SOIL PROPERTIES AND GROWTH TRAITS OF RUBBER (*Hevea brasiliensis)* SEEDLINGS AS AFFECTED BY CONTROLLED BURNING OF VEGETATION WITH PREMIUM MOTOR SPIRIT

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ABSTRACT

The study was conducted in Iyanomo, Benin City to examine the influence of fire caused by petrol or Premium Motor Spirit (PMS)on some physical and chemical properties of soil and the growth of rubber (Hevea brasiliensis) seedling. The study site was divided into 18 plots of 17 x 18m^2 each and cleared separately. Six (6) treatments allowed were "No burning (control), Natural Burning (NB), burning with PMS at 5 litres/plot (PSMB1), 10 litres/plot (PSMB2), 15 litres/plot (PSMB3) and 20litres/plot (PSMB4)" arranged in a randomized complete block design in three replicates. Rubber seedlings were raised on nursery beds at a plant population of 40,000 seedlings per hectare after the treatment application. Soil physical and chemical properties were analyzed before and after cropping. Data were collected on seedling growth on monthly basis. The result indicated no significant ($p > 0.05$) changes in the physical characteristics of the soil, but there was a slight decline in the silt and clay particles on the surface soil. The result also showed no significant effect ($p > 0.05$) of the treatments on the growth characteristics of rubber seedlings on the field. The study therefore concluded that PMS burning had no significant ($p > 0.05$) impacts on physical and chemical characteristics of the soil and also on the rate of growth of rubber seedlings. Premium motor spirit fire outbreak on farm lands in southern Nigeria does not translate to total destruction of the land as the land is capable of returning back to agricultural production after a given period of time.

Keywords: Petrol, Rubber seedlings, Growth rate, Soil properties, Iyanomo, Southern Nigeria.

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INTRODUCTION

Crude oil is made up of compounds of hydrogen and carbon, which at normal temperature and pressure may be gaseous, liquid or solid, depending on the complexity of their molecules (Odu, 2000). The importance of petroleum in the world's economy led to rapid development of the oil and gas industry in Nigeria in the early 1960's. Today, petroleum accounts for over 90% of Nigeria's foreign exchange earnings (Odu, 2000). Most of Nigeria's petroleum is produced in the Niger Delta, which is regarded as one of the richest but most fragile ecosystems in the world (Odewumi, 1987). Crude oil transportation by pipeline from production wells to flow stations and finally to oil terminals for loading into oil tankers or for supply to refineries is necessary in petroleum development.

The technology of pipelining, and tankers construction have progressed to a stage where the probabilities of small insidious leakages have been reduced to a practical minimum. Accident on the other hand, can still happen resulting in significant burning and pollution of the environment (Odu, 2000). Oil prospective activities have potential effects on the economy, biotic and abiotic component of the environment from the point of exploitation, transportation, spillage, seepage, etc. Most accidents involving petroleum products invariably result in pollution of the environment through contamination of the soil and water bodies; or also through fire that may have devastating effects on the vegetation.

Effects of fire on plants vary significantly based on the area, fire behaviour, fire duration and the amount of subsurface heating, which causes injury and mortality of plants. Post fire responses also depend upon the characteristics of the plant species on the site, their susceptibility to fire (Miller, 2000). Several incidences of petroleum fire have occurred in Nigeria and in some other oil producing regions of the world. Bringing back into productive use, soils burned by petroleum fire have remained a huge challenge. This study was therefore designed to investigate the effects of petroleum fire on some soil physical and chemical properties, and its possible effects on the growth of rubber.

MATERIALS AND METHODS

This study was conducted at the Rubber Research Institute of Nigeria (RRIN), Iyanomo near Benin City, Edo State in 2009/2010 cropping season. The area falls between latitudes 6°00¹ and 7°00¹ N and longitudes 5°00¹ and 6°00¹E. It falls within the humid rain forest zone with mean annual rainfall of 2000 mm, with a peak in the month of July and September. Selected physicochemical properties of the soils before cropping (Table 1) shows that the pH of the area was acidic (pH 4.28 and 4.39 in H_2O), the organic carbon was 13.2 – 17.9 g kg^{-1}, Total N was 3.2 – 4.10 g kg^{-1}, available P was 8.58 – 11.88 mg P kg^{-1}.The texture of the area was Loamy sand. .

Table 1: Pre cropping physico-chemical properties of the soil

	Values	
Parameter	**0 – 15 cm**	**15 – 30 cm**
Sand (%)	89.2	84.2
Silt (%)	1.9	4.84
Clay (%)	8.9	10.96
Textural class	Loamy sand	Loamy sand
pH	4.28	4.39
Organic carbon (g/kg)	13.2	17.0
Total Nitrogen (g/kg)	3.20	4.10
Available Phosphorus (mg/kg)	8.58	11.88
Exchangeable Acidity (cmol/kg)	2.2	1.20
Potassium (cmol/kg)	0.22	0.15
Sodium (cmol/kg)	0.10	0.09
Calcium (cmol/kg)	1.83	1.42
Magnesium (cmol/kg)	1.02	0.82
Cation Exchange Capacity (cmol/kg)	5.37	3.68
Base Saturation (%)	58.3	67.39
Zinc (mg/kg)	19.74	15.06
Manganese (mg/kg)	163.21	116.51
Copper (mg/kg)	7.61	7.01
Iron (mg/kg)	92.36	70.81

Rubber seeds were obtained from the rubber plantation. They were pre-germinated in pre-nursery and later transplanted to the field.

The experimental site was cleared manually using cutlass to cut the vegetation and the land area was divided and spaced into eighteen plots of 17 x 18 square meters each before twelve of the plots were burnt separately with varying volumes of PMS according to treatments. Three of the plots were burnt naturally without fuel while another three plots were not burnt. The experiment was arranged in a randomized complete block design with six treatments and each treatment was replicated thrice. The treatments were:

T1 = No burning (control),
T2 = Natural Burning (NB),
T3 = burning with 5 litres of PMS/plot of 15 x 18m^2 of land (PMSB1),
T4 = burning with 10 litres of PMS/ plot of 15 x 18m^2 of land (PMSB2),
T5 = burning with 15 litres of PMS/ plot of 15 x 18m^2 of land (PMSB3) and
T6 = burning with 20 litres of PMS/ plot of 15 x 18m^2 of land (PMSB4).

The treatments were arranged in a randomized complete block design in three replicates. Rubber seedlings were raised on nursery beds at a plant population of 40,000 seedlings per hectare after treatment application. Soil physical and chemical properties were analyzed before and after cropping. Data were generated on seedling growth on monthly basis. Each plot measured 2m^2 with 1m furrow separating each plot, giving a total land area of 216m^2.

Soil Sampling: Soil samples were collected randomly from fifteen observational points in the site at the depth of 0 – 5 cm and 15 – 30 cm before the experiment. The samples were thoroughly mixed to form a composite sample and used for pre-planting soil analysis. Also, auger soil samples were collected from three observational points at depth of 0 – 15 and 15 – 30 cm in each plot immediately after crop harvest. The auger soil samples were air - dried, sieved with a 2 mm sieve and stored in labelled polythene bags for chemical analysis.

Data collection: Data were collected on plant height, number of leaves, plant girth and leaf area at two months intervals till the seventh month.

Laboratory Analysis: Particle size distribution was determined by hygrometer method of IITA (1979), after dispersing the soil with sodium hexameta-phosphate (calgon). Soil pH was determined at 1:2.5 soil to water ratio using glass electrode digital pH meter. Available phosphorous was extracted using Bray-1 solution, (IITA, 1979) and the phosphate in the extract was assayed dicolorimetrically by the molybdenum blue colour method as described by IITA (1979). Organic carbon was determined by chromic acid wet oxidation procedure as described by IITA (1979). Calcium and magnesium content of the solution were determined volumetrically by EDTA titration procedure (IITA, 1979). The level of calcium, potassium, and sodium were determined by flame photometry. Exchangeable basses were extracted using 1.0N neutral ammonium acetate solution. The total nitrogen of the soil and plant were determined by Micro-kjeldahl procedure as described by IITA (1979). Exchangeable acidity was determined by the KCl and titration method of IITA (1979).

Data Analysis: Data on growth from various treatments were analyzed and measurable variables from treatment were tested for significance using the analysis of variance (ANOVA) procedure in a randomized complete block design and Duncan for mean separation using GENSTAT (2005).

RESULTS

The Effect of controlled bush burning with PMS on Soil Texture: The results of the effect of petroleum fire on some soil physical properties are presented in Table 2. The soil physical properties were generally coarse textured. The sub-soil

(15-30cm) had a finer texture than the topsoil (0-15cm). The clay concentration at the top soil (0-15cm soil depth) were 7.3, 7.4, 3.9, 7.1, 8.5 and 9.3% for the Control, NB, PMSB1, PMSB2, PMSB3 and PMSB4 treatments respectively whereas at 15 – 30 cm soil depth the clay concentrations were 9.0, 13.7, 6.0, 7.1, 7.8 and 10.6% in that order for the treatments. Silt concentration however ranged between 3.3 and 3.9% at 0-15cm soil depth and varied from 3.2 to 10.7% at 15-30cm soil depth. Sand concentration varied from 87.3 to 89.6% at the top soil layer; and 82.4 to 91.0% at 15-30 cm soil depth. The mean values showed higher sand concentration in all the treatments compared with the control due to the depletion of the smaller soil particles (silt and clay) as a result of leaching of the smaller particles down the profile by rain. However, the changes observed in the soil fractions were not statistically significant ($p > 0.05$).

Table 2: The Effect of controlled bush burning with varying levels of PMS on soil texture.

	Clay (%)		**Silt (%)**		**Sand (%)**	
Soil depth	**0 – 15 cm**	**15 – 30 cm**	**0 – 15 cm**	**15 – 30 cm**	**0 – 15 cm**	**15 – 30 cm**
Treatments						
Control	7.3	9.0	3.9	4.9	88.8	86.1
NB	7.4	13.7	3.3	3.9	89.3	82.4
PMSB l	3.9	6.0	2.9	10.7	89.6	83.3
PMSB 2	7.1	7.1	3.3	2.0	89.6	91.0
PMSB 3	8.5	7.8	3.3	3.2	87.3	89.0
PMSB 4	9.3	10.6	3.3	3.8	87.4	85.6
Mean	**7.25**	**9.03**	**3.33**	**4.75**	**88.67**	**86.23**
SEM	**1.85**	**2.44**	**3.05**	**3.09**	**33.71**	**36.96**

Control = No burning; NB = Natural Burning; PMSB 1 = Burning with 5 litres of PMS/plot; PMSB 2 = Burning with 10 litres of PMS/plot; PMSB 3 = Burning with 15 litres of PMS/plot; PMSB 4 = Burning with 20 litres of PMS/plot; SEM = Standard error of mean, PMS = Premium motor spirit.

The Effect of controlled bush burning with PMS on Soil chemical Properties: The results of the effect of petroleum burning on some soil chemical characteristics are presented in Tables 3 and 4. The results showed higher pH values in top soil compared with sub-soil. The soil pH values obtained showed no significant differences between the pH values in the control and the burnt plots. Organic carbon content of the soil in the control and the burned plots ranged from 9.9 – 13.1% in 0-15cm soil depth (Table 2) and 8.0 – 11.0% in 15-30cm soil depth (Table 3). Burning treated plots showed higher organic C content relative to the control plot. However, there were no significant differences ($p < 0.05$) among the treatments at both depths. The results also showed no significant differences among the treatments in the base saturation, total N, available P and exchangeable acidity at both depths. However, burning showed slight increases in micro nutrient content in the soil, but the changes recorded were not statistically different. Furthermore, the effect of burning on soil basic cations (Ca, K, Na and Mg) showed higher cation concentration compared with the control. But the differences recorded were not statistically significant. The micronutrients (Zn, Mn, Cu and Fe) were not statistically different ($p > 0.05$).

Table 3: Influence of controlled PMS burning on some soil chemical properties (0-15cm)

Treatments	pH	Org C	T/ N	Ava P	E/AC	K	Na	Ca	Mg	CEC	B/Sat (%)	Zn	Mn	Cu	Fe
		g/kg		Mg/kg	C mol/kg							Mg/kg			
Control	5.02	10.5	0.45	9.7	0.06	0.17	0.080	1.46	0.58	3.41	77.4	23.4	150.0[ab]	8.02[a]	84.0
NB	5.25	9.9	0.26	8.3	0.40	0.16	0.090	1.21	0.79	2.50	85.2	16.9	136.9[b]	6.15[b]	76.1
PMSB l	5.28	11.8	0.25	12.4	0.47	0.20	0.100	1.48	0.94	3.18	86.1	16.9	140.1[b]	7.50[ab]	71.9
PMSB 2	5.38	10.3	0.32	8.3	0.53	0.19	0.090	1.28	0.88	2.07	82.2	17.6	138.9[b]	7.12a[b]	74.5
PMSB 3	5.41	13.1	0.35	7.9	0.60	0.20	0.097	1.61	0.97	3.48	83.2	26.0.	195.5[a]	8.14[a]	91.9
PMSB 4	5.66	12.1	3.50	11.3	0.33	0.17	0.089	1.37	0.71	3.78	87.4	15.0	140.8[b]	6.64[a]	71.6
Mean	**5.33**	**11.26**	**0.38**	**9.65**	**0.40**	**0.18**	**0.091**	**1.40**	**0.81**	**3.07**	**83.6**	**20.8**	**150.3**	**7.26**	**78.7**
SEM	**0.02**	**0.48**	**0.06**	**4.05**	**0.21**	**0.02**	**0.007**	**0.21**	**0.17**	**0.47**	**5.67**	**10.56**	**21.23**	**0.69**	**11.15**

[ab]Mean values within the same column with different superscripts are significantly ($p < 0.05$) different.

Control = No burning; NB = Natural Burning; PMSB 1 = Burning with 5 litres of PMS/plot; PMSB 2 = Burning with 10 litres of PMS/plot; PMSB 3 = Burning with 15 litres of PMS/plot; PMSB 4 = Burning with 20 litres of PMS/plot; SEM = Standard error of mean; T/N – Total nitrogen, Ave P. – Available P, EAC – Exchangeable acidity, CEC – Cation exchange capacity, B/Sat – Base saturation, PMS = Premium motor spirit.

Table 4: Influence of controlled bush burning with PMS fire on soil chemical properties (15 – 30cm).

Treatments	pH	Org.C	T/N	Avail.P	E/AC	K	Na	Ca	Mg	CEC	B/sat	Zn	Mn	Cu	Fe
		g/kg^{-1}		Mg/ kg	Cmol/kg-$^{-1}$						(%)	Mg/kg^{-1}			
Control	5.07[b]	8.20	0.20	4.4	0.57	0.15	0.09	1.26[b]	0.78	3.95[a]	78.5	20	159.5	0.10	86.0
NB	5.36[ab]	8.30	0.23	8.7	0.47	0.07	0.09	1.29[ab]	0.68	3.27[ab]	73.2	17	168.8	0.45	72.2
PMSB l	5.85[a]	9.50	0.19	2.0	0.27	0.18	0.09	1.28[ab]	0.81	2.82[ab]	83.8	26	174.2	0.54	85.2
PMSB 2	5.21[ab]	8.00	0.27	4.7	1.00	0.21	0.10	1.59[a]	0.97	3.39[ab]	85.0	23	171.4	0.51	88.2
PMSB 3	5.32[ab]	11.00	0.20	8.7	0.57	0.19	0.09	1.35[ab]	0.83	2.50[b]	73.6	21	185.0	0.35	86.7
PMSB 4	5.41[ab]	8.40	0.20	4.4	0.57	0.18	0.09	1.43[a]	0.91	3.10[ab]	85.7	40	137.5	0.15	73.4
Mean	**5.37**	**8.9**	**0.22**	**6.1**	**0.62**	**0.16**	**0.09**	**1.37**	**0.79**	**3.17**	**80.0**	**24.5**	**166.07**	**0.35**	**81.9**
SEM		**1.47**	**0.03**	**3.55**	**0.64**	**0.06**	**0.008**	**0.12**	**0.20**	**0.27**	**7.01**	**8.17**	**16.25**	**0.19**	**9.56**

[ab]Mean values within the same column with different superscripts are significantly ($p < 0.05$) different.

Control = No burning; NB = Natural Burning; PMSB 1 = Burning with 5 litres of PMS/plot; PMSB 2 = Burning with 10 litres of PMS/plot; PMSB 3 = Burning with 15 litres of PMS/plot; PMSB 4 = Burning with 20 litres of PMS/plot; SEM = Standard error of mean; T/N – Total nitrogen, Ave P. – Available P, EAC – Exchangeable acidity, CEC – Cation exchange capacity, B/Sat – Base saturation; PMS = Premium motor spirit.

Effect on the growth of rubber seedling: The result of the effect of petroleum fire on rubber seedling growth characteristics is presented in Tables 4 - 8. Generally, there was a steady increase in plant height, number of leaf, stem girth and leaf area irrespective of the treatment, but the values were not statistically significant ($p > 0.05$). The crop did not show any response in growth characteristics (Height, Girth, Number of leaves, and leaf area) to PMS burning, except at the 6th and 7th MAP for rubber plant height and girth, where PMS burning significantly reduced the plant height and girth of rubber. The result obtained also showed no particular pattern in the growth response of the crop to burning.

Table 5: Influence of controlled bush burning with PMS on the number of leaf of rubber seedling

Treatment	2MAP	3MAP	4MAP	5MAP	6MAP	7MAP
Control	4.40	6.73	7.46	9.20	9.73	10.8
NB	4.67	6.33	7.26	10.0	9.26	12.68
PMSB l	4.73	6.33	7.20	9.26	10.08	11.97
PMSB 2	4.46	5.53	6.33	7.55	7.66	9.33
PMSB 3	4.46	6.06	7.73	8.46	8.93	13.0
PMSB 4	6.13	7.01	7.60	8.68	8.66	8.50
Mean	**4.81**	**6.33**	**7.26**	**8.86**	**9.05**	**11.05**
SEM	**0.70**	**0.53**	**0.55**	**0.91**	**0.88**	**2.05**

[ab]Mean values within the same column with similar superscripts are not significantly ($p > 0.05$) different. Control = No burning; NB = Natural Burning; PMSB 1 = Burning with 5 litres of PMS/plot; PMSB 2 = Burning with 10 litres of PMS/plot; PMSB 3 = Burning with 15 litres of PMS/plot; PMSB 4 = Burning with 20 litres of PMS/plot; SEM = Standard error of mean; MAP = Months after planting.

Table 6: Influence of controlled burning with PMS on rubber seedling leaf area (cm^2)

Treatment	2MAP	3MAP	4MAP	5MAP	6MAP	7MAP
Control	15.26	17.70	23.93	30.27	35.05[a]	34.42
NB	10.47	11.92	14.47	23.62	22.06[b]	29.95
PMSB l	12.76	16.18	19.17	27.91	28.71[ab]	32.20
PMSB 2	11.12	12.29	19.80	20.73	29.01[ab]	24.71
PMSB 3	11.12	13.06	17.88	28.06	32.15[a]	31.62
PMSB 4	10.59	14.32	18.59	24.04	27.00[ab]	24.71
Mean	**11.89**	**14.25**	**18.97**	**25.77**	**29.00**	**29.60**
SEM	**0.92**	**1.73**	**2.09**	**3.11**	**0.91**	**3.68**

[ab]Mean values within the same column with different superscripts are significantly ($p < 0.05$) different.

Table 7: Effect of bush burning with PMS on the height of rubber seedling (cm)

Treatment	2MAP	3MAP	4MAP	5MAP	6MAP	7MAP
Control	39.55	46.56	55.87	66.07	83.62	96.43[a]
NB	37.35	43.66	49.55	61.27	64.07	75.31[b]
PMSB l	42.77	45.77	53.17	55.95	63.19	73.61[bc]
PMSB 2	39.11	46.61	52.62	64.44	68.25	79.81[ab]
PMSB 3	39.57	46.14	53.78	66.38	72.07	91.31[a]
PMSB 4	39.31	47.89	53.67	65.03	75.03	71.16[c]
Mean	39.61	46.11	53.11	63.19	71.04	81.27
SEM	1.96	1.54	1.74	4.17	5.08	7.96

[ab]Mean values within the same column with different superscripts are significantly ($p < 0.05$) different.

Table 8: Effect of controlled bush burning with PMS on the girth of rubber seedling (cm)

TREATMENT	2MAP	3MAP	4MAP	5MAP	6MAP	7MAP
Control	0.403	0.494	0.664	0.775	1.018^{a}	1.120^{a}
NB	0.371	0.479	0.607	0.697	0.870^{ab}	1.034^{ab}
PMSB l	0.407	0.483	0.649	0.778	0.943^{ab}	1.057^{ab}
PMSB 2	0.390	0.496	0.606	0.699	0.786^{b}	0.852^{b}
PMSB 3	0.381	0.481	0.606	0.743	0.928^{a}	1.089^{ab}
PMSB 4	0.435	0.499	0.659	0.778	0.889^{ab}	0.963^{ab}
Mean	0.40	0.49	0.63	0.75	0.91	1.02
SEM	0.03	0.01	0.03	0.04	0.06	0.09

^{ab}Mean values within the same column with different superscripts are significantly ($p < 0.05$) different.
Control = No burning; NB = Natural Burning; PMSB 1 = Burning with 5 litres of PMS/plot; PMSB 2 = Burning with 10 litres of PMS/plot; PMSB 3 = Burning with 15 litres of PMS/plot; PMSB 4 = Burning with 20 litres of PMS/plot; SEM = Standard error of mean; MAP = Months after planting.

DISCUSSION

The effect of petroleum fire on soil physical and chemical properties: Soil texture is an important characteristic of the soil, which is useful in evaluating the capacity of the soil to maintain mineral nutrient that are essential for plant growth, Soil physical properties of the burned plots did not vary significantly (P > 0.05) from that of the control. But there was a general decline in the finer particles (silt and clay), while the sand content increased. This is attributed mainly to the effect of the removal of vegetation cover and land cultivation leading to decline of the silt and clay content of the soil. This result was in line with the submission of Yasin *et al*., (2010) who reported that sand content increased as land use changed from forest to other purposes

Generally it was observed that the pH values of the burned plots were higher than that of the control at both soil depths 0 – 15cm and 15 – 30cm. This increment in pH could be due to the increase in the soil cations (Ca, Mg, K, Na) from ash following the fire as was earlier reported by Sanchez, *et al.* (1983). The lower pH in the plot burned with PMBS 3 of petrol both in the 0 – 15cm and 15 – 30cm soil depth could be ascribed to reduced buffering capacity of the soil, newly exposed soil surface and the released of Al during heating. This agreed with the report of Giovanni *et al.* (1990) that heating soil up to 200^{o}C and above lowered the soil pH. The relatively higher soil organic content of the burnt plots to the control could be attributed to the effect of the burning as was earlier reported by Kyuma *et al.*, (1985) in Thailand sub humid tropical forest.

The relative significant higher CEC of the control plot to the other treatments (burned plots) at the lower depth (15 – 30cm) could be due to the heating effect of the petroleum on the soil. This is because soil cations are bounded to the soil particle surfaces by chemical bonds, that are broken down leading to cation releases to soil because, for every 10^{o}c rise in temperature the rate of every reactions is doubled. This agrees with the report of Sertsu and Sanchez (1978) that soil heating reduced its CEC.

Effect on growth of Rubber seedling: The lack of significant difference between the control treatment and the other treatments with regard to rubber seedling number of leaves, area, girth and height could be attributed to the fact that major macro nutrient (N, P, K) required for rubber seedling growth and development were optimum for the crop across the treatments and they were not significantly reduced in the soil by the treatments as was observed in the analysed soil chemical properties.

CONCLUSION AND RECOMMENDATION

- Burning using premium motor spirit (petrol) in the southern Nigeria had no significant immediate effect on some physical and chemical characteristics of the soil.
- Levels of Premium motor spirit burning also had significant effect on young rubber seedling growth characteristics.
- Premium motor spirit fire outbreak on farm lands in southern Nigeria does not translate to total destruction of the land. Hence the land is capable of returning back to agricultural production after a given period of time.
- Further research need to be carried out to ascertain the effect of petrol fire at higher concentrations.

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