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MULCHING EFFECT OF *DACTYLADENIA BARTERI* (HOOK. F. EX OLIV.), *LEUCAENA LEUCOCEPHALA* (LAM.) DE WIT, *GLIRICIDIA SEPIUM* (JACQ.), AND *SENNA SIAMEA* (LAM.) LEAVES ON SOIL TEMPERATURE, MOISTURE REGIME AND YIELD OF MAIZE

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ABSTRACT

A two-year field study was conducted to investigate the effects of mulches of multipurpose trees on soil properties and yield of maize. The field layout was a randomized complete block design with five replicates. Results of the study showed that the mulching effect of the prunings was highest with *Dactyladenia barteri* and lowest with *Leucaena leucocephala.* Moisture tension less than 50 hPa were more frequent under *Dactyladenia barteri* at 10cm and *Senna siamea* at 30cm soil depth. There were significant increases in maize grain yield over the control in both years. Mulching effect on grain yield was higher in the second season cropping than in the first season cropping. The effect of mulch applied at the start of the first season cropping on second season grain yield was highest under mulches of *Leucaena leucocephala* and *Dactyladenia barteri.*

INTRODUCTION

One of the advantages of alley cropping is that the above ground portion of the hedgerows are pruned periodically and applied as mulch to the associated crops. The practice of mulching in agriculture is known to enhance the physical, chemical and biological factors that influence crop growth and productivity. The benefits of mulching include, reduction in soil temperature, weed competition, and soil erosion as well as enhanced infiltration, soil moisture regime, nutrients and soil structure (Lal 1975, 1983; Kamara 1986; Budelman 1989; Mbagwu 1990; Tomer *et al,* 1992; Makus *et al,* 1994). Soil temperature and moisture regimes as altered by different mulches and seedbed preparation had significant effect on crop production. In areas with very high soil temperature and limited moisture, the combined effect of reduced soil temperature and moisture conservation provides ecologically more sound conditions for crop growth. This experiment was designed to study the effect of prunings of *Leucaena leucocephala, Dactyladenia barteri, Gliricidia sepium* and *Senna siamea* applied as mulch on soil. *Gliricidia sepium* is a fast growing leguminous tree, native to Mexico and Central America, which is currently grown in many parts of the tropics for firewood, living fence post, fodder, soil improvement, stakes and plantation shades (Ngulube and Nwabumba, 1994). *Leucaena leucocephala* is also a fast growing leguminous tree shrub and perhaps the most widely studied

tree in relation to alley cropping. *Dactyladenia barteri* grows widely in Eastern Nigeria where it is commonly used for yam staking. Previous studies (Tian 1992) have shown that these different plant materials have contrasting chemical and biochemical properties. Prunings from shrub trees used in alley cropping have been evaluated for decomposition pattern and nutrient release characteristics (Tian, 1992). The objectives of this study are to assess mulching effects of plant materials with contrasting chemical and biochemical properties on (a) soil temperature reduction (b) soil moisture conservation, and (c) maize grain yield.

MATERIALS AND METHODS

The experiment was conducted at the International Institute of Tropical Agriculture, Ibadan (7^{O} 31'N and 3^{O} 54'E), southwestern Nigeria. Field layout was randomized complete block design (RCBD) with five replicates. The soil is an Alfisol (Oxic Paleustalf). The land has been fallow for six years before manual clearing in March 1993. The slashed material was dried on the plots for some days, then gathered and removed. There was no burning. The plots were 5m x 5m in size. Maize (var TZSR-W-DMR) in 1993 and TZSR-Y-DMR in 1994) was planted at inter-row spacing of 50cm and intra-row spacing of 30cm without tillage. Three seeds were planted per hole and thinned down to 2 plants two weeks after seed germination. In the first season, half of each plot was cropped to maize. In the second season, the same portion was cropped again (double cropping). Also, the portion not cropped in the first season was also cropped (single cropping). Prunings of *Leucaena leucocephala, Dactyladenia barteri, Gliricidia sepium* and *Senna siamea* were applied a week after seed germination. The prunings were applied at the rate of 5t/ha in 1993 and 10t/ha in 1994. The control plot had no pruning applied. At the time of thinning, the control plots were manually weeded using hoes. A second weeding was done on the control plots four weeks after at which a few weeds in the mulched plots were removed by hand. Maize planted on April 27, 1993 was harvested on August 19, 1993. The first season maize in 1994 was planted on May 17, and harvested on August 22, while the second (minor) season maize crop was planted on September 1, and harvested on December 1, 1994.

Soil water tension was monitored using tensiometers installed at 10cm and 30cm depths A pressure transducer described by Marthaler *et al* (1983) was used. The measurements were made daily from June 6, 1994 to November 28, 1994. Also, soil temperature was measured with a soil thermometer in the afternoon (15.00 h) at 5cm depth every week from June 7, 1994 to November 23, 1994. Measurement was done in the afternoon when the sun is hottest and its impact on the soil, highest.

Statistical Analysis

Data analysis was carried out using the SAS software. Variation in soil temperature and soil water potential was assessed using repeated measures analysis of variance. Temperature and moisture potential readings were further subjected to frequency distribution to show the distribution of soil temperature and soil water potential. Initial effect (Ei) of mulch on soil temperature was computed as the mean of soil temperature reduction over the first one month after mulching. The effective period (Ep) of mulch was computed as the length of time during which soil temperature reduction exceeds the mean of LSD(0.05) over the entire period. Maize yield was analyzed using analysis of variance procedure. Differences between treatment means were separated using least significant difference.

RESULTS AND DISCUSSION

Soil temperature

Soil temperature varied from one month to the other. Temperature fluctuations followed a similar pattern under the mulches and the control. The trend showed a general decrease in soil temperature from June to October and an increase thereafter (Fig. 1). Temperatures were lowest under *Dactyladenia barteri* and highest in the control plot. Differences in soil temperature between mulch treatment and control was least under Gliricidia mulch with a value of 0.41°C and more under Dactyladenia mulch with a value of 1.23 °C. Lower soil temperatures under mulch relative to the control is consistent with previous reports (Maduakor *et al* 1984; Kamara 1986; Mbagwu 1991; Makus *et al* 1994). This could be

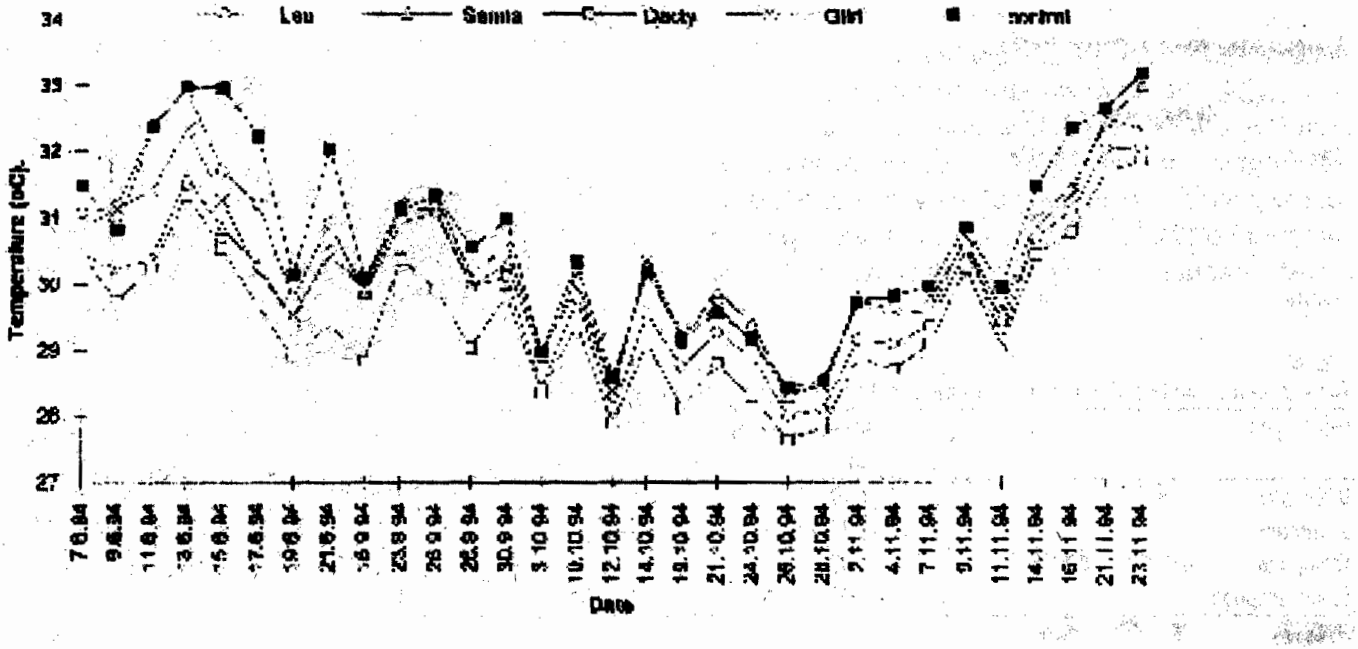

Fig. 1 Weekly soil temperatures at 5cm soil depth under different mulches, Ibadan, 1994

related to the ability of the mulch materials to remain long on the soil surface.

Temperatures less than 30°C were most frequent under *Dactyladenia barteri* and least frequent in the control plot. The reverse was the case for frequency of temperatures more than 32°C (Table 1). Since soil thermal regime is a function of the contact coefficient, a product of thermal conductivity and the volumetric heat capacity of the soil (Lal, 1975), the more frequent low temperatures under mulch can be explained by the lower contact coefficient of the soil underlying the mulch layer.

Table 1 Frequency distribution of soil temperature (°C) at 5cm soil depth under mulch of different tree species. Ibadan, Nigeria, 1994.

Frequency	Leucaena	Senna	Dactyladenia	Gliricidia	Control
< 30.0	16	14	21	14	10
30.1 - 32.0	11	15	10	14	13
> 32.0	4	2	0	3	8

In crop production, conditions favourable to seed germination, shoot and root development are very important at the early growth stages of a plant. Excessive high temperatures can result in low seed germination, stunted root and shoot development (Harrison-Murray and Lal 1979). The initial effect (Ei) of

mulch on soil temperature related to this early growth stage of the plant is shown in Table 2. In dry conditions, the length of time during which mulch can effectively reduce soil temperature and conserve soil moisture is also of extreme importance in crop production. Evaluation of initial effect (Ei) of mulch showed that the mulches tested differed.

Soil moisture Regime

The important parameter which links soil water to plant growth is not soil water content but soil moisture potential. Repeated measures analysis showed that soil moisture potential at 10cm varied from week to week but followed a similar pattern in all treatments (Fig 2). A similar trend was also shown for soil moisture potential at 30cm soil depth. Makus (1994) reported similar soil moisture at 30cm and 45cm depths in both mulched and bare soil. High moisture potential indicated dry spells. Consequently, during the

period under study, dry spell occurred between weeks 24 – 26 corresponding to the second half of June, weeks 31 – 33 corresponding to the first half of August, and weeks 44 – end of measurement corresponding to middle of November. Moisture potential less than 50 hPa at the 10cm depth was most frequent under Dactyladenia but least frequent under Gliricidia (Table 3). Low moisture potential indicates low energy requirement for extracting water by plants' roots and thus, greater availability of water to crops. Soil moisture potential higher than 500 hPa was less frequent under Senna but more frequent in the control.

Table 2. Initial and Effective period of mulch effect of prunings of some woody species at Ibadan, Southwestern Nigeria.

Mulch type	Initial effect[Ei] (oC)	Effective period of mulch effect[Ep] (days)
D. barteri	-1.47	112
S. siamea	-1.24	35
G. sepium	-0.47	28
L. leucocephala	-0.03	21

At the 30cm soil depth, the frequency of moisture tension less than 50 hPa was more under Senna but less under Gliricidia while moisture potential greater than 500 hPa was less frequent under Senna and Dactyladenia but more frequent under Leucaena and Gliricidia. In the major cropping season, mean of soil moisture potential was lowest at both 10cm and 30cm depths under *Senna siamea*. Also, moisture potential > 500 hPa was less frequent under Dactyladenia mulch in the second season (September-November). More frequent low moisture potential under mulch and more frequent high moisture potential in the no-mulch control can be explained by reduced evaporation losses due to the presence of mulch; in agreement with Lal, (1975) and Mbagwu, (1991).

Table 3. Frequency distribution of soil moisture tension (hPa) under different mulches at different depths; 1994

Freq	Leucaena		Senna		Dactyladenia		Gliricidia		Control	
(hPa)	10cm	30cm	10cm	30cm	10cm	30cm	10cm	30cm	10cm	30cm
< 50	105	86	108	123	121	120	99	78	102	117
50-100	17	33	16	13	17	11	15	37	17	8
100-200	7	19	16	18	8	14	20	21	13	22
200-300	11	9	6	4	3	9	11	6	8	4
300-400	8	11	12	4	2	6	4	12	5	3
400-500	5	3	6	2	12	4	8	7	8	7
> 500	19	11	8	8	9	8	15	11	19	10

Maize grain yield in the first season varied from 3.53 t/ha in the control plot to 5.23 t/ha in plot with *Senna siamea* mulch (Table 4). Maize yields decreased in all plots in the first season of 1994 relative to 1993, and the higher rate of mulch in the second year was unable to compensate for the decline. Similar observation has been reported under semi-arid conditions in Burkina Faso (Tilander 1993). The second season maize grain yield in the double cropping was in the range of 1.18-2.19 t/ha. The portion cropped only at the second season produced grain yield varying from 1.81 t/ha in the control to 3.70 t/ha in *Leucaena leucocephala* mulch. The single cropping produced higher yields than the double cropping which in absolute figures varied from 0.63 t/ha in the control plot to 1.51 t/ha in plot treated with *Leucaena leucocephala* mulch. Maize grain yields were higher in the first season than in the second. Lal (1978) obtained similar results. Beneficial effects of mulch on maize yield may be due to

release of mineral nutrients from mulch materials during decomposition (Kamara 1986) and favourable physical properties. In the first season of 1994, the beneficial effect of mulching on maize grain yield was least (44%) under Dactyladenia mulch and highest (72%) under Gliricidia (Fig. 3). Mulching effect on grain yield of maize was greater in the second season than in the first season and was more pronounced in treatments of Leucaena and Dactyladenia mulches. Increase in maize yield over the control was greater in the single cropping than in the double cropping and the first season. In the Gliricidia and Senna treatments, mulch effect on maize grain yield in plots cropped two times were more in the second cropping than in the first cropping while the reverse was true in treatments of Leucaena and actyladenia.

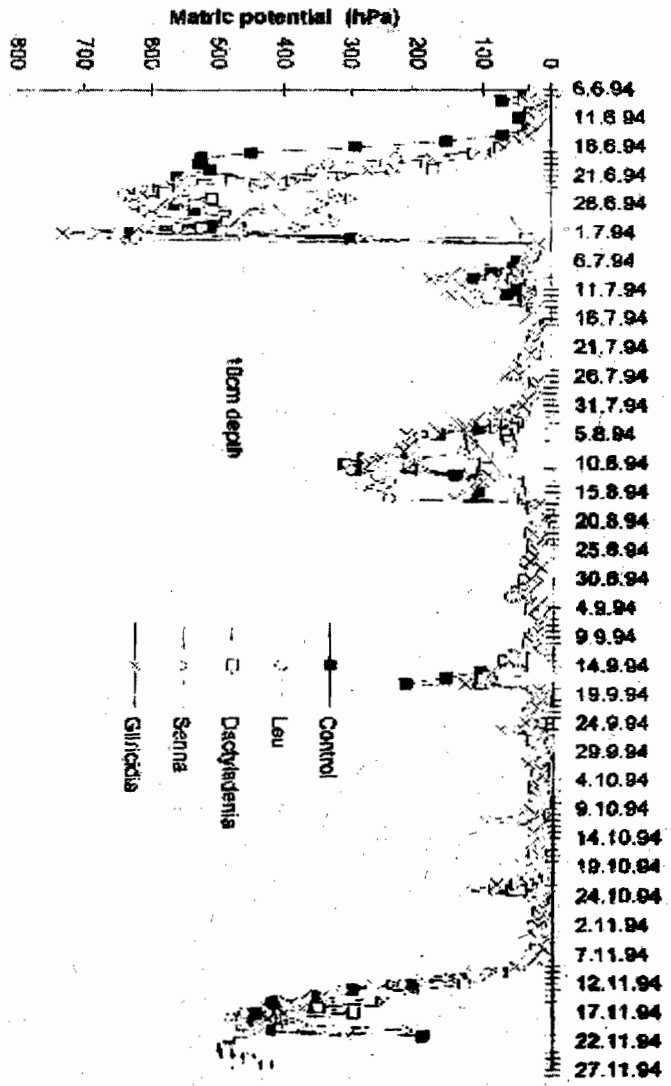

Fig. 2 Seasonal variation in matric potential at 10cm soil depth under mulches of different tree species

Table 4: Maize grain yields as influenced by mulches of different ree species

	Maize grain yield (t/ha)				
	First season		Second season		
	1993		1994		
Mulch Type		Double	Single	Double	Single
Gliricidia	7.39	4.82	1.74	1.18	2.79
Leucaena	7.06	4.71	2.19	0.65	3.70
Dactyladenia	6.68	4.49	2.07		3.50
Senna	6.60	5.23			2.95
Control	4.66	3.53			1.81
LSD(0.05)	1.55	1.42			1.50

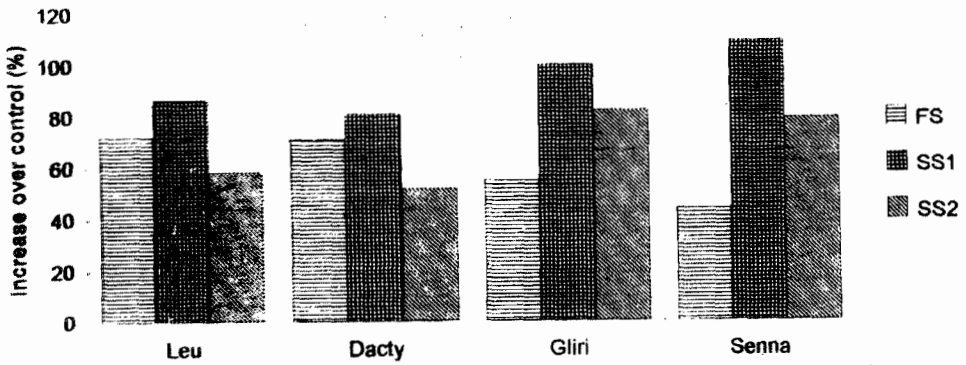

Fig 3: Mulch effect on maize Yield in the first season (FS) and second season on plots cropped once (SS1) and twice (SS2) in 1994.

Grain yield

Maize grain yield was highest under *Leucaena leucocephala* in the second season in both the areas cropped once and those cropped twice (Table 4). Maize grain yield was higher in the first season with mulches of easily decomposable plant materials and can be attributed to plant nutrients especially N and K contributed by the mulch (Mureithi *et al* 1994). In the second season, maize yield was higher with more recalcitrant plant materials due to mulch effect on soil temperature and moisture regime. Higher maize yield resulting from mulch application has been reported from other studies (Lal, 1978; Mulongoy and Van der Meersch, 1988; Mbagwu, 1991)

Beneficial effect of mulching on maize grain yield was shown in each cropping period. In the first season of 1994, *Senna siamea* mulch showed the highest effect, due probably to the very low frequency of high moisture potential relative to other treatments. In the second season however, *Leucaena leucocephala* showed the highest effect, and was closely followed by *Dactyladenia barteri*. In the second cropping season, reduction of soil temperature appeared to be the most important factor cotrolling crop performance. Soil temperature was below supra optimal (>30°C) levels under Leucaena and Dactyladenia mulches. It is shown very clearly, that the mulch effect on maize grain yield was high under Leucaena and Dactyladenia where the reductions in soil temperature were equally high. Yield advantage of mulch applied at the first season of 1994 was higher at the second season cropping than the first, even in the plots cropped twice during the year. The second season usually receives less rainfall (42%, 33% and 48% of annual rainfall in 1992, 1993 and 1994 respectively), which makes

the effect of mulch more pronounced. The early cessation of rainfall and increasing soil temperature from the end of October, about the flowering and fruiting stage of the second season maize, could have adverse effects on crop yield in the second season. This type of situation makes mulching a necessary practice in enhancing crop productivity especially for second season cropping.

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