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INFLUENCE OF TILLAGE AND MULCH ON SOIL WATER

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BY

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ABSTRACT

A study was conducted in late cassava field to examine the effects of tillage systems and mulch on soil water, and to establish a relationship between soil moisture tension and moisture content in Umudike soils. The tillage treatments were: conventional practice (ploughing, harrowing and ridging), minimum-tillage (digger-made narrw holes), and zero-tillage (pushing cassava cuttings directly into the soil). Mulch treatments were: no-mulch and grass-mulch at 2.5 t/ha. Soil water was measured gravimetrically and, in situ, by tensiometers. Soil water in the zero- and minimum-tillage systems was significantly higher ($P = 0.05$) than that of the conventional practice. Mulch also significantly ($P = 0.01$) increased soil water. An equation, $y = 2978.5164e^{-0.1127x}$ described moisture tension/moisture content relationship.

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INTRODUCTION

The concept of tillage is to create soil environment favourable to plant growth (Klute, 1982), yet it is responsible for major part of soil structure deterioration. Reduced tillage minimises soil manipulations, and reduces its vulnerability to erosion (Onstad, 1972; Lal, 1976). The response of crops to different tillage systems is indicative of profound changes in soil physical and chemical properties which manifest in desirable or poor crop growth and yield. These changes affect the moisture level and distribution, gas and heat exchange throughout the tilled layer (Baxter *et al*, 1983). Where high bulk density and water stress develop, poor rooting results (Philip and Kirkham, 1962; Stibble and Kadas, 1977).

It has been observed for three consecutive years that late cassava in minimum-and zero- (reduced) tillage systems suffered more from drought stress (stunted internodes and relatively small leaves) than those under conventional practice at early stages of development. This study was intended to examine the effects of different tillage practices and mulch on soil water, and to describe a relationship between soil moisture tension and moisture percentage in Umudike soils.

MATERIALS AND METHODS

The experiment was carried out at the National Root Crops Research Institute, Umudike (5°30'N, 7°30'E) with annual rainfall ranging from

2,000 to 2,500mm, most of it occuring between April and September. The texture of the surface soil (0 - 20cm) is sandy clay loam, and other selected properties are given in Table 1.

Table 1: Soil physical and chemical properties of Umudike.

Bulk density ($g\ cm^{-3}$)	Total Porosity (%)	Infiltration $mmhr^{-1}$	pH	Exchangeable Cations (me/100g)					Organic C(%)	Total N(%)	P Bray I (ppm)
				Ca	Mg	K	Na	Acidity			
1.60	39.6	39.7	5.3	0.93	1.68	0.25	0.07	2.97	2.40	0.09	3.15

The experimental design was a split-plot in a randomised complete block with mulch treatments as main plots and tillage as sub-plots. The mulch treatments were no-mulch and grass mulch at 2.5 t/ha on dry weight basis. The tillage treatments consisted of (i) conventional practice (ploughing, harrowing and ridging) (ii) minimum-tillage (digger-made narrow holes) and (iii) zero-tillage (pushing cassava cuttings directly into the soil). All treatments were replicated 4 times, and cassava cultivar, TMS 30211, was the test crop. Tilled plots were ploughed in the last week of October, 1983 and planting was done in Mid-November. Dry grass mulch was applied around each stand soon after planting and two jetfill tensiometers were installed in each sub-plot at 20cm depth. A composite of three soil samples (15-20cm depth) was taken weekly in duplicate in each sub-plot at the time tensiometer readings were made, for gravimetric analysis. Average soil mixture percentage and suction for

the treatments were analysed statistically for each month from December, 1983 to March, 1984. A linear regression analysis was adopted in showing the relationship between moisture content and logarithm of tension.

RESULTS AND DISCUSSION

The average soil moisture percentage as influenced by tillage systems and mulch is presented in Figure 1. The corresponding values of moisture tension is shown in Figure 2. There was significantly higher soil moisture content ($P = 0.01$) in reduced tillage systems for December 1983 and January, 1984, compared to the conventional tillage. Soil water in December increased by 16.7% in zero-tillage and 10.5% in minimum-tillage. In January, the increases were 19.7% and 13.7% respectively, relative to conventional practice. Soil water in February and March was significantly higher ($P = 0.05$) in zero-tillage than in conventional tillage but the differences in minimum and conventional systems were not significant. For the entire period of study, soil water increases in zero- and minimum-tillage systems over conventional practice were 14.0% and 8.7%, respectively. A similar trend was obtained from the tensiometric measurements except that a relatively higher soil moisture tension corresponded with lower soil moisture content.

When soil is tilled, total porosity is increased up to 10-19% of the original value (Kowal, 1968). This enhances vapour movement both by diffusion and by mass flow of air (Linden, 1980), resulting in an increase in moisture evaporation rate (Van Doren Jr. and Triplett, 1977;

Phillips et al, 1980). Zero-tillage on the other hand is insulated by a layer of low conductivity (dry soil) on the surface which reduces evaporation losses (Hillet et al, 1975). Possibly, it is this phenomenon of differential of evaporation that produced higher level of soil water in reduced tillage systems.

Mulch significantly ($P = 0.01$) increased soil water in December, January and February but the difference in March (with 205mm rainfall) was not significant. An increase of 18.2% over no-mulch was recorded for the entire period, and may be largely due to insulating effect of mulch on the soil surface which decreased evaporation rate.

The poor growth of late cassava on reduced tillage systems could not possibly be due to low level of soil water since it has been shown that moisture retention in these systems was remarkably higher than in the conventional practice. Other unfavourable soil physical conditions such as high bulk density and mechanical impedance could have been responsible for the poor growth. The average bulk density for the untilled soil was 1.6g cm^{-3}. That of conventional system was 1.15 g cm^{-3}. The value of mechanical impedance at 13.6% moisture content as measured by pocket penetrometer on the conventional tillage was nearly zero. Those of zero- and minimum tillage exceeded 4.5 kg cm^{-2}. This clearly indicates that under the above conditions, the young cassava roots were sharply impeded and seemed to be unable to take advantage of relatively higher moisture level beyond 15cm depth. Mulching, under the above conditions did not improve growth. The question now is how much tillage is desirable for late cassava under Umudike

conditions, to stimulate root development while at the same time eliminate excessive soil erosion during the heavy rains?

A correlation coefficient of -0.86 was obtained in the regression analysis involving the values of soil moisture content and logarithm of moisture tension shown in Figure 2 and 3. Corresponding values for the slope and y-intercept were -0.04896 and 3.4740, respectively. Using exponential function, the equation: $y = 2978.5164\ e^{-0.1127x}$, described their relationship, where y is the matric suction and x is gravimetric moisture content. This relationship is graphically shown in Figure 3.

It is hoped that the above expression will be a valuable tool in predicting soil moisture levels in sandy clay loam soils not only for Umudike but also in areas with similar eco-system.

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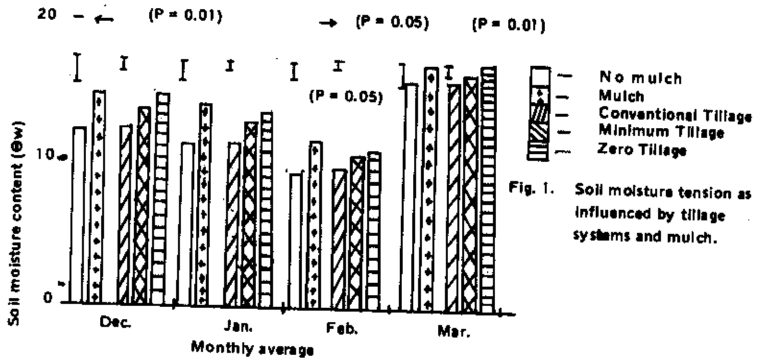

Fig. 1. Soil moisture tension as influenced by tillage systems and mulch.

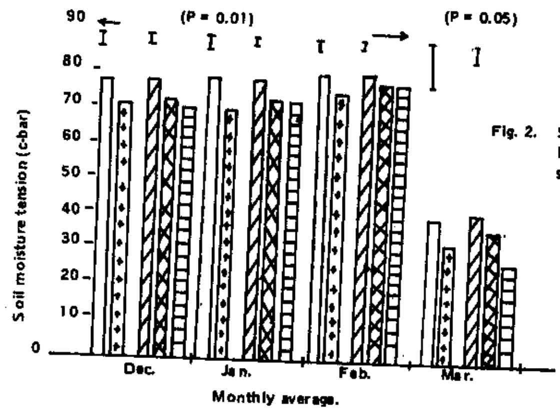

Fig. 2. Soil moisture tension as influenced by tillage systems and mulch.

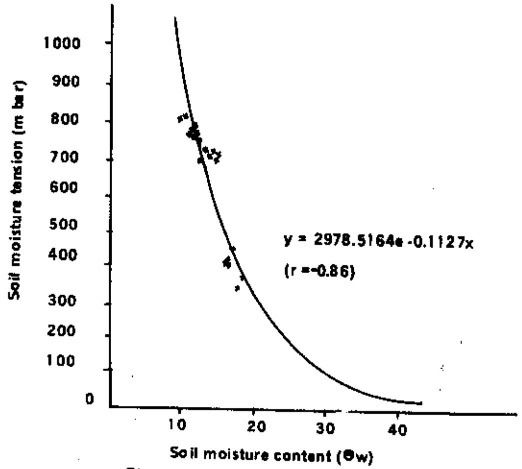

Fig. 3 Relationship between soil moisture tension and soil moisture content (Θ_w)