed a general increase in the exchangeable bases content of the treated soils relative to the pre cropping values in the second season. This increase is attributed to the nutrient properties of the urea applied. Similar results have earlier been reported by Poon (1982), Lim *et al* (1983). Ca increased from the pre cropping of 1.42cmol/kg in 2011 to the mean of 1.49cmol/kg while in 2012, it rose likewise from the pre cropping of 1.47cmol/kg to 1.51cmol/kg. The untreated plot (control) had the lowest mean value of 1.45cmol/kg as against the pre cropping while. There was increase in magnesium (Mg) from the pre cropping of 0.56cmol/kg (2011) and 0.54 (2012) to the mean value of 0.69cmol/kg, while in 2012, it increased from its pre cropping to a mean of 0.63cmol/kg. K in 2011 decreased from the pre cropping of 0.14cmol/kg to the mean of 0.084cmol/kg. This could be due to the sandy nature of the soils and the high precipitation of the area that promote nutrient losses through leaching (Ojanuga, 2006), while in the 2012 season, potassium increased generally from the pre cropping value of 0.10cmol/kg to the mean value of 0.29cmol/kg.

Table 6.2: Effect of rubber effluent application on some exchangeable cation after cropping

	Ca (cmol/kg)		Mg (cmol/kg)		K (cmol/kg)	
Rubber effluent (L/ha)	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
0	1.43	1.45	0.62	0.60	0.09	0.26
50	1.46	1.48	0.64	0.60	0.08	0.11
100	1.49*	1.48	0.66	0.60	0.11*	0.15
150	1.48*	1.51	0.69	0.63	0.11*	0.29
Mean	1.46	1.48	0.65	0.61	0.09	0.17
LSD U (0.05)	**0.003**	**0.021**	**NS**	**NS**	**0.011**	**0.177**

NS = Not significant and means with the same asterisks in the column are not significantly different from one another at 5% level of probability

Effect of rubber effluent on some soil micro nutrient after cropping

The results of the influence of rubber effluent application on soil micro nutrients are presented in Table 6.3. There was a general increase in the trace element (Zn, Fe, and Cu). Extractible zinc increased from a mean of 17.32mg/kg in the first cropping season (2011) to a mean of 23.64mg/kg whereas in the second cropping season (2012), it increased from the pre cropping of 18.10mg/kg to a mean of 23.51mg/kg. Extractible iron (fe) increased in its mean value generally for both season. In the first season (2011), it increased from its pre cropping of 64.2mg/kg to a mean value of 77.25mg/kg. For 2012 season, iron increased as well from the pre cropping of 63.4mg/kg to a mean value of 79.45mg/kg. Copper increased tremendously as well for both 2011 and 2012 seasons. For the first season, Cu rose from the pre cropping of 6.9mg/kg to a mean of 7.55mg/kg while in 2012 season, copper increased from the pre cropping of 6.5mg/kg to a mean of 7.61mg/kg

The increase in the micro nutrient concentration could be accounted for by mineralization of nutrients after land clearing and cultivation, leading to release of nutrients to the soil (Collins et al. (1999).

Table 6.3: Effect of urea application on some soil micro nutrient after cropping

Level of N (Kg/ha)	Zn (mg/kg)		Fe (mg/kg)		Cu (mg/kg)	
Urea	2011	2012	2011	2012	2011	2012
0	20.47	22.25	64.20	65.79	7.11	7.03
50	20.93*	22.09	69.87	69.70	7.44*	7.25
100	22.09*	22.26	76.90	78.42	7.54*	7.29
150	23.64*	23.51	77.25	79.45	7.55*	7.61*
Mean	21.78	22.53	72.56	73.39	7.41	7.30*
LSD (0.05)	0.98	0.97	NS	NS	0.156	0.364

NS = Not significant and means with the same asterisks in the column are not significantly different from one another at 5% level of probability

Discussion

The physicochemical characteristics of the study area was loamy sand in texture, characterised by low pH, low nutrient status and low water holding capacity as observed by Juo (1981) and Kang and Juo., (1986). The sandy nature may be due to excessive rainfall experienced in the region or influence of the parent material. This also explains why the soils have low potassium reserve as typical sandy soils have ion exchange capacity which determines the quantity of ions that a soil can retain against leaching (Eden, 2007). The fertility status of the soil is greatly determined by the capacity of the soil to hold exchange ions (both anion and cation).

The P content of the soil of the study area was generally low, the low native P could be attributed to the presence of aluminium (Al) and iron (Fe) and their oxides and hydroxide which increases the p-fixation (Sample, et. al., 1980) the low total nitrogen which may be a result of excess leaching and low organic carbon content of the soil prior to treatment. Exchangeable bases in the soil were also very low, with Ca having the highest value at 1.76cmol/kg which is less than 4cmol/kg being the lower limit for fertile soils (FAO, 1992). Other cations such as Potassium (K) and Magnesium (Mg) were also low, a characteristics of the soil derived from coastal plain sands. The result is in line with the rating of National Special Programme for Food Security NSPFS, (2005) that the exchangeable potassium content of the soils of this region is low (0.2cml/kg). The low availability of K and other basic cations may be caused by low pH. Whalen, *et. al* .,(2000) reported that the soil pH affect nutrient solubility and influences the sorption or precipitation of nutrient with aluminium and iron. Also Hue (1992) reported that increasing pH of acidic soils improves plant availability of macro nutrients but reduces the solubility of elements such as aluminium and manganese. The percentage base saturation was expectedly low since the basic cations were low which is as a result of high precipitation leading to strong weathering and leaching condition of the area. This is further indicative of low fertility status of the soil of the study area. The properties of the rubber effluent showed that it contains both micro and macro nutrients that can be utilized by crops. Similar results have also been recorded by Senevirantne, (1997) and Orhue, *et. al.,* (2005). The basic fact according to Orhue, et. al., (2005) is that most of the effluents whether obtained from processing of crepe, crumb, concentrate latex contains the basic plant nutrients. The use of organically sourced fertilizer materials is expected to come as a complement for mineral fertilizer which is becoming extremely expensive and difficult to get for the average Nigerian farmer and indeed most of the third world farmers. There is need to formulate and improve the organic fertilizer to suit various soils in the five ecological zones of the country since Nigerian soils vary in their characteristics with respect to pH, organic matter content, availability of plant nutrient ECEC and erosion related problems. There is also a need to develop organic fertilizer to suit various crops and cropping system in various parts of the country.

The result showed that vine length, leaf area, leaf number, yield and yield components were significantly increased by the treatments.

Conclusion

The study reveals that the application of rubber effluent had a positive impact on the growth and yield of fluted pumpkin. The application of 7,142l/h of rubber effluent gave the best vegetative and yield attributes and likewise was not significantly different from the application of 4,761/ha as they were at par at 5% level probability. This study therefore recommends the application of 4,761L/ha of rubber effluent for good production of fluted pumpkin and could be seen as an alternative for synthetic fertilizer.

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