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EFFECTS OF MULCH MATERIALS ON OIL PALM NURSERY SEEDLING PERFORMANCE, MOISTURE CONSERVATION AND TEMPERATURE REGULATION

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ABSTRACT

The effectiveness of four mulch materials; palm oil mill effluent solids (P.S) bunch refuse (B.R.) shredded polythene sheet (S.P.S.), and kernel shell (K.S); were evaluated against a no mulch control in an oil palm nursery seedling trial in Benin. Mulch materials generally enhanced vegetation growth, conserved water, produced higher dry matter and maintained lowered seasonal mean maximum temperature compared with the control. Stem girth, leaf area and seedling height were significantly increased by S.P.S., K.S. and B.R. while P.S reduced same compared with the control. Height to weight ratio was significantly increased by P.S. Dry matter production and root density were significantly increased by bunch refuse. Weed weight was significantly reduced in plots mulched with P. S. and S.P.S. Irrigation intervals were increased by 16.7% in plots mulched with B.R. while K.S.; S.P.S and P.S. reduced same by16.7, 33.3 and 150.0 percent respectively as a result of their relative stability throughout the experimental period. Soil temperature at 5cm depth was reduced by between 0.2 and 3.8°C by all mulch materials compared with the control. Results obtained showed that all four mulch materials evaluated were effective in enhancing the performance of the oil palm seedling in the nursery polybag.

INTRODUCTION

Mulching oil palm nurseries improve seedling growth through enhanced soil moisture conservation, prevention of soil compaction, provision of nutrients, reduction of blast disease, reduction in soil temperature especially the amplitude of temperature wave, improved soil structure and suppressed weed growth (Gun *et al*, 1961; Turner and Gillbank, 1974; Hartley, 1977; Iremiren, 1982 and Lal 1975). Various mulch materials are being used in large scale oil palm polybag nurseries with the type determined by availability and cost. Such materials include empty bunch refuse, rice husk, saw dust, wood shavings, dry grass, shredded polythene and kernel shell (Iremiren, 1982). This study was designed to evaluate the effectiveness of palm oil mill effluent solids (POME solids) as a mulching material compared with three other mulch materials; bunch refuse, shredded polythene sheet and palm kernel shell, on growth, dry matter production, moisture conservation and soil temperature in nursery polybag oil palm seedlings.

MATERIALS AND METHODS

This study was conducted in a nursery at NIFOR, near Benin City. Surface soil samples (0-15cm) were packed to a bulk density of 1.46gcm^{-3} in 12 litre capacity polybags. Chemical and physical properties of the soil are presented in Table 1. Five treatments, oil palm bunch refuse (200gm/bag); palm kernel shell (500gm/bag); shredded polythene sheet spread over the surface area of the polybag with a slit for the seedling to grow through; palm oil mill effluent solids (500gm/bag) and no

Table 1: Chemical and physical properties of soil at the experimental site

Parameters		Depth (cm) 0-15	- 15-30
Sand (%)		88.3	88.2
Silt (%)		4.4	4.7
Clay (%)		7.3	7.1
Organic matter (gkg^{-1} x 0.1)		1.38	1.24
pH (water)		5.00	4.90
Total N (gkg^{-1} x 0.1)		0.15	0.13
Available P ($mgkg^{-1}$)		3.89	3.72
Exchangeable cations (Cmol kg^{-1})			
	K	0.20	0.18
	Ca	1.9	1.8
	Mg	0.90	0.50
Bulk density (mgm^{-3})		1.45	1.44
Available water (mm)			
(0.01-.15MPa)		20.8	22.4
(0.03-.15MPa)		15.7	16.4

mulch as control were evaluated in a completely randomised design replicated five times. Each plot consisted of three oil palm seedlings arranged at 1 x 1m spacing. Mulch materials were applied at the beginning of the dry season on the 14th of October.

Daily soil matric potential and temperature (°C) were monitored with tensiometers installed at 15cm and thermometers installed at 5, 10 and 15cm depths respectively. All treatments were irrigated when the tensiometer scale read -0.01Mpa (Megapascal, Mpa, is a unit of atmospheric pressure which is used in place of bars and 1 Mpa = 10 bar). Monthly plant height and leaf production were measured. At harvest, that is after 8 months of treatment application, leaf area, stem girth, dry matter and root density measurements were taken. Six (6) months after treatment application, weeds in each plot were hand pulled and weighed to determine the weed biomass under the different mulch treatments.

Table 2: Effects of mulch materials on mean height (cm) of oil palm seedling

Treatments	October	November	December	January	February	March	April	May
				Mean height (cm)				
Bunch Refuse	27.4	33.8	44.6a	58.0a	63.3a	67.5a	68.3a	70.3a
Kernel Shell	26.6	31.7	41.2ab	52.7b	59.1a	62.5a	65.8a	68.9a
Shredded Polythene Sheet	29.0	32.5	42.4a	54.8ab	59.9a	64.2a	66.0a	68.1a
POME Solids	27.8	30.4	37.0b	45.4c	50.2b	55.3b	56.5b	58.3b
No Mulch	28.7	33.4	40.4ab	50.7b	58.5a	62.0a	63.0a	65.5a
LSD (5%)	ns	ns	5.2*	4.2*	4.5*	5.4*	8.5*	5.9*

A. Means within the same column followed by the same letters are not significantly different from each other at 5% level using the Duncan's multiple range test.

RESULTS AND DISCUSSION

Oil Palm Seedling Growth

Plant height

Seedling heights under different mulch treatments are presented in Table 2. In the first two months of treatment application, seedling heights were statistically the same. As the dry season characterized by high solar radiation, air temperature and atmospheric moisture demand progressed, significant variations in plant heights became obvious from the third month in December. Bunch refuse and shredded polythene sheets enhanced vigorous growth compared with the no mulch treatment. Plant heights were in the order 37.0<40.4<41.2<42.4<44.6cm for POME solids, no mulch, kernel shell, shredded polythene sheets, and bunch refuse respectively. In January the same trend was exhibited except that POME solids significantly reduced seedling height. Between February and March, the initial vegetative flush exhibited by seedlings mulched with bunch refuse, polythene sheets evened out compared with the heights of seedlings mulched with Kernel shell. In February and March, seedling heights ranked in the order bunch refuse>kernel shell>polythene sheets>no mulch> POME solids. With the onset of rains in April only seedlings mulched with POME solids were significantly different from the control. At harvest, that is after 8 months of treatment application, it was observed that seedlings mulched with POME solids were shorter (10.9%) than seedlings under the no mulch treatment. Seedlings mulched with bunch refuse, kernel shell and polythene sheets were taller than those under the control treatment by 7.4, 5.3 and 3.9 % respectively (Haron *et al*, 2001, Iremiren 1982 and Lal, 1975)

Stem girth

Seedlings mulched with POME solids were statistically lower in their girths compared with seedlings mulched with the other mulching materials and the control (Table 3). The mean girths were 11.2, 12.7, 13.6, 13.8 and 14.1cm for POME solid, no mulch, shredded polythene sheets, kernel shell and bunch refuse respectively. POME solids reduced stem girth by 12.3 percent. This trend was similar to that of the effects of mulch materials on plant height at harvest.

Table 3: Effects of mulch material on oil palm growth parameters and dry matter production.

Treatments	Stem Girth (cm)	Leaf Area (cm^2)	Total Dry matter (g)	Height to weight ratio[2]	Mean Fresh weed weight (g)	Root density (mgm^{-3})
Bunch Refuse	14.13a	1298.27a	90.0a	0.26c	6.2ab	3.23a
Kernel shell	13.84a	1574.81a	70.6b	0.36b	6.8a	2.26b
Shredded Polythene Sheet	13.63ac	1801.91a	70.0b	0.33bc	3.8ab	2.19b
POME Solids	11.15b	681.85b	37.4c	0.53a	2.8b	1.02c
Control –no mulch	12.71c	1551.45a	61.5b	0.37b	6.4a	1.94bc
LSD (5%)	1.09*	558.4*	15.9*	0.09*	2.9*	0.95*

Y = data transformed by $\sqrt{\text{raw data} + 0.5}$

Z = means within the same column followed by the same letters are not significantly different from each other at 5% level using the DMRT.

Leaf area

Mulching generally did not enhance seedling leaf area compared with the no mulch control (Table 3). POME solids performed poorly, reducing leaf area by 56.1 percent, which was significantly lower than other mulched and unmulched treatments. The consequences of reduced leaf area were reduced total dry matter and less vigorous seedlings (Table 3).

Height to weight ratio

Effects of mulch materials on the height to weight ratios of oil palm seedlings are presented in Table 3. POME solids significantly increased the ratio while bunch refuse decrease same significantly. The implication is that the lower the ratio the more susceptible the seedlings are to lodging when transplanted in the field.

Mean weed weight

POME solids significantly reduced mean weed weight per seedling (Table 3). Despite the fact that lower soil moisture suction was maintained in POME solids mulched plots, weed growth was significantly suppressed by it because the POME solids formed a complete mat on the surface (Wood, 1977; Chan *et al* 1980; Tan and Pillai 1976: Wade and Sanchez 1983 and Iremiren, 1982).

Dry matter production

Effects of different mulching materials on dry matter production at harvest of oil palm seedlings are presented in Table 3. Bunch refuse affected the highest dry matter production which significantly differed from all other treatments. Mulching with POME solids significantly lowered dry matter accumulation compared with the control and other mulching materials. Shredded polythene sheets and kernel shell were not better than the no mulch control in terms of dry matter production (Iremiren 1982).

Table 4: Effects of mulch materials on nursery oil palm seedling irrigation intervals (days), irrigation volume (L) and soil temperature (°C).

Treatments	Irrigation intervals (days)	Volume of irrigation (L)	Soil Depths (cm) < 5	10	15 >
			Soil Temperature (°C)[a]		
Bunch Refuse	5	25.92	38.8	39.6	39.1
Kernel Shell	7	20.52	41.1	38.8	39.2
Shredded polythene Sheet	8	20.52	41.7	39.8	40.0
POME solids	15	5.40	42.4	39.8	40.0
Control – no mulch	6	19.44	42.6	39.3	40.0

a. = Data are means of 24 weeks over a dry season.

The highest dry matter production by the bunch refuse treatment could be due to dry season low maximum temperature range, high available water and increased available nutrients which resulted from mineralisation of the mulch materials (bunch refuse) over the experimental period (Iremiren, 1982).

Root density

Effects of mulch materials on root

Density of the oil palm seedling are presented in Table 3. Bunch refuse significantly enhanced the proliferation of roots per unit volume of soil exploited. Mean root density of seedlings mulched with POME solids although lowest of all treatments did not differ significantly from those of the control treatment. The order was 1.02, 1.94, 2.19, 2.26 and 3.23mg/cm^3 for POME solids, no mulch, polythene sheets, kernel shell and bunch refuse respectively. This resulted in enhanced seedling growth and dry matter accumulation, water use and soil temperature regulation (Tables 3 and 4). Bunch refuse which had the highest root density also had the highest plant height, stem girth and dry matter production. The shortest irrigation interval and lowest temperature range observed throughout the experimental period in the bunch refuse treatment could be responsible for observed highest root density. The effects of other treatments on these parameters followed the same trend as their root density.

Soil moisture regime

Effects of mulch materials on irrigation intervals and volume of irrigation are presented in Table 4. Throughout the dry season period all mulch materials except bunch refuse reduced the frequency of irrigation compared with the control. Kernel shell, shredded polythene sheets and POME solids reduced irrigation intervals by 16.7, 33.3 and 150 percent respectively. The implication is that they conserved more water for use by oil palm seedling than the unmulched plots due to the fact that they covered the soil surface over the experimental period. On the other hand, bunch refuse increased the frequency of irrigation by 16.7 percent over the control. This was the result of the more vigorous vegetative growth of seedlings mulched with bunch refuse and the faster breakdown of the mulch material which effected higher water use hence more frequent irrigation. POME solids reduced total volume of irrigation by 72.2 percent, while bunch refuse, kernel shell and polythene sheets increased same by 33.3, 5.6 and 5.6 percent throughout the dry season respectively. The volume of water saved by mulching with POME solids amounted to 14.04 litres whereas the other mulch materials, bunch refuse, kernel shell and shredded polythene sheet increased irrigation volume by 6.48, 1.08 and 1.80 litres respectively. This agrees with the findings of Tan and Pillai (1976) that guarded POME application to young rubber plants enriched the soil, kept it moist and helped to prevent weeds and led to good growth.

Three representative irrigation cycles in January, February and March typified the mean seasonal effects of mulch materials on soil matric potential (Table 5). Throughout these cycles, seedlings mulched with POME solids thrived under very high and constant soil moisture potential less than 0.01MPa. Seedlings mulched with kernel shell, polythene sheets and the no mulch treatments had irrigation cycles or intervals lasting between 5 and 6 days whereas bunch refuse treatments exhibited cycles lasting between 2 and 5 days. The relative superiority of POME solids as mulch materials in conserving soil moisture compared with the other materials could probably be due to its relative stability and the almost complete soil surface cover effected with the re-arrangement of its fine solid fractions consequent upon water application over a period of eight months.

Table 5: **Effects of mulch materials on soil matric potential (-MPa) in three irrigation cycles of polybag oil palm seedlings.**

Treatments	Matric Potentials (-MPa)																				
	January						February							March							
	26th	27th	28th	29th	30th	31st	13th	14th	15th	16th	17th	18th	19th	7th	8th	9th	10th	11th	12th	13th	14th
Bunch Refuse	.04	.08	.09	.19	00	00	.20*	.03	.05	.03	.11	.20*	00	.13*	.05	-	.06	.08	.11*	.08	.11*
Kernel Shell	.19*	.03	02	.03	.03	.09	.17*	.01	00	.02	.03	.16*	00	.15*	.01	-	00	00	.01	.01	.09
Shredded Polythene Sheets	.02	.01	01	.02	.03	.13*	00	00	.01	.01	.01	.03	.11	.19*	.07	-	00	00	00	.05	.12*
POME Solids	00	00	00	00	00	00	00	00	00	00	00	.16*	00	.02	.01	-	00	00	00	.01	.03
Control	.03	.18*	00	00	00	00	.19*	00	00	00	00	.26*	00	00	00	-	00	00	00	.08	.25*

* = irrigation days.

Soil temperature regime

Effects of mulch materials on weekly midday (1200 to 1400 hours) soil temperature at 5, 10 and 15cm depths over the dry season in nursery polybag oil palm seedlings are presented in Table 4.

Soil temperature was highest at the 5cm depth and lowest at the 10cm depth between 1200 and 1400 hours. Mean seasonal soil temperature at 5cm was reduced by bunch refuse, kernel shell and polythene sheets by 3.8, 1.5 and 0.9 °C respectively compared with the control (Wade and Sanchez, 1983). Seedlings mulched with these three materials produced the highest dry matter and this agrees with the findings that high soil temperature retarded crop growth in tropical soils and reducing this by mulched was beneficial to the crop (Lal, 1975)

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