AN EVALUATION OF DIFFERENT MULCHES USED IN SOIL MOISTURE CONSERVATION OF COCONUT LANDS

BY
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ABSTRACT

An investigation on the ability ofdifferent types of mulches to conserve soil moisture and their effect on coconutpalm (Dwarfx Tall; CRIC 65) was carried out in Madampe soil series at Bandirripuwa Estate, Lunuwila located in agro ecological region of IL_3 of Sri Lanka. Different types ofmulches compared in this study were dried coconut fronds and leaves, cover crop with Pueraria phasioloides and Brachiaria milliformis versus bare soil (Control). Soil moisture status was monitored using the neutron scattering technique. Leaf water potential of coconut with respect to different treatments was also monitored during dryperiod

Results showed that Brachiaria milliformis and Pueraria phasioloides extracted significantly ($p<0.001$) more waterfrom soils than diied mulch and the control. The amount of water extracted in the above treatments were 74.4Yo, 62.5Yo, 59.79yo and 61.3% respectively. However, the extraction was not significantly different when the rainfall was greater than 100 mm. About 33 mm of water retained in Brachiaria milliformis introduced soil profiles even by the end of dry period Water losses by Pueraria phasioloides grown plots, specially through evapotranspiration, were [1]higher in initial stages of the dry period, but later stage losses were lower than that of Brachiaria due to defoliation of Pueraria leaves during severe dry period Leaf water potential of coconut with respect to stress conditions of different treatments revealed that Pueraria phasioloides and Brachiaria milliformis did not adversely affect coconut palm grown in Madampe series, although those live materials extracted more waterfrom soilprofile compared to the other treatments. In general, dry mulching wasfound to be the most efficient moisture conservative practice that can be adoptedfor coconut lands.

INTRODUCTION

Coconut (*cocos nucifera* L.) is one of the major plantation crops in Sri Lanka which covers about 416,000 ha and is found in different types of soil with diverse moisture regimes. Coconut grown in drought prone soils is often subjected to periodic moisture deficits during the dry season (Abeywardena 1971).

Due to the water stress in drought susceptible soils during the dry period, the cells of the absorption zone of coconut roots become inactive by suberization and dehydration, adversely affecting the nutrient and water absorption process. This causes a setback in the growth of young palms and a reduction in the yield of bearing palm (Vidhana Arachchi 1996). Therefore suitable moisture conservation practices are necessary to minimize drought damage of coconut. Presently, Coconut Research Institute has recommended moisture conservation practices such as mulching, husk/coir dust pits to overcome the drought darnage of coconut (Nlahindapala and Pinto 1991). Uthaian et al., (l993) reported that mulches are beneficial in most of the perennial crops grown in subtropical situations.

Vidhana Arachchi (1996) found that effective root zone of coconut for moisture absorption in Andigarna and Madampe soil series is localized at a depth range from 0 to 120 cm and 0 to 250 cm respectively. Further, the maximum absorption zone occurs at a distance 100 cm away from the

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palm but the adsorption zone extends up to 200 cm from the palm. Therefore, the placement of conservation practices within the effective zone is important. Knowledge on the amount of moisture retained in soils due to different moisture conservation practices is important for fine tuning of the current recommendations. Quantitative data on this aspect are also not presently available to introduce the most suitable conservation practice to the growers to upgrade the coconut production. Although many studies have been made on the effect of drought on physiological activities in several annual crops (Rajagopal *et al*, 1977), the perennial tree crops have received very little attention, presurnably due to the problems, encountered in stress studies from their large size, non-homogeneity in a population and long period required to obtain increasing degrees of water stress in the field. The aim of this study was, therefore, to evaluate moisture conservation ability of different mulching systerns and their effect on coconut palm.

MATERIALS AND METHODS

Experimental site

The experimental site was in Madampe series soils at Bandirripuwa Estate, Lunuwila in a low country intermediate zone (08^0 02N, 79^0E; 35 m altitude) of Sri Lanka. Madampe series belongs to the Great Soil Group of Latosols and Regosols on old Red and Yellow Sands. The soils of Madampe series are very deep, imperfectly drained, sandy to course loarn (Somasiri *et al*., 1994). Some soil physical properties of Madarnpe series in the different horizons are indicated in Table 1.

Treatments

Different types of mulches already existing for which are about five years in the manure circle of a 27 years old coconut plantation (Dwarf x Tall; CRIC 65) were evaluated. Different types of mulches applied around the base of the coconut palm covering 1.75 m radius (effective root zone of coconut), such as (a) dried mulch with coconut fronds and leaves; (b) cover crop with *Pueraria phasioloides* and with Brachiaria milliformis were compared with the control. Bare soil without any material around manure circle served as the control. Five coconut palms per treatment were taken randomly for the study.

Soil moisture measurements

For soil moisture measurements, aluminum access tubes were installed using a steel guide tube. Aluminum tubes were installed at a distance of l m away from the coconut palm up to a depth of 1.5 m, leaving 20 mm from soil surface as the highest moisture extraction is known to occur at this particular distance (Vidhana Arachchi 1996). The tubes were then sealed with a rubber cap. The neutron probe was calibrated with respect to different horizons of Madampe series (Bell 1987). Soil moisture measurements were then taken weekly during dry period from September 1996 to March 1997 using the neutron moisture meter (Troxler Electronic Laboratories Inc. Research and Triangle Park, NC 27709 USA. Model 4302 and Serial No. 166). Ten years rainfall data from 1985 to 1995 were used to select the above dry period to establish the experiment.

Detennination of evapotranspiration losses and leaf water potential ofcoconut

Evapotranspiration loss of different treatments during the dry period was estimated as described by Bell (1987). Percolation loss through the soil profile was not accounted during the estimation of evapotranspiration loss as it is negligible in the dry period.

Jayasekera *et al*. (1993) reported that leaf water potential, of coconut has wide variation during wet and dry months and therefore, measurements were taken weekly at the end of dry period to minimize the effect of variation. The ninth leaf was used as the standard leaf for all the measurements and the water potential of leaf of coconut was measured weekly using pressure bomb apparatus (Scholandar type; Model 560939) cluring the end of dry period as clescribed by (Jayasekera et al, 1993).

RESULTS AND DISCUSSION

Soil water storage and depletion

Previous studies have shown that water storage capacity of Madampe series in rooting depth of coconut was 186 ±15 mm (Vidhana Arachchi 1996). Conservation ability of stored water in the soil profile by different types of mulches were compared with the control and the results are indicated in Fig. 1. It was observed that the total water content of soil profiles of different treatments decreased with time when the rains ceased, with small increase in October and December, 1996 due to non-seasonal rainfall. Pair wise comparison with the LSD test revealed that moisture content in soil profiles clecreased compared to the control (bare soil) due to live covers significantly ($p<0.001$). Results clearly showed that *Pueraria phasioloides* and *Brachiaria milliformis* were more capable of intercepting the rain water and store in the soil profile during the initial stage of the dry period under low rainfall conditions compared to the control and dried mulch treatments. However, live covers were responsible for extracting more soil water cluring dry period compared to the control and dried mulch during dry period (Fig. 1). Reduction of stored soil moisture during dry period was 74.4%, 62.5%, 59.7% and 61.3% in *Brachiaria milliformis*, *Pueraria phasioloides*, dried mulch and control respectively. Overall. results showed that application of dried mulch is more efficient to conserve soil moisture than live materials (Fig. 1). Uthaian et al. (1993) also showed that among the different mulches, coir pith was found to be better than other mulches in terms of vegetative growth of coconut.

Soil moisture depletion in different treatments with respect to the depth of soil profiles is illustrated in Figs. 2 and 3. Figure 2 represents the soil moisture depletion under low rainfall condition (from October end to mid December 1996), while Fig. 3 shows soil moisture depletion during the dry pefiod (from mid December 1996 to end of March 1997). Rainfafl higher than 100 mm during the experimental period did not show any significant difference of moisture depletion during the dry period (from mid December 1996 to end of March 1997). Rainfall higher than 100 mm during the experimental period did not show any significant difference of moisture retention in Madampe series under different mulching treatments. However, contrasting soil moisture variations in all treatments were observed beyond 60 cm depth of soil profile during the dry period, which received less than 25 mm per week. Results also showed that *Brachiaria milliformis* and *Pueraria phasioloides* extracted water from soil profile rather than conserving water, while dried mulch that was applied conserved more water throughout compared to the control (Figs. 1,2 and 3). Soil water loss in *pueraria* grown plots was higher than *brachiaria* in the initial stage of the dry period, but at a later stage the loss was lower in *pueraria* plots than *brachiaria* plots due to defoliation of *pueraria* during severe dry period. Therefore, the highest water losses from soil profile during dry period was observed under *Brachiaria milliformis* introduced treatment (Fig. 1).

Evapotranspiration

Water loss from the soil profile during the dry period is mainly caused by the evapotranspiration from the soil surface and response of palm to the moisture stress was shown to depend on the nature of the soil types with different water-holding capacities (Shivashankar *et al* 1991). Therefore evapotranspiration losses were predicted conceming water deficit of soil profile. Evapotranspiration losses from the effective area (manure of circle of coconut) due to different types of mulches were estimated during the dry period starting from December 1996 to March 1997 (Fig. l and Table 2). Results showed that evapotranspiration losses of different mulches significantly (p<0.01) varied compared to the control during the dry period. The evapotranspiration losses in pueraria and *brachiaria g*rown plots were significantly (p<0.01) higher than that of the dried mulch treatment and the control. Evapotranspiration losses by pueraria grown plots was higher in the initial stage of the dry period but at a later stage the loss was lower than in *brachiaria p*lots due to defohation of pueraria leaves. Therefore the highest water losses from sofl profile during dry period was observed under *Brachiaria millifonnis* introduced treatment (Table 2).

The rooting depth ofpueraria is about l m which is quite deep whereas that of *brachiaria i*s about 30 cm which is shallow. Therefore pueraria would extract soil water from deeper soil layers than *brachiaria.* It would result in higher water loss by pueraria and *brachiaria* in the initial stage of the dry period (Plate l and 2).

Leaf water potential of coconut

Plants avoid water stress conditions either through dormancy or tolerate drought through phenological and physiological adjustments. Survival of plants during drought ultimately dependent on the maintenance of cell turgor, which can be promoted by decreasing osmotic potentials through osmotic adjustment (Tumer 1986). Osmotic adjustment has been attributed to the maintenance of stomatal conductance, photosynthesis, leaf water volume and growth (Tumer 1986). Therefore, leaf water potential can be used as an indicator to evaluate the effect of stress condition on plant growth. Results of leaf water potential measurements in coconuts growing under different mulched treatments are given in Table 2. Data on leaf water potential of coconut show the water stress level of different treatments. The results showed that high water loss by *pueraria* and *brachiaria* mulched treatment resulted in an increase in the water potential of coconut leaf compared to other treatments (Table 2). Water potential of coconut leaf *inpuerana a*nd *brachimia* mulched treatment was significantly (p<0.05) higher than that of the dried. mulch treatment and the control. The values of leaf water potential of the above live mulch treatments varied from - 6.5 to -12.9 bars during dry period. Complementary to these results, Jayasekera *et al* (1993) also stated that the leaf water potential of putative drought-tolerant Tall x Tall coconut varied from - l0 to - 12 bars during the hydrological. period. Shivashankar *ef al* (l991) found that when available soil water becomes less than 20 mm, leaf water potential. higher than -16 bars adversely affect the physiological functions of the coconut palm (Var. West Coast Tall), when available soil water is less than 20 mm. However, the available, soil water of the treatment plots in our experiment was not lower than 33 mm. With these evidences and results it could be suggested that water stress created by *Pueraria phasioloides* and *Brachiaria* milliformis grown in suitability class l soils (Madampe series) does not adversely affect the physiological. function of the coconut palm (Dwarf x Tall; CRIC 65). The changes in plant water relations in response to soil water potential are well documented, in the literature (Slatyer 1967; Turner 1974). Overall results showed that mulching of coconut with *Pueraria phaseoloides* and *Brachiaria* milliformis tended to reduce more water from soil profile specially through evapotranspiration and therefore, dried mulch application around manure circle of coconut was found to be most suitable method for efficient conservation of soil moisture during dry period.

CONCLUSIONS

It is evident from results that *Pueraria phasioloides* and *Brachiaria milliformis* are responsible for extracting more water from the effective root zone of coconut compared to the dried mulch and the control. Water losses by *Pueraria phasioloides* grown plots, specially through evapotranspiration, was higher in initial stage of the dry period but at a later stage the loss was, lower than *Brachiaria* clue to defoliation of *pueraria* leaves during severe dry period. Results also showed that stress created by *Pueraria phaseoloides* and *Brachiaria milliformis* does not adversely affect the coconut palms that are grown on soils with high water retention capacity such as Madampe series. Overall results showed that dry mulching is the most efficient moisture conservative practice that can be adopted for coconut lands of Madampe series.

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Table 1. Estimated soil physical parameters of the experimental site (Madampe series)

Parameter	Depth range (cm)		
	0-15	**15-50**	**50-100**
FC (vol/vol %) (10kPa)	9.87 ± 1.83	10.41 ± 2.70	10.97 ± 1.72
PWP (vol/vol %) (1500 kPa)	4.15 ± 1.11	3.73 ± 1.08	4.28 ± 1.20
TAW (%)	5.71	6.18	6.70
RAW (%) (10-100 kPa)	3.06	5.30	5.68
Bulk density g/cm3	1.5 ± 0.01	1.5 ± 0.01	1.52 ± 0.03
Macroporosity (%)	38.4 ± 3.4	33.5 ± 2.3	32.4 ± 3.1
Microporosity (%)	9.8 ± 1.2	9.9 ± 0.5	11.0 ± 1.5
Sand (%)	86.1 ± 5.4	85.4 ± 3.4	84.6 ± 3.2
Silt (%)	2.7 ± 0.5	3.3 ± 0.7	2.4 ± 0.5
Clay (%)	11.0 ± 2.1	11.8 ± 1.4	13.10 ± 1.5

FC – Field capacity
PWP – Permanent wilting point
TAW – Total available water
RAW – Readily available water

Table 2. Mean values of evapotranspiration of treatments and leaf water potentials of coconut palm

Time period (weeks)	T r e a t m e n t s			
	Only soil	Dried nukch	*Pueraria*	*Brachiaria*
	Evapotranspiration (mm/day)			
Under low rainfall				
10	3.92	3.67	5.91	5.08
11	3.78	4.25	5.95	5.62
Under severe dry period				
20	1.79	0.21	1.44	1.48
21	0.08	0.92	0.97	0.45
22	0.09	1.00	1.11	2.45
23	0.08	0.34	0.45	0.55
23	0.77	0.70	0.49	0.59
Leaf water potential of coconut (-bars)				
Under little rain				
10	6.0	6.50	7.00	7.50
11	5.5	7.00	6.50	8.00
Severe dry period				
20	9.17	9.00	9.25	12.13
21	8.30	8.25	9.50	12.50
22	8.58	8.60	8.67	9.75
23	9.58	9.30	9.40	10.75
24	9.78	9.13	10.21	12.85

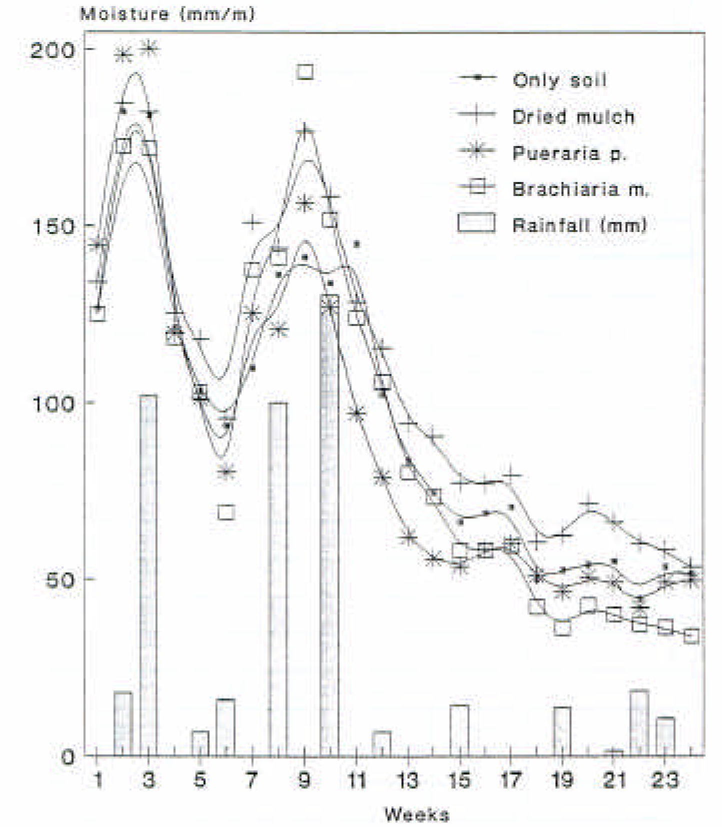

Fig. 1 Variation of soil moisture under different mulches

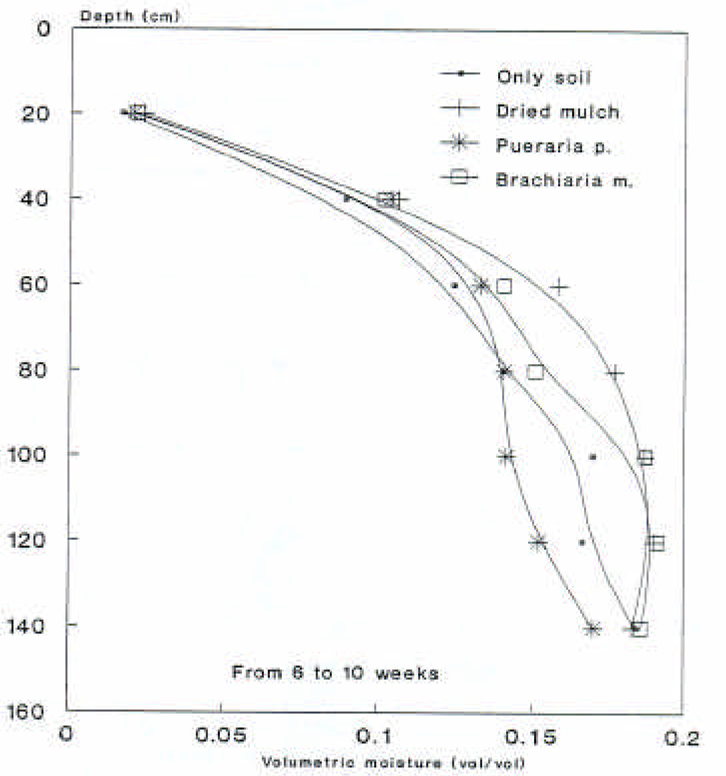

Fig. 2 Variation of soil water content with depth

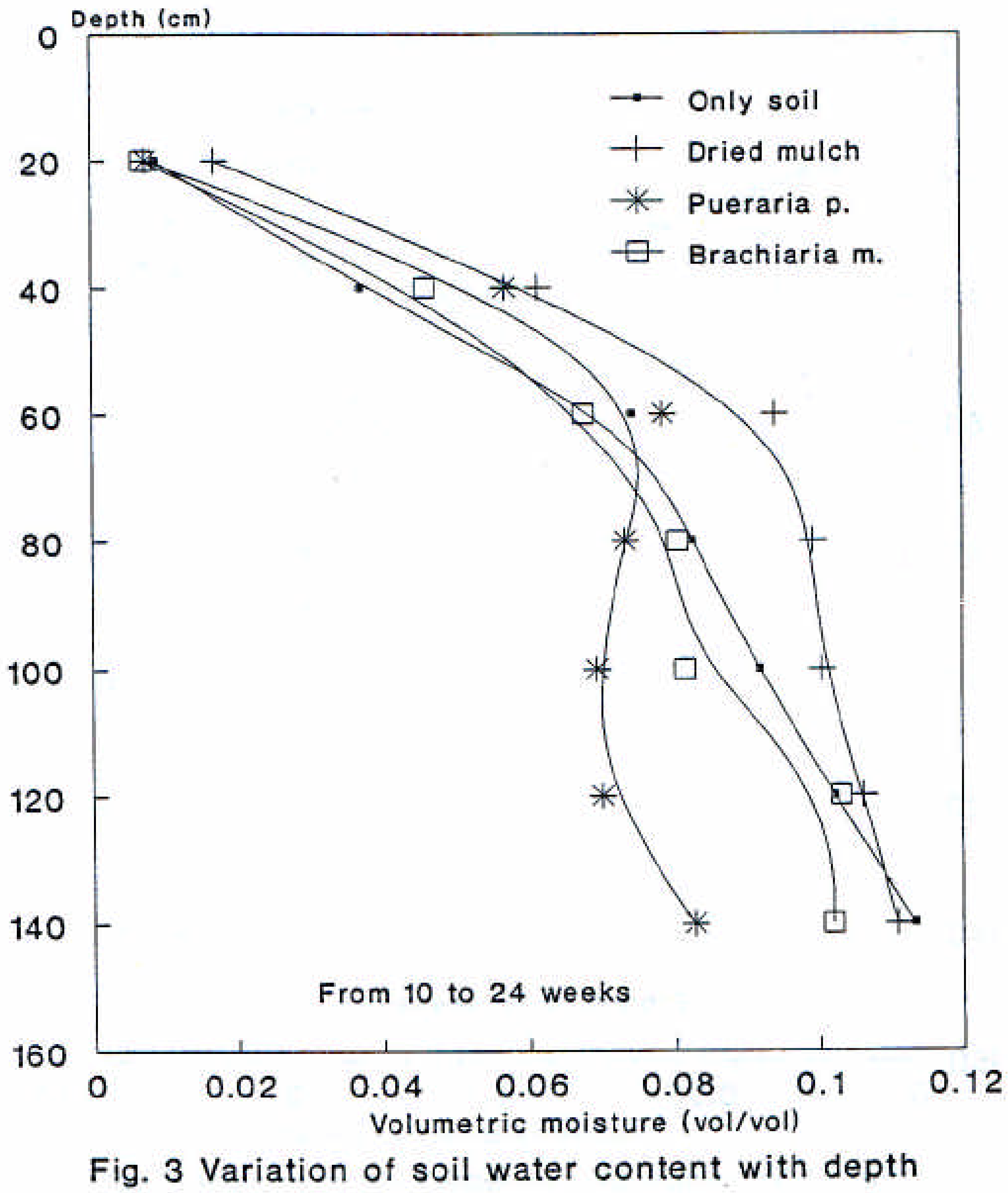

Fig. 3 Variation of soil water content with depth

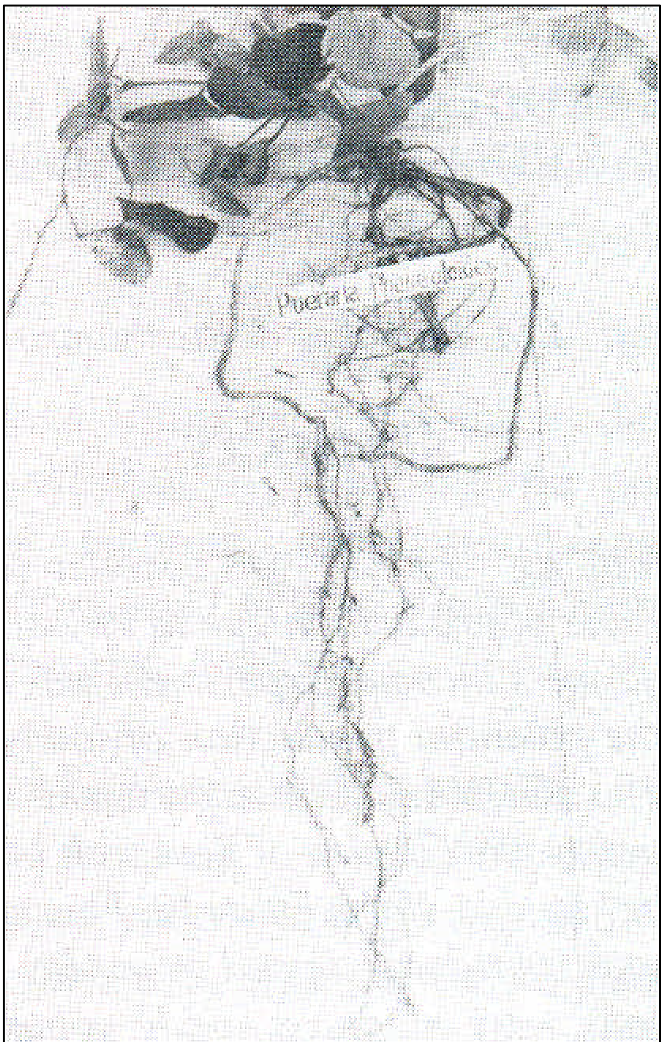

Plate 1. Root system of Pueraria phasioloides

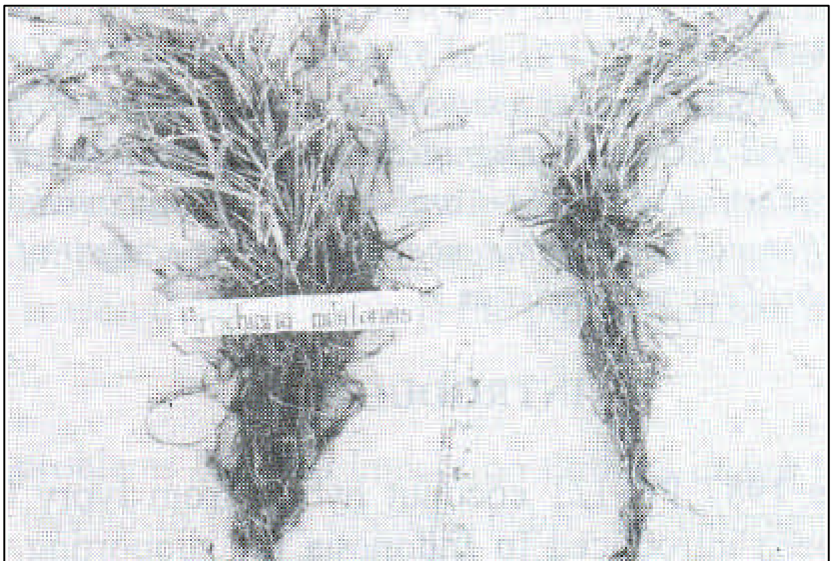

Plate 2. Root system of Brachiaria milliformis