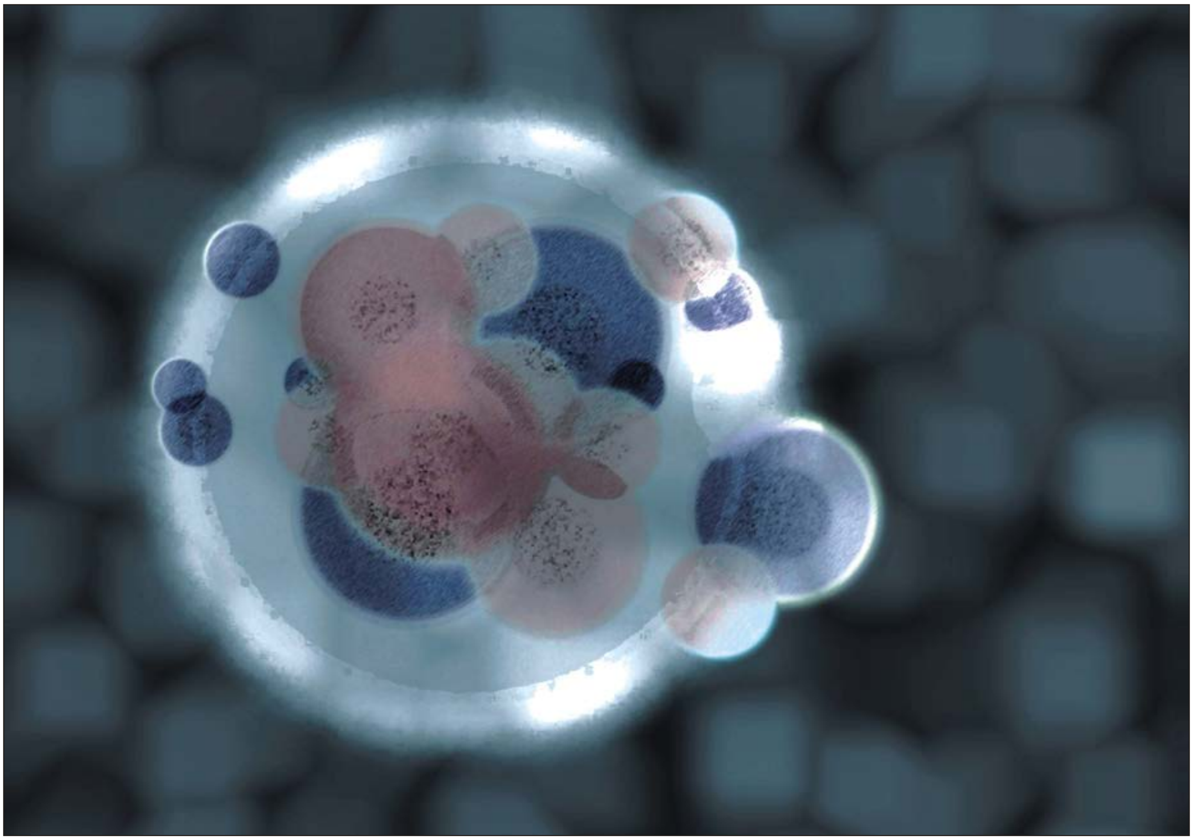

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Effect of Landform and Irrigation Frequency on Cotton (*Gossypium*) Yield in Semi-arid Zimbabwe

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Abstract: The effect of planting irrigated cotton on Tied Ridge (TR) and Flat (F) under three irrigation frequencies (75, 40 and 30% Depletion of Available Moisture, DAM) on yield and water use efficiency was studied at Chiredzi Research Station for two seasons 1990/91 and 1991/92. Growing cotton on tied ridges gave 19 and 35% more yield than on flat in the 1990/91 and 1991/92 seasons, respectively. More available moisture due to water collection on tied ridges as compared to flat was given as the reason for the yield increase. Yields were not affected by frequency of irrigation.

Key words: Cotton, semi-arid, yield, landform, irrigation frequency

INTRODUCTION

It is very important that infiltration rate is higher than the sprinkler application rate so that water is not lost as runoff. The rate of water infiltration into the soil is a universal factor in design and operation of all irrigation systems. However, the infiltration rate is dynamic and it changes greatly even in the course of the growing season especially for well-structured clay soils. This can result in irrigation loss as runoff if the water application rate is not reduced.

Runoff can be reduced by decreasing the application rate, tillage or building structures that hold water. The first option requires reduction of the nozzle size and this results in a lower application rate and the period of irrigation to replenish soil moisture will be longer therefore reducing the area under irrigation. Ripping often makes temporal small changes in storage capacity by increasing the pore size space and loosening the compacted soil. A number of studies have focused on in-field water harvesting techniques[1-4]. These in-field water harvesting techniques have demonstrated to improve soil moisture storage, prolong the period of moisture availability and enhance growth of agricultural crops[2-5].

Tillage influences local surface runoff, infiltration and surface storage by altering soil hydraulic properties and soil surface roughness[6-9]. Infiltration is increased due to increased soil porosity and breaking up of crust. Tillage operations have been reported to increase the infiltration capacity by 1 to 50 mm h^{-1} on crusted soils[9]. Some studies[10,11] have shown that tillage can reduce infiltration capacity because they disrupt pore continuity between the top and subsoil. Natural reconsolidation by the raindrop impact and the redistribution of soil particles by splash and flow[12,13] after tillage gradually reduces soil porosity and surface roughness.

The objective of this study was to determine the effect of two types of tillage systems (tied ridge and flat) and three irrigation frequency on the yield of cotton.

MATERIALS AND METHODS

The experiment was carried out on a sandy clay loam soil (chromic luvisols, typic rhodastalf) derived from paragneiss in the 1990/91 and 1991/92 seasons. A Randomised Complete Block Design with four replicates was used. The experiment treatments were a combination of two landforms (Flat, F and Tied Ridges, TR) and three irrigation frequencies (75% DAM, 40% DAM and 30% DAM). The open pan was used for irrigation scheduling.

Cotton K603 was sown at 30 cm in rows and 1 metre apart on the 28th October and 21st October in 1990 and 1991, respectively. 210 kg ha^{-1} single super phosphate and 30 kg N ha^{-1} as compound X was applied as basal fertilisers and two top dressings of 60 kg N ha^{-1} as ammonium nitrate were applied at first flowering and eleven weeks after planting. Two aluminum access tubes were installed in each plot to a depth of 90 cm in the 1991/92 season to enable weekly measurement of soil moisture.

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RESULTS

A total of 460 and 171 mm of rainfall was received in the 1990/91 and 1991/92 seasons, respectively. The rainfall was well distributed in the 1990/91 season when 34, 115, 100 102 and 78 mm were received in November, December, January, February and March, respectively. 13, 22, 41, 2 and 70 mm were received, respectively in the same months during the 1991/92 season (Fig. 1). The more rainfall received in the first season resulted in less irrigation water being applied.

Table 1: Effect of landform and irrigation frequency on cotton yield, height and water use efficiency

	1990/91			1991/92		
	Yield	WUE	Height (cm)	Yield	WUE	Height (cm)
Landform						
Flat	1512	0.244	82.00	1271	0.214	68.00
Tied ridge	1805	0.294	83.00	1723	0.291	74.00
Significance	0.05	0.05	NS	0.001	0.001	0.05
Irrigation frequency						
75% DAM	1602	0.245	87.00	1440	0.229	69.00
40% DAM	1801	0.284	83.00	1431	0.248	70.00
30% DAM	1573	0.278	78.00	1661	0.280	73.00
Significance	NS	NS	0.05	NS	NS	NS
Interaction	NS	0.05	NS	NS	NS	NS
Trial mean	1659	0.269	82.00	1497	0.252	70.70
SE Landform	79.94	0.013	1.56	70.28	0.012	1.57
SE Irrigation	97.90	0.016	1.91	86.07	0.015	1.93
CV	16.70	16.30	6.55	16.26	16.45	7.70

Table 2: Effect of landform and irrigation frequency on cotton yields.

	1990/91 season			1991/92 season		
	75 DAM	40 DAM	30 DAM	75 DAM	40 DAM	30 DAM
Tied ridge	1652	1832	1931	1604	1670	1896
Flat	1551	1770	1214	1275	1241	1347
% yield increase	7	4	59	26	35	41

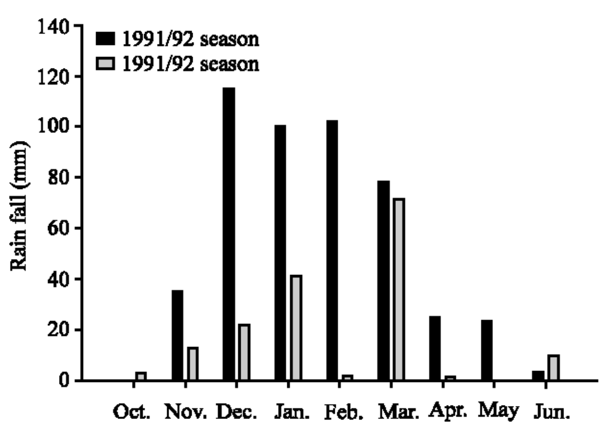

Fig. 1: Monthly rainfall distribution at Chiredzi Research Station

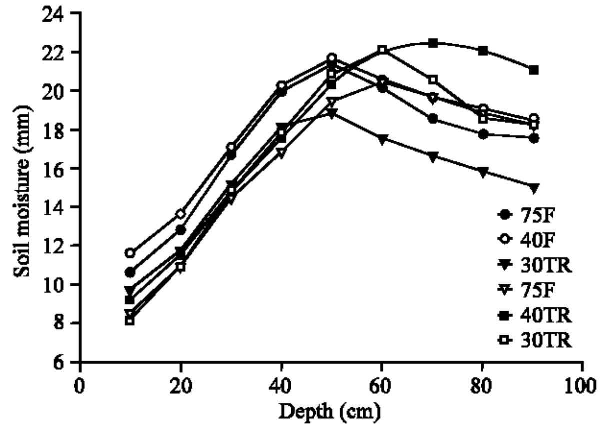

Fig. 2: Effect of landform and frequency of the average soil moisture distribution

Soil moisture was more on flat than tied ridge up to a depth of 55, 50 and 45 cm for the 75 DAM, 40% DAM and 30% DAM, respectively. Tied ridge had more moisture beyond these depth and had more total soil moisture. There was, on average, an increase in the difference in soil moisture between tied ridge and flat as irrigation frequency increased (Fig. 2) and this is also reflected in the difference in yield between tied ridge and flat that increases as irrigation frequency increased (Table 2).

More yields were obtained in the 1990/91 season than the following 1991/92 season. Tied ridging gave significantly ($p>0.001$) higher yields than flat in both years. The increase was 20 and 35% in the 1990/91 and 1991/92 season, respectively. The three irrigation frequencies had no significant differences in yield but the 40% DAM had higher yields than 75 and 30% DAM in the 1990/91 season while the 30% DAM outperformed the other two in the following 1991/91 season.

Tied ridging resulted in higher water use efficiency in both years. The percentage increase in water use efficiency of tied ridge over flat was 20 and 30%, respectively in the 1990/91 and 1991/92 seasons. There was a significant interaction between landform and irrigation frequency in the 1990/91 season when WUE increased with increase in irrigation frequency on tied ridge (Table 1).

DISCUSSION

More frequent irrigations resulted in more water being lost as runoff because the antecedent soil moisture was high each time irrigation water was applied hence there is more difference in soil moisture between tied ridge and flat because there was no runoff at all from tied ridges for they capture all the rainfall and irrigation water.

The effect of tied ridge on yield was less pronounced in the 1990/91 season than the 1991/92 season because of more and well distributed rainfall, which tends to even out the difference between tied ridge and flat. Based on these two contrasting years, tied ridging appear to be of greater value in drier years under all the irrigation regime than flat tillage.

Tied ridges have 10% more surface area than flat and this resulted in more soil evaporation taking place from tied ridge than flat hence flat has more moisture than tied ridge at about the top half of the measured profile. The more yield on tied ridge is attributed to more water that was available for use than on flat where some rainfall and irrigation water was loss as runoff. Twenty plus years of cultivation might have reduced the infiltration capacity of the soils such that the sprinkler discharge rate is now more than the soil's infiltration rate hence some of the rainfall and irrigation water is lost as runoff. Some studies have shown that tillage influences local surface runoff, infiltration and surface storage by altering soil hydraulic properties and soil surface roughness[6-9,14]. Infiltration is increased due to increased soil porosity and breaking up of the crust.

Infiltration decreased as the season progressed on flat plots because of the crusting nature of such soils. This resulted in less soil moisture compared to tied ridge that hold irrigations and rainfall. Some studies[10,11] have shown that tillage can reduce infiltration capacity because they disrupt pore continuity between the top and subsoil. Natural reconsolidation by the raindrop impact and the redistribution of soil particles by splash and flow[12,13] tillage gradually reduces soil porosity and surface roughness.

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