COMPARISON OF SOME MULCHES FOR USE IN BRAZILIAN EUCALYPT NURSERIES[1] /

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Resumo

Cinco coberturas-mortas (cascas de arroz, acículas de pinho, palha, serragem de eucalipto e pó de carvão vegetal) foram comparadas quanto à sua influência sobre â conservação da umidade do solo, a germinação e a sobrevivencia de Eucalyptus saligna *Sm.*

Sob condições áridas, palha, cascas de arroz e acículas de pinho demonstraram as mais baixas taxas de evaporação da umidade do solo assim como as mais altas taxas de sobrevivência de mudas. Porém, sob condições não áridas, as coberturas-mortas de serragem e palha exibiram significativamente mais altas sobrevivencia, apesar da alta potencialidade de evaporação da umidade do solo com a cobertura de serragem. O maior taxa de evaporação ocorreu com pó de carvão vegetal, espessura de 1 cm. Esta cobertura produziu um numero baixo de plantas, mostrando, porém, a maior biomassa por planta, o que foi atribuido, provavelmente, ao nível alto de cations básicos e, também, ao alto pH (9.5) da cobertura-morta.

Para um controle efetivo da erosão, coberturas-mortas de fibras compridas, caracteristicas da cobertura de acículas de pinho, foram designadas como essencias.

Introduction

This paper reports on experiments which seem to be essential for comparative evaluations of fibre mulches. A desirable cellulose mulch should have a low water-holding capacity and good drainage properties. Such a mulch will create an effective barrier to soil-water diffusion to the atmosphere and thereby retain a greater soil-moisture supply for plant growth (1). With thick mulch covers, water-holding capacities and drainage properties are important considerations. In this study however, mulch layers only 1 cm thick were examined, and those characteristics are not critical and therefore not reported.

This study was part of a Canadian/Brazilian research and development program designed to evaluate cellulose fibre mulches by examining their chemical composition and their influence on soil-moisture conservation and the vegetative growth of *Eucalyptus saligna* Sm. This research program was carried out at the Federal University of Viçosa, Viçosa, Brazil from early September to late November, 1979. Meteorological conditions during the study period are shown in Table 1. Viçosa lies at an elevation of 670 m at 20° 45' S latitude and 42° 7' W longitude in southeastern Brazil. The region is within the Brazilian Highlands and the topography is generally hilly with narrow river valleys.

A mulch may best be defined as a protective covering, either spread or left upon the ground, for the purpose of increasing soil productivity primarily through microclimatic modification (3). In

1 Received for publication 18 February, 1980. The authors would like to thank Universidade Federal de Viçosa Professors Jose Mauro Gomes, for providing the mulches and equipment, and Roberto Ferreira de Novais, for assisting with the chemical analysis of the mulches

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addition to conserving soil water (5, 12), and moderating soil-surface temperatures (16), the practice of mulching often increases plant growth by suppressing weeds (9), by decreasing wind and water erosion (7, 20), and by providing nutrients (10). Cellulose fibre mulches also supply the soil with a new carbohydrate source which often increases soil microbial populations and subsequently causes nitrogen depletion (19). Fertilizing may overcome this problem and is frequently part of a mulching program. Difficulties exist however, in selecting the most efficient mulch for a particular site and species, and this study evaluates some mulches which are commonly used in Brazil. Dry grass and rice husk mulches, for example, have been reported to have improved the height performance of *Eucalyptus citriodora* Hook seedlings, in São Paulo nurseries, compared to a sawdust mulch or a fine soil cover, and germination was better under the dry grass than under any other mulch (6). The height growth of *Pinus taeda* L. nursery stock has also been improved by mulching. Oliveira and Bridi (15) observed better growth using a pine needle cover than with rice husk or leaf mould mulches.

Materials and methods

Six treatments consisting of a bare soil control and 5 cellulose fibre mulches – rice husks, pine needles, charcoal dust, straw, and eucalypt sawdust – were evaluated.

Experiment 1. Chemical analysis of the mulches

Three replicates of each mulch were analysed for Ca, Mg, K, P, and N using standard soil analysis techniques as outlined in 'Methods of Soil Analysis' – Parts 1 and 2 (2). Ca and Mg were determined by atomic absorption in a lN KCl solution. P and K were extracted using the North Carolina extracting solution (0.05N HCl and 0.025N H_2SO_4), and N was determined by the Kjeldahl method. For pH determination, it was necessary to grind the rice husks, pine needles, and straw mulches to ensure proper particle distribution. A mulch:water ratio of 1:5 provided a suitable slurry for measurement.

Experiment 2. Effect of mulch cover on soil-water evaporation and early germination of *E. saligna*

To investigate the influence of a mulch cover on soil-water conservation, the mulches were applied to potted bare soil; the soil and mulch were then saturated with water and weighed every 48 hours. The randomized block experiment consisting of all 6 treatments was replicated 3 times in a 30-35°C greenhouse. Each of the 18 experimental units consisted of a 17.5 g plastic container (evaporation from the sides and bottom was therefore zero) with a surface area of 95 cm^2, 30 seeds of *E. saligna*, and a 1 cm mulch layer over 678.5 g of air-dried soil.

In order to decrease soil variability, the soil (31 percent clay, 3 percent silt, and 66 percent sand) was passed through a 2 mm mesh sieve and packed to an 8 cm depth in each container. Soil-water saturation was determined by allowing 100 cm^3 of water to saturate 100 g of soil, and after drainage ceased, the remaining water constituted the soil-water saturation per 100 g of soil. Initially, 200 cm^3 of water were added per pot to saturate the soil, with an additional 50 cm^3 added at the third 48-hour watering period, and 100 cm^3 at the fourth watering period to ensure adequate moisture for seed germination. When evaporation became negligible, the experiment was ended.

Experiment 3. Effect of mulch cover on biomass accumulation and survival of *E. saligna*

Three hundred seeds of *E. saligna* were sown in plots of sieved soil (the same composition as in Experiment 2) in an outdoor nursery. The plots measured 957 cm^2 and were covered with a 1 cm layer of mulching material, watered, and screened to keep out birds. The randomized experiment consisting of 6 treatments was replicated 3 times. After 50 days, the seedlings were harvested, counted, and their dry weights determined.

Results and Discussion

Experimental 1. Chemical analysis of the mulches

As shown in Table 2, the charcoal dust mulch exhibited a relatively high cation content as well as a high pH. The soils used in many Brazilian eucalypt nurseries, particularly those of the dry central region of Brazil, are acidic (pH 5.0 or less) and are low in Ca, Mg, K, and P (14) and the application of a charcoal dust mulch would possibly increase the pH at the soil surface aside from having a certain fertility value by itself.

Table 2 also indicates that all the mulches have a low nitrogen content. Allison (1) points out that if a mulch has a carbon:nitrogen ratio greater than 25-30 (a nitrogen content less than 1.2-1.5%), the decomposition rate of the mulch by soil microorganisms will likely decrease. As much of the N is used by the soil organisms, little will be left available for plant growth. The mulches used in this study might require N fortification to enhance the amount available to a seedling crop.

Experiment 2. Effect of mulch cover on soil-water evaporation and early germination of *E. saligna*

The charcoal dust mulch had the highest moisture evaporation rate over the 12, 48-hour periods, and was grouped with the controls and the sawdust mulch which also had a high evaporation potential (Figure 1). The low albedo of a black mulch cover such as charcoal results in greater radiation absorption and thus surface temperatures increase. Saturation vapour pressures increase over the environment vapour pressures (13) and hence water evaporation rates are higher.

In accordance with Kijne (10), the data for cummulative evaporation was divided into two stages, a constant-rate period, and a falling-rate period. During the first stage, the evaporation rate is determined by external factors of the environment and by the mulch:soil-surface conditions, when the soil is saturated with water. The conductive properties of the mulch and of the underlying soil become important variables during the second stage, the falling-rate period (8). Particle size distribution, for example, influences water loss when the soil-moisture becomes limiting.

The transformation necessary to describe the distinct stages of the evaporation functions is given in Table 3. The linear functions were divided into 2 mulch evaporation groups according to the slope homogeneity test (18). It was also observed that an inverse relationship existed between rates of evaporation and the survival of *E. saligna* seedlings (Table 3).

Table 3 also indicates that the straw, rice husk, and pine needle mulches significantly decreased soil-water evaporation, compared with the bare soil control. This suggests that an inefficient water transport mechanism might have been created by these mulches since they were not in immediate surface contact over the entire soil surface but were frequently separated by air pockets. In contrast, the sawdust and charcoal dust mulches have a high surface-air to volume ratio, resulting in more direct ground surface contact which increases the possibility of heat transfer, leading to greater upward water flow and greater evaporation. In addition, capillary flow through these mulches might also be possible to some extent, which would help increase the rate of evaporation. This process has been referred to as the 'wick effect' (3).

Experiment 3. Effect of mulch cover on biomass accumulation and survival of *E. saligna*

Variance-ratio testing of the 0.05 percent probability level of the total *E. saligna* biomass per mulched plot revealed no significant differences although the charcoal and sawdust mulches resulted in the highest biomass values (Table 4). Seedling survival per plot was significantly affected at the 0.05 percent level and have been separated in Table 4 into groups using Ducan's Multiple Range Test.

Charcoal dust and the controls are in both groups and this would suggest a minimum biological role of mulching under the conditions of this experiment.

Table 1. Meteorological data for Viçosa, Brazil (Instituto Nacional de Meteorologia, 1979).

	Sept.	Oct.	Nov.
Average Temp (°C)	17.8	21.0	21.2
Total Monthly Precipitation (mm)	34.1	34.8	360.5
Total Monthly Evaporation (mm)	90.9	137.5	128.0
Total Monthly Insolation (h)	134.1	164.6	181.5

Table 2. Summary of chemical analysis of the mulches.

Mulch	Ca%	Mg%	K%	N%	P%	pH
Charcoal dust	2.60	1.50	0.58	0.49	0.02	9.5
Pine needles	0.84	1.00	0.26	0.74	0.01	5.3
Rice husks	0.10	0.26	0.32	0.35	0.01	6.4
Eucalypt sawdust	0.42	0.70	0.12	0.09	0.01	6.1
Straw	0.26	0.61	0.40	0.92	0.02	6.5

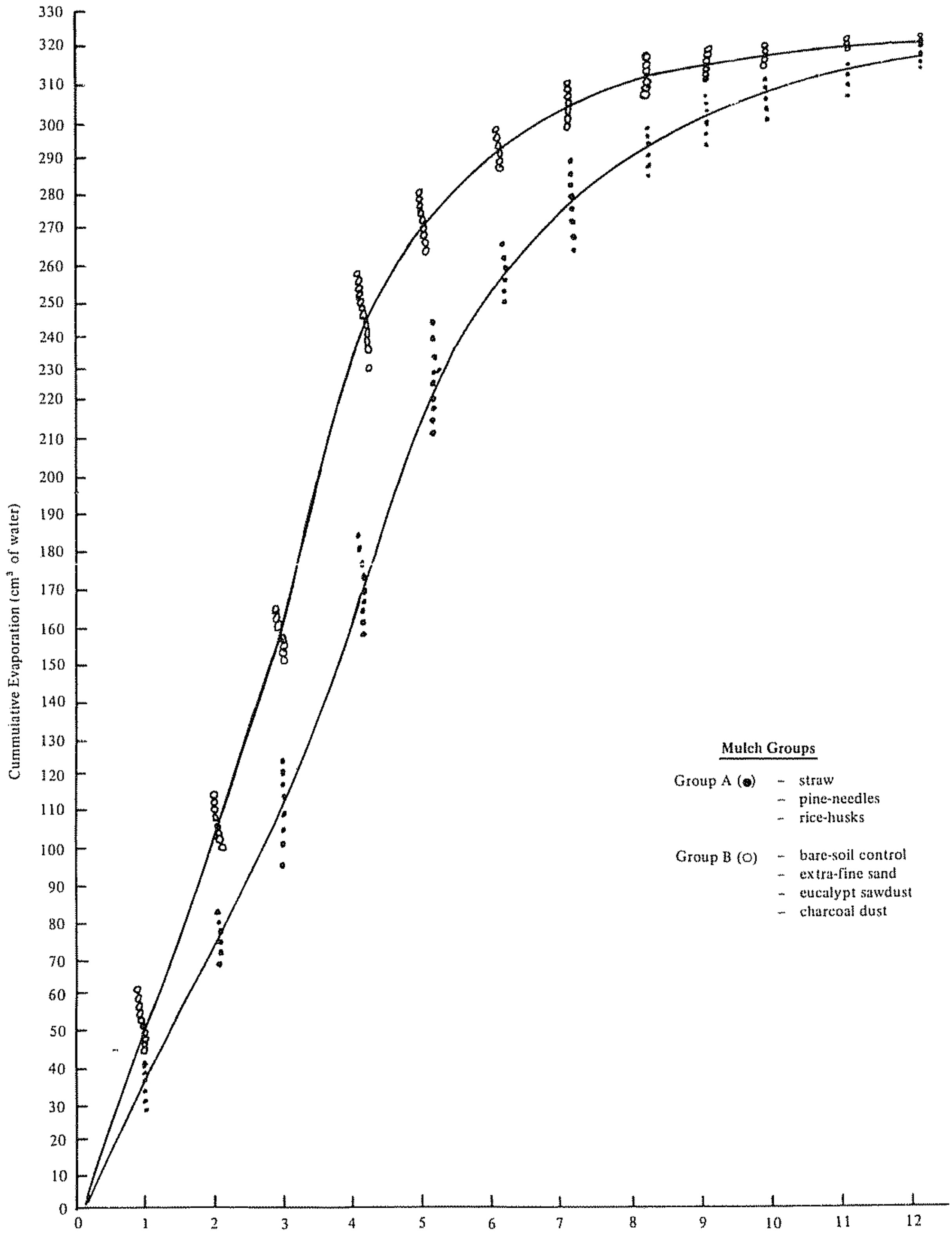

Fig. 1. Cummulative evaporation of water under various mulch covers. (The two mulch groups were determined by slope homogeneity tests on the linear transformations of the functions).

Table 3. Comparison of soil-moisture evaporation functions and *Eucalyptus saligna* survival under various mulch covers.

Mulch	Evap. Functions	Y Mean	Std. Err.	Groupings*	No. Survival (12 days)	Groupings**
Straw	Y_1	2 499	34	A	11	B
Rice husks	Y_2	2 559	119	A	16	A
Pine needles	Y_3	2 602	105	A	11	B
Sawdust	Y_4	2 656	22	B	2	C
Charcoal dust	Y_5	2 671	20	B	2	C
Bare soil (control)	Y_6	2 642	13	B	0	C

* Similar group letters indicate no significant differences at the 0 05% level using the slope homogeneity test (18).

** Similar group letters indicate no significant differences at the 0 05% level using Duncan's Multiple Range Test

$$Y_1 = -141\,724T + 711\,871T^2 - 1\,317\,977T^3 + 11\,480$$
$$Y_2 = -142\,982T + 714\,139T^2 - 1\,313\,019T^3 + 11\,647$$
$$Y_3 = -150\,984T + 781\,238T^2 - 1\,482\,452T^3 + 11\,974$$
$$Y_4 = -144\,046T + 732\,897T^2 - 1\,344\,719T^3 + 11\,632$$
$$Y_5 = -144\,389T + 738\,999T^2 - 1\,363\,965T^3 + 11\,631$$
$$Y_6 = -144\,663T + 740\,300T^2 - 1\,367\,777T^3 + 11\,637$$

Equations developed at the 0 01% level using the function $y = t\,(\alpha t - \beta)$, where y = cummulative evaporation (cm^3), t = time (48-h/periods), α and β = coefficients transformed by $Y = 1/y$ and $T = 1/t$ to achieve the linear form $Y = \alpha + \beta T$ (4).

Equations developed for $4 < t \leqslant 12$

The 1 cm mulch layers were possibly too thin to have a noticeable biological effect, as thicker mulch covers have been reported to increase crop yields (13, 17). The largest and healthiest-appearing seedlings were, however, obtained with the charcoal dust and this might be attributed to its chemical characteristics.

Table 4. Biomass accumulation and mean survival per mulched plot for *Eucalyptus saligna*

Mulch	Total oven-dry weight (g)	Mean survival per plot	Grouping*
Sawdust	2 82	61	A
Straw	2 13	60	A
Bare soil (control)	1 36	30	AB
Charcoal dust	3 65	18	AB
Pine needles	0 99	9	B
Rice husks	0 38	8	B

* Similar letters indicate no significant differences at the 0 05% level using Duncan's Multiple Range Test.

The sawdust mulch had a high evaporation rate and also gave the highest survival per plot, while those mulches with low rates of evaporation (pine needles and rice husks) resulted in poor seedling survival. This relationship is in direct contrast to the results of the indoor water evaporation experiment where the mulches with high evaporation rates resulted in poor survival. It is possible that under the relatively more arid conditions of the greenhouse, the greater evaporation rates exhibited by the short-fibred mulches (charcoal dust and sawdust), combined with greater heat absorption, proved to be more detrimental to newly germinated seedlings compared with the lower rates of evaporation shown by the long-fibred mulches (straw, rice husks, and pine needles). Watering was carried out by the nursery staff every day throughout experiment 3, whereas the watering for the indoor experiment was done every 48 hours.

Conclusions

In situations where watering might be irregular or intermittent, long-fibred mulches such as pine needles, straw, and rice husks might prove to be more beneficial than short-fibred ones which have greater soil-surface contact and hence higher evaporation rates. Long-fibred mulches increase the length of the diffusion path from the soil surface to the atmosphere, thereby minimizing capillary flow and thus water movement out of the soil.

Long-fibred mulches also tend to lodge crosswise in rills, reducing soil and seed displacement (20) and this feature, combined with their low water evaporation potentials, would likely be of more value for slope stabilization than short-fibred mulches. Kill and Foot (11) for example, when comparing various cellulose pulp mulches, found that long-fibred ones were more effective in reducing soil loss than short-fibred ones.

Pine needle, rice husk, and straw mulches also have low water-holding capacities and although short-fibred mulches such as sawdust retain more moisture, the soil under them might actually be dry. This could prove detrimental in instances where a short-fibred mulch slurry was added as a protective cover to a dry surface. Hence, it would seem that long-fibred mulches are more desirable for soil-moisture conservation, particularly where watering (rainfall) is infrequent.

Nevertheless, there may be opportunities to employ a mulch such as charcoal dust where the soil surface pH properties might be improved, especially with the often highly acidic soils used in Brazilian nurseries. In these situations, watering would be controlled and the high evaporation rate of a short-fibred mulch would not likely be detrimental to plant germination and growth.

Summary

Five cellulose mulches were evaluated on the basis of their chemical constituents, pH, and water evaporation potentials. Mulch covers 1 cm thick were examined and water-holding capacities and drainage characteristics were not considered.

Under greenhouse conditions where watering occurred once every 48 hours, the highest water evaporation rates were found with the short-fibred charcoal dust and eucalypt sawdust mulches. Survival of *Eucalyptus saligna* seedlings was also poorest with these mulches. In contrast, seedling survival and biomass accumulation were poorest in the nursery with the long-fibred pine needle and rice husk mulches which had low soil-moisture evaporation rates.

As a possible explanation for these contrasting results, it is suggested that under intermittent watering situations such as occurred in the greenhouse, short-fibred mulches with more direct soil surface contact proved detrimental to germinating seedlings because of their higher evaporation rates and greater heat absorption. When watering is more uniform, such as in a nursery, these mulches may be of value, especially if their chemical contents and pH ameliorate the soil surface. Long-fibred mulches, however, would appear to be of more benefit for soil stabilization in situations where watering is not controlled due to their low water-evaporation rates, high water-holding capacities, and their tendency to lodge crosswise in rills.

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SOCIEDAD LATINOAMERICANA DE NUTRICION

VOL. XXXI JUNIO, 1981 No. 2

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