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# RESPONSE OF PLANTAIN TO MULCH ON A TROPICAL ULTISOL: PART II. EFFECT OF DIFFERENT MULCHING MATERIALS ON SOIL HYDROLOGICAL PROPERTIES*

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A b s t r a c t. The research reported here compares the effects of five different mulches and an unmulched control on water infiltrability, moisture content profiles and variation of soil moisture suction on an Ultisol under plantain in southeastern Nigeria. The mulch treatments were elephant grass, plastic, elephant grass on plastic, plastic on elephant grass, wood shavings and unmulched control.

At 5 months after planting (MAP), wood shavings, elephant grass on plastic and elephant grass treatments increased water infiltrability by 128 %, 40 % and 15 % respectively, in comparison with the unmulched treatment. Plastic on elephant grass and plastic mulches decreased water infiltrability by 14 % and 28 %. Mulching effect on infiltrability at 10 MAP followed the same trend as at 5 MAP; however, lower infiltrability values were measured at 10 MAP than at 5 MAP. Lower infiltrability values were also measured at 15 MAP than at 5 MAP.

Soil moisture content measured over a period of one year was higher under elephant grass and wood shavings mulches than under other mulch treatments. Moisture content measured on 7 January 1988 (17 MAP) was highest under elephant grass and lowest under unmulched treatment at the 0-60 cm depth. Below the 60 cm depth, there was no difference in moisture content among treatments. During the dry season, the exposed surface of unmulched plot experienced higher moisture stresses due to evaporation than the mulched treatments.

Within row moisture suction measured at 10 and 30 cm depths was lowest under elephant grass mulch, while between row suction at 10 cm depth was lowest under wood shavings mulch than other treatments. Plastic mulch alone and in combination with elephant grass had higher suction than other mulch treatments, during most of the period of measurement.

## INTRODUCTION

Drought stress is an important factor limiting crop production even during the rainy season for soils in the humid and subhumid tropics [3,4,8,9]. The high incidence of drought stress may be attributed to a number of causes such as erratic rainfall distribution [9], high evapotranspiration rates [7], low water holding capacity of soils [8] and shallow effective rooting depths of many crops [12]. Consequently, efficient management of rain and effective utilization of soil water are vital for high and sustained yield of many rainfed crops in the humid and subhumid tropics. Soil water management and conservation assumes special significance in a crop like plantain which is sensitive to moisture stress. In addition, plantain has a prolonged growing season, the production of one crop usually extending beyond the end of the period of high soil moisture. Soil-moisture regime from

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** Requests for reprints to be addressed to O.A Opara-Nadi the end of the annual moisture cycle to the time when the bunches are harvested may therefore, affect the production potential of plantain in some agro-ecological zones.

Plantains cultivated in the early season use the rainfall to acquire adequate biomass during their vegetative growth to enable them withstand to some degree the moisture stress of the following dry season [11]. On the other hand, those established at the beginning of the late season (September) usually grow vigorously, proliferating 4-5 leaves month [10], but later most of these young plantains die off because of high moisture stress prevalent during the dry season [1].

Soil covers or mulches are beneficial to plantation crops like plantain because of their capacity to conserve moisture and make the moisture available over a long period [2]. Consequently, consumptive use of water may be considerably reduced by mulching. Information on the effect of mulching on the soil hydrological properties under plantain is lacking. Diurnal and seasonal fluctuations in soil moisture regime in the crop root zone determine the per cent and rate of survival of plantains. A knowledge of the magnitude of diurnal and seasonal fluctuations in soil hydrological properties is, therefore, important in planning for agricultural operations and in developing appropriate soil management systems for commercial plantain production.

The objective of this investigation, which is part of a detailed study on the response of plantain to mulch, was to determine the effect of different mulching materials on soil water infiltrability, soil water reserve and depletion patterns of an Ultisol under plantain in southeastern Nigeria.

## MATERIALS AND METHODS

### Location and experimental layout

The field experiments were conducted on an acid Ultisol (Oxic Paleudult) at Onne, a substation of the International Institute of Tropical Agriculture (IITA) located in the high rainfall region of southeastern Nigeria. Details of the experimental location, physical and chemical characterization of the soil and experimental layout have been reported in an earlier paper [13].

### Soil monitoring

#### *Water infiltration*

Infiltration was measured with a double-ring infiltrometer in January 1987, June 1987 and November 1987, i.e., five (5 MAP), ten (10 MAP) and fifteen (15 MAP) months after planting, respectively. Measurements were made on four replicates of each treatment and approximately at the centre of the plot. The plastic and organic mulches were carefully removed from those plots which had it before the infiltrometer was pushed into the soil. All measurements were done for 3 h and water was poured always into soil.

#### *Soil moisture*

Soil moisture samples for gravimetric moisture content determinations were taken within the plant rows and at two weeks intervals over a period of one year (August 1986 - August 1987). Samples were taken from one location in each plot and from the 0-5 cm depth. Profile moisture content (gravimetric) was determined from one location in each plot at 10 cm depth increment between 0 and 100 cm. Samples were taken at four weeks intervals within the plant rows.

#### *Soil moisture suction*

Tensiometric measurements of soil moisture suction were made at 10 cm depth between and within the plant rows in each plot using mercury tensiometers. Similarly, suction measurements at 30 cm depth were made within the plant rows only. One tensiometer was installed at each depth in each plot. All tensiometers were installed at a distance of 1 m from the plant crop. Another set of two tensiometers per plot was installed at 10 cm depth and at distances of 10 and 20 cm from the plant crop in the unmulched control, elephant grass and wood shavings treatments.

The two tensiometers for each distance were installed on opposite sides of the plant crop and directly under the leaves. A daily reading of moisture suction was made from August 1987 to January 1988 (from the peak of rainy to the peak of dry season).

## RESULTS AND DISCUSSION

### Water infiltrability

Soil water infiltrability was significantly affected by the type of mulch applied (Table 1).

Generally, infiltrability was highest at 5 MAP in all plots and decreased appreciably at 10 and 15 MAP. At 5 MAP, soil water infiltrability in all treatments followed the order: wood shavings > elephant grass on plastic > elephant grass > control > plastic on elephant grass > plastic. However, only wood shavings was significantly different from the control. Also, in comparison with the unmulched treatment, wood shavings, elephant grass on plastic and elephant grass treatments increased water infiltrability by 128 %, 40 % and 15 %, respectively. On the other hand, plastic on elephant grass and plastic treatments decreased water infiltrability by 14 % and 28 %, respectively when compared with the unmulched treatment.

**Table 1.** Effect of mulching materials on water infiltrability (cm/3h)

| Treatment | Months after planting (MAP) | | |
|---|---|---|---|
| | 5 | 10 | 15 |
| Unmulched control | 209.0a[1] | 46.1a | 24.7a |
| Elephant grass | 240.2a | 49.3a | 74.0c |
| Plastic | 150.3a | 34.0a | 30.4ab |
| Elephant grass on plastic | 292.1ab | 51.2ab | 32.4ab |
| Plastic on elephant grass | 180.4a | 37.2a | 67.3bc |
| Wood shavings | 476.0b | 112.1b | 59.6abc |

[1] Different subscripts stand for significance at P=5 % (Duncan's multiple test).

Mulching effect on water infiltrability at 10 MAP followed the same trend as at 5 MAP. However, differences in infiltrability among treatments were not very appreciable except under wood shavings mulch, which had the highest infiltrability. Only wood shavings was significantly different from the control. However, in comparison with the unmulched treatment, wood shavings, elephant grass on plastic and elephant grass treatments increased water infiltrability by 143 %, 11 % and 7 %, respectively, while plastic on elephant grass and plastic treatments decreased infiltrability by 19 % and 26 %, respectively.

At 15 MAP, water infiltrability was higher under mulch treatments than the unmulched treatment. Infiltrability was of the order: elephant grass > plastic on elephant grass > wood shavings > elephant grass on plastic > plastic > unmulched treatment. Only elephant grass and plastic on elephant grass mulches had significantly higher infiltrability than the control. When compared with the unmulched plot, infiltrability was greater by 200 %, 172 %, 141 %, 31 % and 23 % under elephant grass, plastic on elephant grass, wood shavings, elephant grass on plastic and plastic mulches, respectively.

### Soil moisture status

The effect of different kinds of mulch on gravimetric moisture in the 0-5 cm depth measured from August 1986 to August 1987 is shown in Fig. 1. Soil moisture content was higher under either elephant grass or wood shavings mulch than under all other treatments during most of the period. Among plastic, elephant grass on plastic, plastic on elephant grass and unmulched treatments moisture content varied from treatment to treatment.

Gravimetric soil moisture profiles under the different mulching treatments are shown in Figs 2 and 3 for 2nd September 1987 (13 MAP) and 7th January 1988 (17 MAP), respectively. Gravimetric soil moisture profiles in September and January represent the end of the rainy season and peak of the dry season, respectively. The incidence of crop failure because of high moisture stress prevalent during the dry season requires adequate monitoring of soil moisture content under mulching practices. At the end of rains in September, differences in moisture content profiles among all treatments was not so pronounced (Fig. 2). However, the exposed soil surface of the unmulched plot experienced high moisture losses due to evaporation during the August break (dry spell) in late August [5,6]. Moisture content differences under mulched and unmulched plots were significant within the first 30 cm of the soil depth except for the elephant grass on plastic treatment which had lower moisture content than the other treatment below the 50 cm depth. During the dry season (January), significant differences in profile moisture content among some treatments occurred only in the 0-60 cm depth.

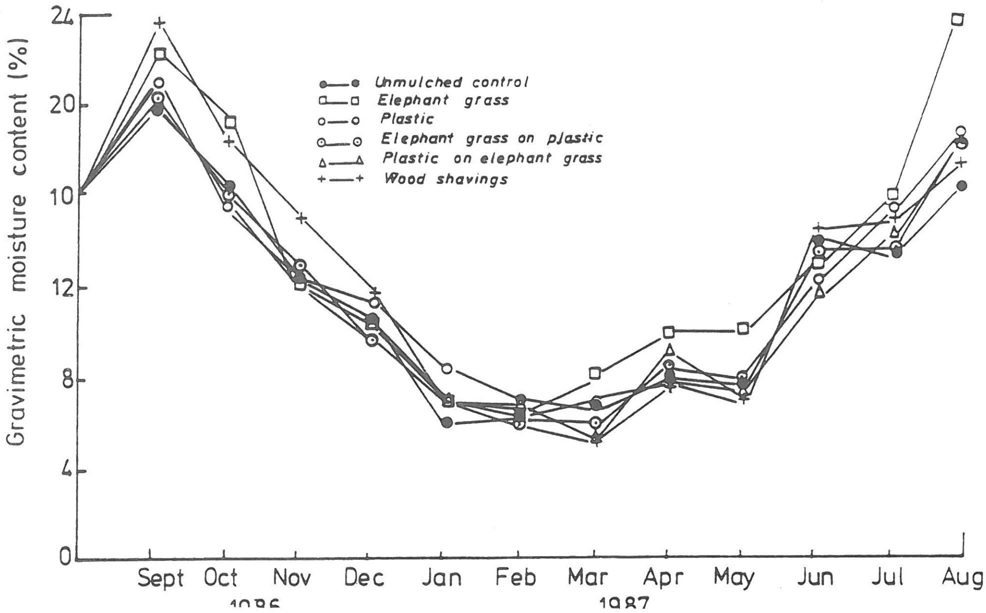


Fig. 1. Monthly soil moisture variations of 0-5 cm layer under plantain for different mulching treatments.

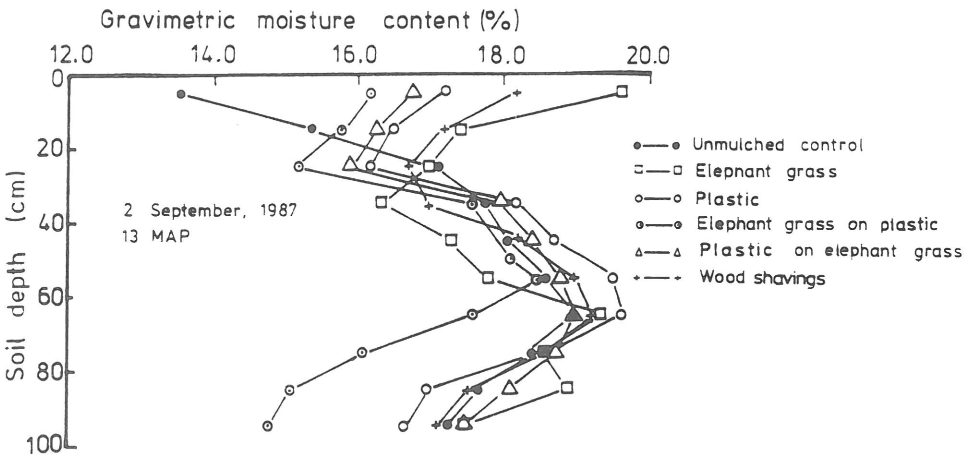


Fig. 2. Soil moisture profiles under plantain for different mulch materials in September 2, 1987 (13 MAP).

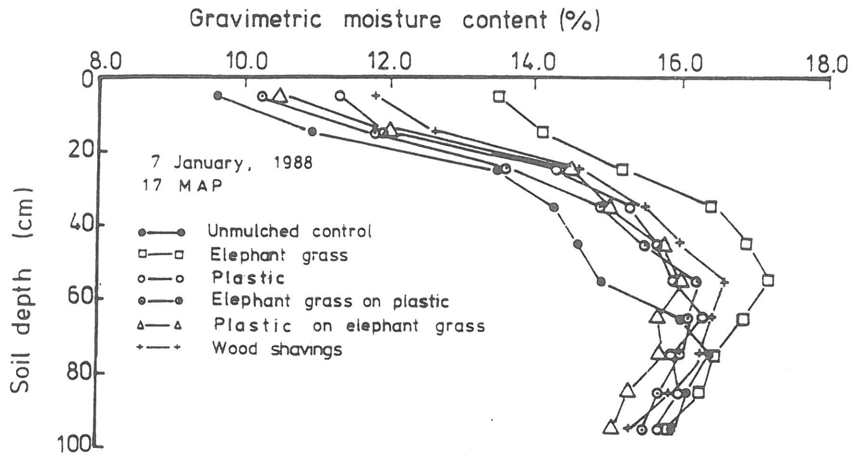


**Fig. 3.** Soil moisture profiles under plantain for different mulch materials in January 7, 1988 (17 MAP).

Soil moisture depletion was also more pronounced within this depth (Fig. 3). Elephant grass mulch maintained a higher and more favourable soil moisture reserve than the other treatments. On the other hand, soil moisture reserve was least in the unmulched treatment. The higher moisture content under elephant grass mulch than other treatments may be attributed to better plant cover and higher infiltration under elephant grass mulch before the cessation of the rains.

### Soil moisture suction

Fluctuations in soil moisture suction at 10 cm depth in December 1987 under the different mulch treatments are shown in Figs 4 and 5 for row and inter-row measurements, respectively. Fig. 6 shows soil moisture suction within the plant row at 30 cm depth. Data presented in Figs 4, 5 and 6 provide a good estimate of the changes in soil moisture from day to day and also provide additional information on moisture availability to the crop during the dry season. For the within row measurements at both 10 and 30 cm depths, suction was lowest under elephant grass treatment, whereas for the between row measurements at 10 cm depth, suction was lowest under wood shavings treatment. Among the other treatments, soil moisture suction varied from treatment to treatment in all depths both within and between the plant rows. The resaturation of the soil profile following a heavy rain on 5th December was never complete in all treatments at 30 cm depth within the plant row (Fig. 6). On the other hand, profile moisture resaturation following the rain on 5th December was complete for elephant grass, elephant grass on plastic and unmulched plots within the crop row at 10 cm depth (Fig. 4). Similarly, profile moisture resaturation between the crop rows at 10 cm depth was complete for plastic and elephant grass on plastic treatments (Fig. 5).

The effects of mulching treatments on soil moisture suction at 10 cm depth measured at 10 and 20 cm distances from the plant crop are compared for unmulched, elephant grass and wood shavings in Fig. 7. For 10 cm distance, soil moisture suction was highest in unmulched plot throughout the period of measurement. Higher suctions were recorded under wood shavings mulch than elephant grass mulch during the first 6 days only. Subsequently, suctions were identical for both elephant grass and wood shavings. On the 5th of December for example, suctions of 60, 19 and 12 centibars were recorded under unmulched, elephant grass and wood shavings

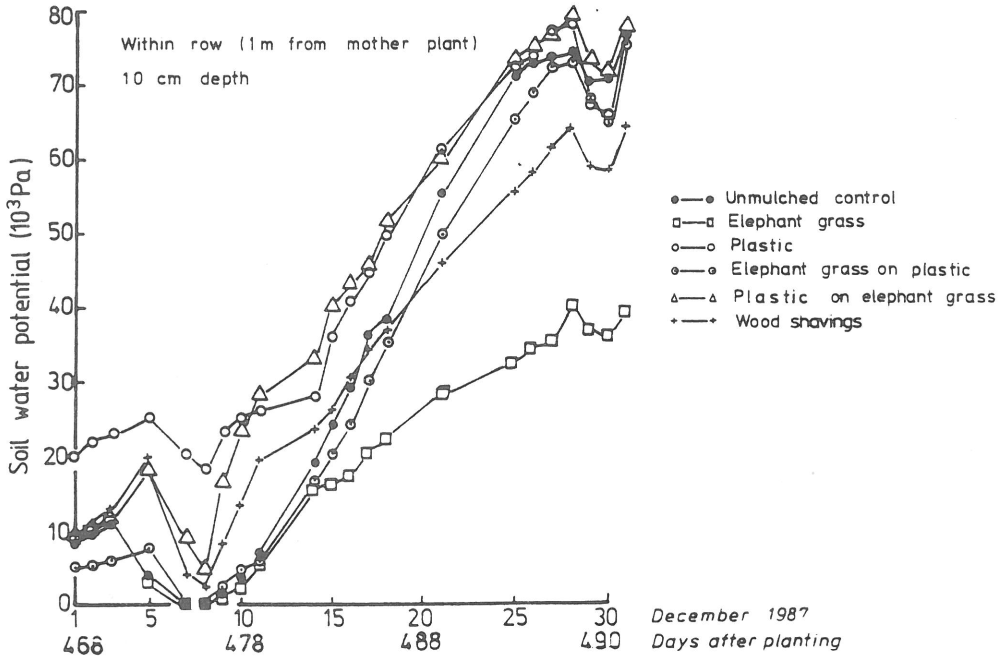


**Fig. 4.** Variation of soil water potential at 10 cm depth (within row) under plantain for different mulch materials.

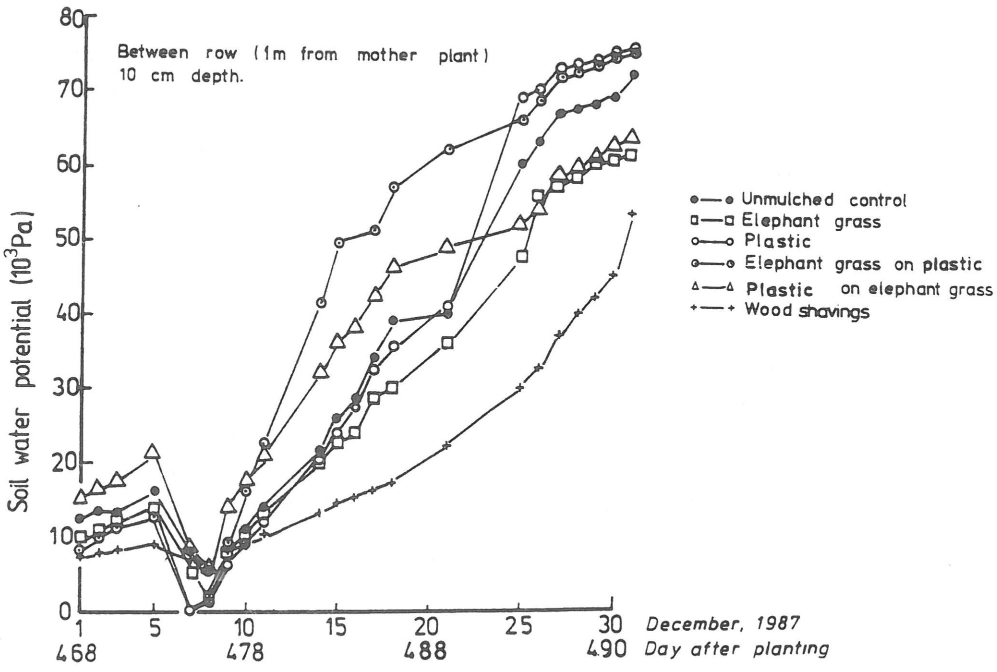


**Fig. 5.** Variation of soil water potential at 10 cm depth (between rows) under plantain for different mulch materials.

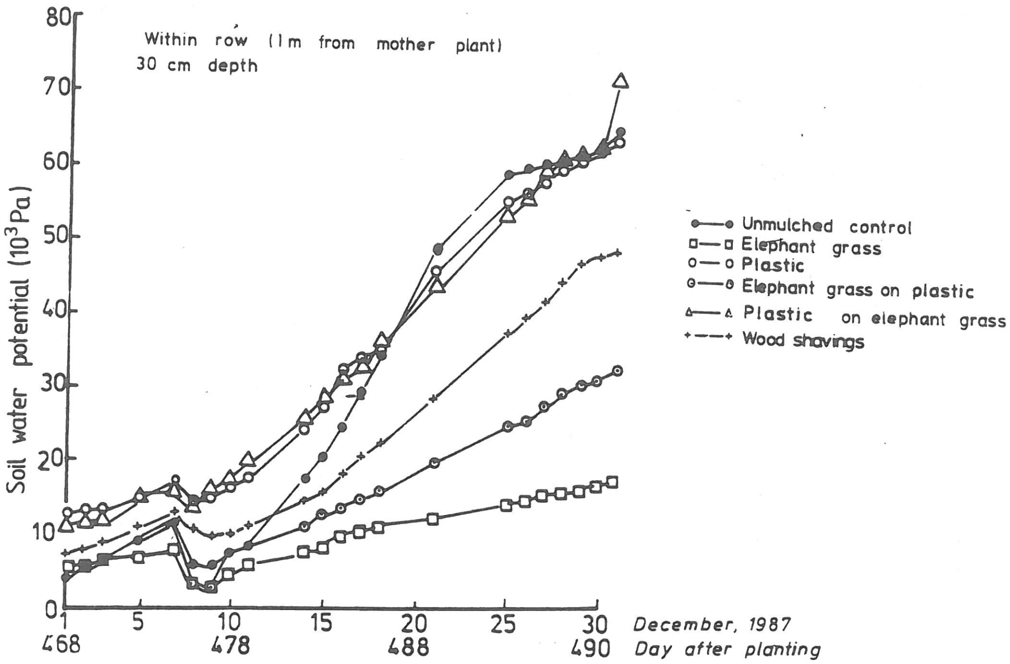


**Fig. 6.** Variation of soil water potential at 30 cm depth (within row) under plantain for different mulch materials.

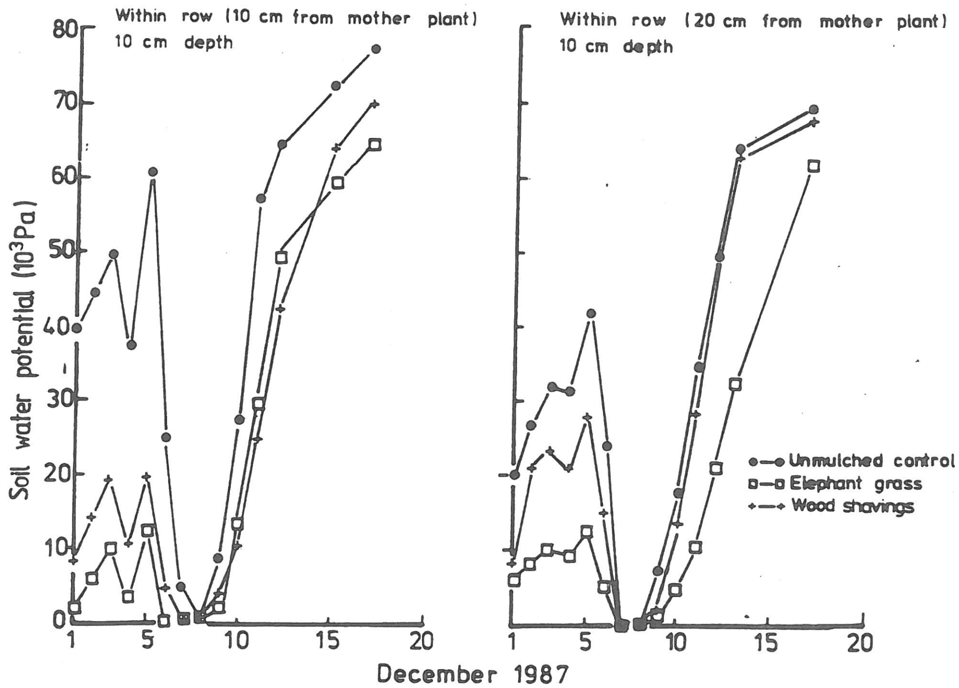


**Fig. 7.** Variation of soil water potential at 10 cm depth (within rows measured at 10 and 20 cm distances from mother crop for three mulching treatments.

treatments, respectively, whereas on the 10th of December, suctions of 27, 13 and 11 centibars respectively were recorded for the same treatments. The resaturation of the soil profile following a rain on the 5th December was attained on the 6th December for elephant grass treatment, and the 7th December for unmulched treatment. The trend in soil moisture depletion at 20 cm distance from the plant crop was similar to that at 10 cm distance. Moisture suction was lowest under elephant grass treatment throughout the period of measurement. Suctions were higher in unmulched treatment than wood shavings treatment during the first 6 days but, subsequently, suctions were identical for wood shavings and unmulched treatments. Higher suctions were recorded at 10 cm than 20 cm distance from the plant crop in the unmulched treatment during the first 6 days. The reverse was the case for elephant grass and wood shavings treatments. The resaturation of the soil profile following a rain on 5th December was attained on 7th December in all plots.

## CONCLUSIONS

1. Soil water infiltrability was highest under wood shavings mulch than under all other treatments.
2. Soil moisture content was highest for elephant grass treatment and lowest for unmulched treatment.
3. Soil moisture suction was lowest for elephant grass mulch in comparison with the other treatments.

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