Conservation tillage in cotton and maize fields in Malawi

Allan D.C. Chilimba

Ministry of Agriculture and Irrigation, Soils Commodity Team, Chitedze Agricultural Research Station, P.O. Box 158, Lilongwe

Abstract

Studies were undertaken to assess the effect of conservation tillage. Three methods; flat, old ridges, and new ridges were tested, considering soil properties, root growth and cotton yields at two sites where vertisols were dominant. Another study was initiated to quantify the amount of soil water conserved by tied ridges (TR), boxed ridges (BR) and open ridges (OR) with and without maize stalk mulching at different nitrogen fertilization levels in a maize field. Two nitrogen levels (46 and 92 kg N/ha) and a contol (0 kg N/ha), were used with maize as the test crop.

The tillage systems had an effect on rooting depth, porosity, infiltration rates and available water content. The rooting depth and infiltration rate were lower for planting on flat than for ridges, however they had no effect on cotton yield at Ngabu. Cotton yields in old ridges and new ridges were slightly higher than planting on flat at Zunde. There was significant interaction between mulching and nitrogen application on soil water conserved at Bvumbwe. Soil water conserved increased as nitrogen application increased in un-mulched treatments, whereas, in the fourth year, soil water increased as nitrogen application increased in the mulched plots. Mulching reduced grain yields in the second and third year but in the fourth year, box or tied ridging improved grain yield. Mulching slightly increased grain yields in the fourth year particularly in BR.

Soil water conserved decreased as nitrogen application increased in un-mulched plots at Chitedze but in the third year, soil water conserved was decreasing as nitrogen application rate increased in mulched plots. Soil water conserved was increasing as nitrogen application rate increased in un-mulched plots. Mulching significantly reduced grain yield in NR but the differences disappeared in TR and BR in first year and second season. There was interaction between mulching and ridging techniques on grain yield. Grain yield improved with the introduction of mulched tied or box ridging, whereas, lack of mulching resulted in decrease in grain yield in BR.. Mulched BR at 46 kg N/ha out-performed all the treatments in grain yield. Mulching and nitrogen application enhanced microbial activities which is essential in nutrient recycling.

Introduction

Water is the most important natural resource that has the greatest impact on agricultural production. Inadequate and poorly distributed rainfall and poor soil fertility are the major constraints to crop production under rain-fed agriculture (Nyakatawa, 1996). Some of World Bank recommendations for drought mitigation and sustainable strategies were to encourage water infiltration and retention practices which maximize rainfall use in crop production. Also practices which reduce moisture evaporation from the soil and measures that build up soil organic matter to improve water and nutrient retention in the soils (Elwell and Rook, 1996).

In Malawi, the organic matter content of a soil was found to drop to 59 % in the first year of cultivation and nationally, crop yields were estimated to be dropping by 2% annually (Elwell and Rook, 1996). Data are available in the region showing that the current tillage practices contribute significantly to loss of rainfall as surface runoff but information showing that conservation will have immediate and beneficial effects on productivity and inputs is lacking. In Malawi, quantitative data for predicting the potential of soil erosion and for determining critical land use management alternatives do not exist (Kapila and Mwafongo, 1995). Results reported from station and farm showed that tied ridges significantly increased yields of crops and economic returns to additional labour required for tied ridges on maize (Jones *et al.*. 1987; Nyamudeza, 1987; Jones and Nyamudeza, 1991). Boxed or tied ridges increase water infiltration into soil and reduce soil erosion, thereby, increasing the profile water content (Sanders, 1988; Ashworth, 1990; Hulugalle, 1987; Saka *et. al.,*1995).

High levels of crop yields are seldom reached on vertisols due to various limitations such as tillage difficulties, low infiltration rates and permeability and nutrient deficiencies. Farmers grow their cotton on flat, ridges and old ridges and in order to assess the effects of their tillage systems on soil properties, root growth and cotton yields, the study was initiated. Maize is a staple food in Malawi and sustaining high crop yields during the present climatic change, when the region faces persistent droughts is a great challenge to all scientists. Priority areas of research are the control of run-off and soil erosion, the improvement of rainfall infiltration and soil water balance and promotion of integrated management of crops and leguminous tree-crops to enhance land unit productivity.

Table 1. The effect of tillage on rooting depth, infiltration rate and cotton yields at Ngabu.

Tillage systems	Infiltration rate (cm/hr)	Rooting depth (cm)	Cotton yields (kg/ha)
Planting on flat	3.27	40	2742
Planting on old ridges	8.38	54	2808
Planting on new ridges	9.41	51	2642

Table 2. Effect of tillage systems on infiltration, available soil water, porosity and cotton yield.

Tillage systems	Infiltration rate (cm/hr)	Available water Content (%)	Porosity (%)	Cotton yield (kg/ha)
Planting on flat	15.63	8.97	49.95	1650
Planting on old ridges	18.87	11.50	56.60	1728
Planting on new ridges	18.94	13.33	56.5	1723

Rain-fed agriculture provides an important contribution to the subsistence of smallholders who represent 85% of all farmers. Such farmers are dependent upon rainfall reliability. In a country with a high human population with high land pressure, the benefits of water conservation could be considerable in increasing maize yields. The only feasible alternatives to improve soil water availability for crops are off-field water harvesting to supplement rainfall, the prevention of run-off losses from the field and the control of water within field run-off to ensure maximum utilization by the crop. Malawi suffers from persistent droughts, which greatly affect the yields of many crops produced by smallholder farmers for they depend on rain-fed agriculture.

The objectives of the experiments were, to study the effect of different tillage systems on:

- soil properties,
- root growth and cotton yields,
- to quantity the effects of water conservation techniques on soil water conserved,
- to determine the contribution of the water conserved on the yield of maize and
- to determine the interaction of water conserved and nitrogen application on maize yield.

Materials and methods

Conservation tillage on vertisols was done on cotton at Ngabu and Zunde in Shire valley. The land was ploughed by oxen drawn plough and ridges were also made by ox drawn ridger. The treatments consisted of planting on flat, planting on old ridges and planting on new ridges. The experiment was laid out as randomized block design with six replications. Plot size was 6 metres by 5 ridges and the ridges were spaced at 91 cm.

Conservation tillage was also conducted at Bvumbwe in Shirehighlands and at Chitedze in Lilongwe plain. The trial was laid out as Randomized Complete Block Design with three replicates. The treatments of the experiment consisted of boxed ridges (BR), tied ridges (TR) and open ridges (OR) with and without mulching at three levels of nitrogen application, 0, 46 and 92 kg N/ha.

The ridges were spaced at 90 cm apart and three seeds were planted per station spaced at 90 cm apart. Twenty kilogram of maize stalks was placed in the furrow as a mulch in each plot for the mulching treatments. Urea and 23.21.0 +4S were used as the sources of nitrogen and phosphorus respectively. MH 17 was the maize variety used. The same field was used throughout the years in order to assess cumulative effect of mulching on soil water conservation.

The soil water measurements started two weeks after emergence, and thereafter, every two weeks using gravimetric method (direct method). The two middle ridges by 4 metres was the net plot where grain and soil water data were collected. Microbial carbon was determined in the third year at Chitedze.

Results and discussions

Conservation tillage in cotton fields

Tillage systems affected rooting depth and infiltration rate at Ngabu. The rooting depth and infiltration rate were lower on planting on flat than planting on ridges. However cotton yields were slightly higher planting on old ridges than on flat or new ridges.

At Zunde, old ridges and new ridges had higher porosity, infiltration rates and higher available water content than planting on the flat. Cotton yields in old ridges and new ridges were slightly higher than planting on flat. The infiltration rates were higher at Zunde than at Ngabu because Zunde had a more typical vertisol than at Ngabu and as a result, there were more

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cracks at Zunde than at Ngabu which increased infiltration rate.

Conservation tillage in maize field

At Bvumbwe where the soil was sand loam, mulching increased the amount of soil water. There was interaction between mulching and ridging techniques in sub soil. Mulching significantly increased soil water conserved in TR and BR but the difference decreased in OR (Figure 1a). There was significant interaction between mulching and nitrogen application on soil water conserved in the second year. Soil water conserved increased as nitrogen application increased in un-mulched treatment (Figure 1c) whereas, in the fourth year, soil water increased as nitrogen application increased in mulched treatment (Figure 1d). Mulching reduced grain yields in second year (Figure 2e). In the fourth year, box or tied ridging improved grain yield both in mulched and un mulched plots (Figure 2f). Mulching did not reduce in OR or TR but increased grain yield in BR although heavy rainfall was experienced in the season.

Nitrogen application helped to conserve soil water in the second year in un-mulched because the nitrogen gave vigorous vegetative growth. Bvumbwe is in the Shire highlands where temperatures are low compared to Lilongwe plain which reduced evapotranspiration resulting in an increase in soil water conserved. However, in the fourth year, soil water increased with nitrogen application in mulched treatment while un-mulched was not affected by nitrogen application.

The contribution of decomposed maize stalks used as a mulch helped to improve water holding capacity of the soil which led to an increase in nitrogen use efficiency and resulted in good vegetative cover which reduced evapotranspiration.

At Chitedze where soil is sandy clay loam, the first year of the experiment, soil water conserved was attained at 46 kg N/ha in mulched plots (Figure 3a). Soil water conserved decreased as nitrogen application increased in un-mulched plots (Figure 3a). In the third year, soil water conserved was decreasing as nitrogen application was increased in mulched plots, whereas, in un-mulched, soil water conserved was increasing as nitrogen application increased (Figure 3b).

Chitedze is in Lilongwe plain where temperature is higher than Shire highlands. Nitrogen application resulted in vigorous vegetative growth but consumptive use of soil water by the maize plant increased and evapotranspiration was also high due to higher temperature, soil water conserved decreased with nitrogen application.

However, the trend changed in the third year, soil water conserved decreased with nitrogen in mulched while un-mulched was not affected. The mulched gave vigorous plant growth and gave higher maize yields. As a result the water consumptive use was higher than in un-mulched and the higher evapotranspiration led to decrease in soil water with nitrogen application. In the third year also, soil water conserved increased with nitrogen application in un-mulched, which could indicate that the maize plants helped to reduce surface evaporation.

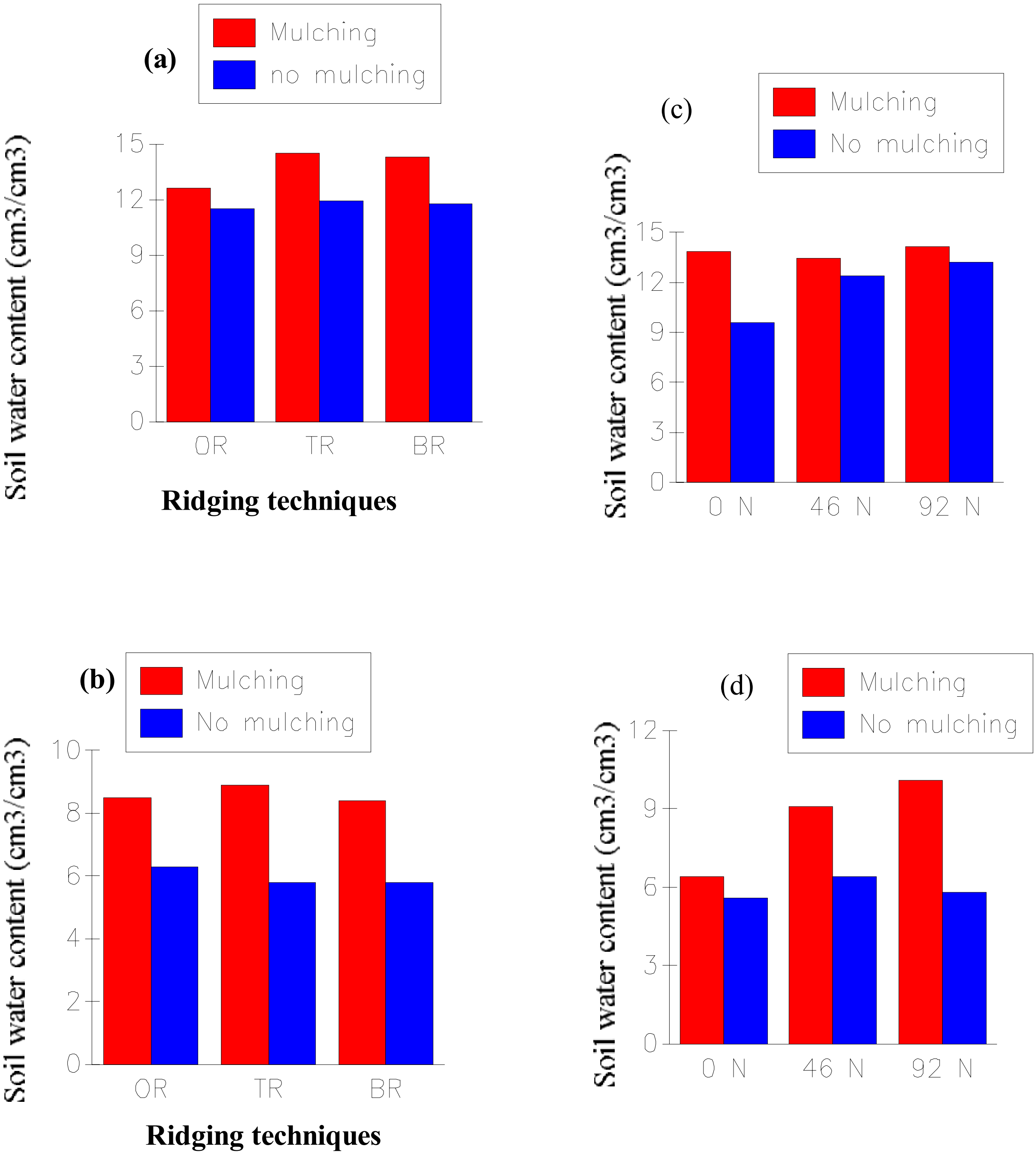
Mulching significantly reduced grain yield in OR and TR in first year. In second year, mulching reduced grain yield in BR. Mulching improved grain yield in BR (Figure 3e).

There was three-way interaction between mulching, nitrogen and ridging techniques on grain yield. Mulched BR at 46 kg N/ha outperformed all the treatments in grain yield (Figure 4a). Mulching and nitrogen application enhanced microbial activities which is essential in nutrient recycling (Figure 4b).

At all sites, continuous growing of maize in the same field resulted in decline in grain yield.

Conclusion

Mulching and nitrogen application enhanced microbial activities which is essential in nutrient recycling. The use of crop residue such as maize stalk, which has high C/N ratio as a mulch improved maize yield in third and fourth year. This showed that the use of maize stalk can enhance sustainable cropping systems for small holder farmers in Malawi.



Key: OR = Open ridging
TR = Tied ridging
BR = Box ridging

Figure 1: Soil water conserved as affected by ridging techniques, nitrogen application and mulching at Bvumbwe

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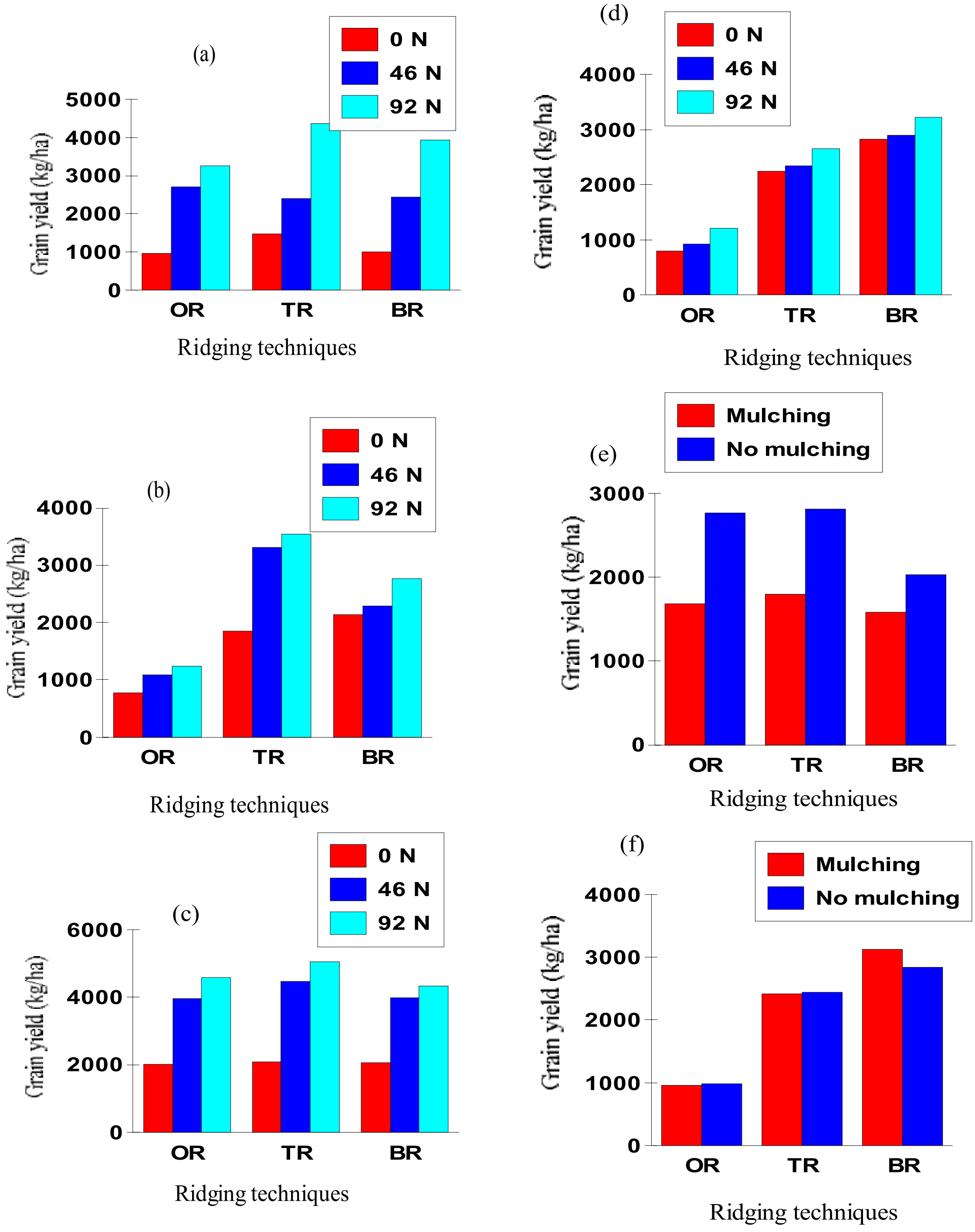


Figure 2. Grain yield (kg/ha) as affected by ridging techniques, nitrogen application and mulching at Bvumbwe.

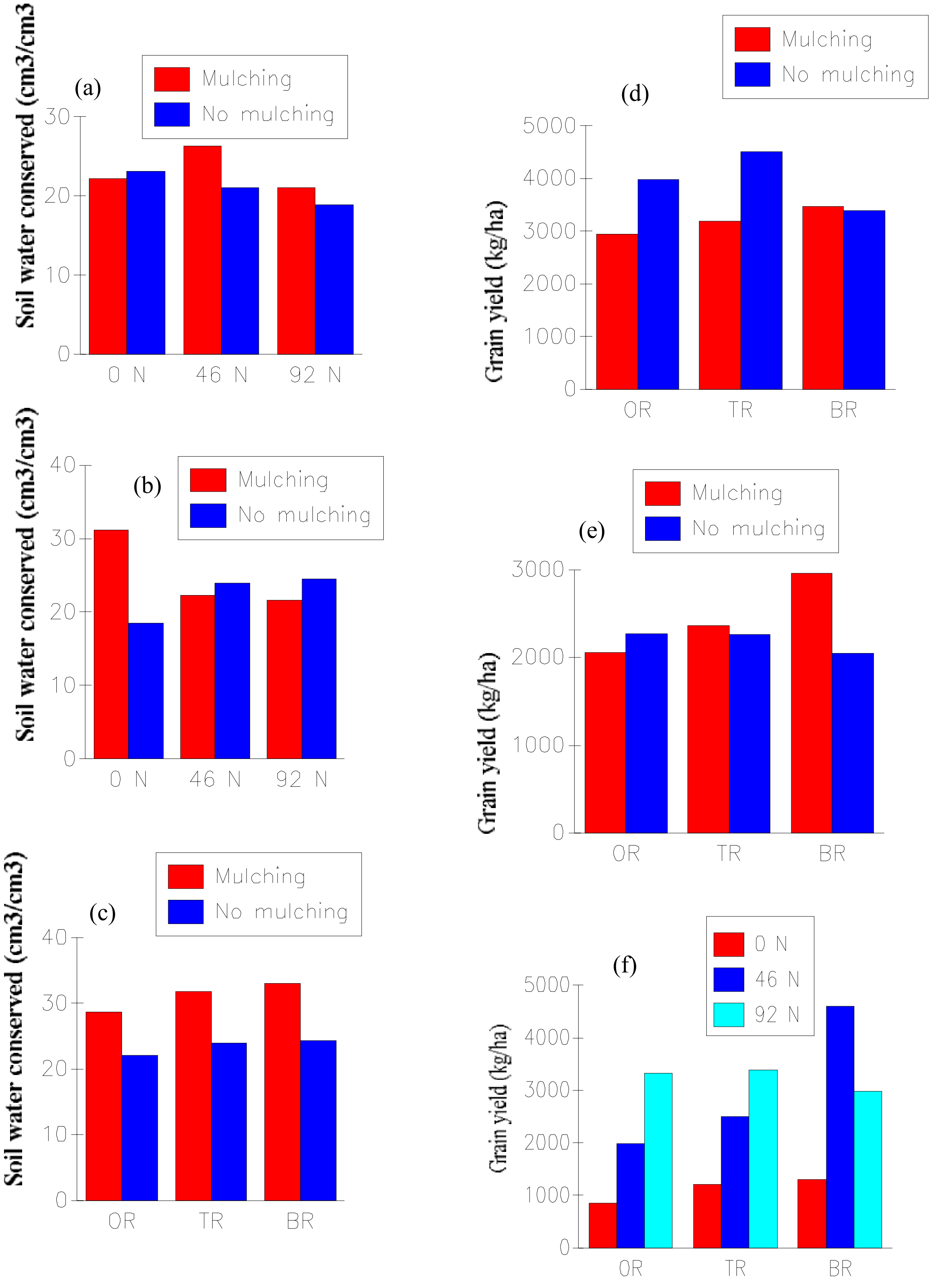
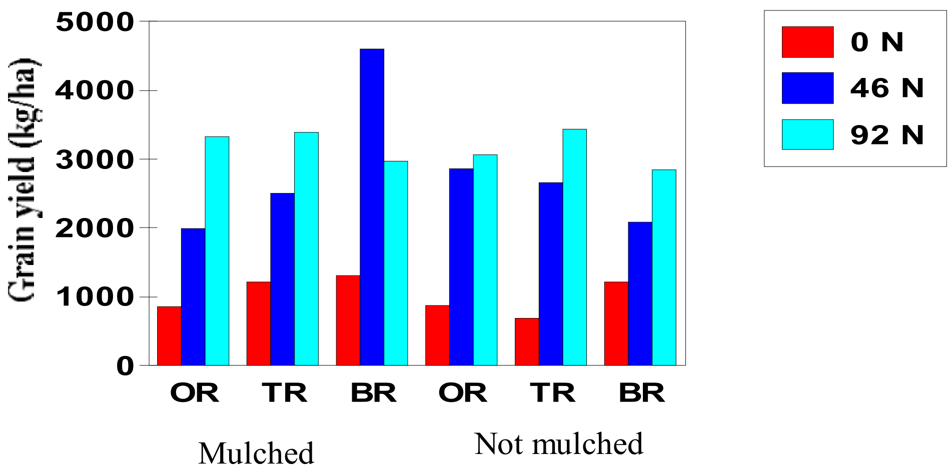


Figure 3: Water conserved (cm^3/cm^3) and grain yield (kg/ha) as affected by mulching and nitrogen; mulching and ridging techniques (a, b, c) and (d, e, f) respectively, at Chitedze

(a)



(b)

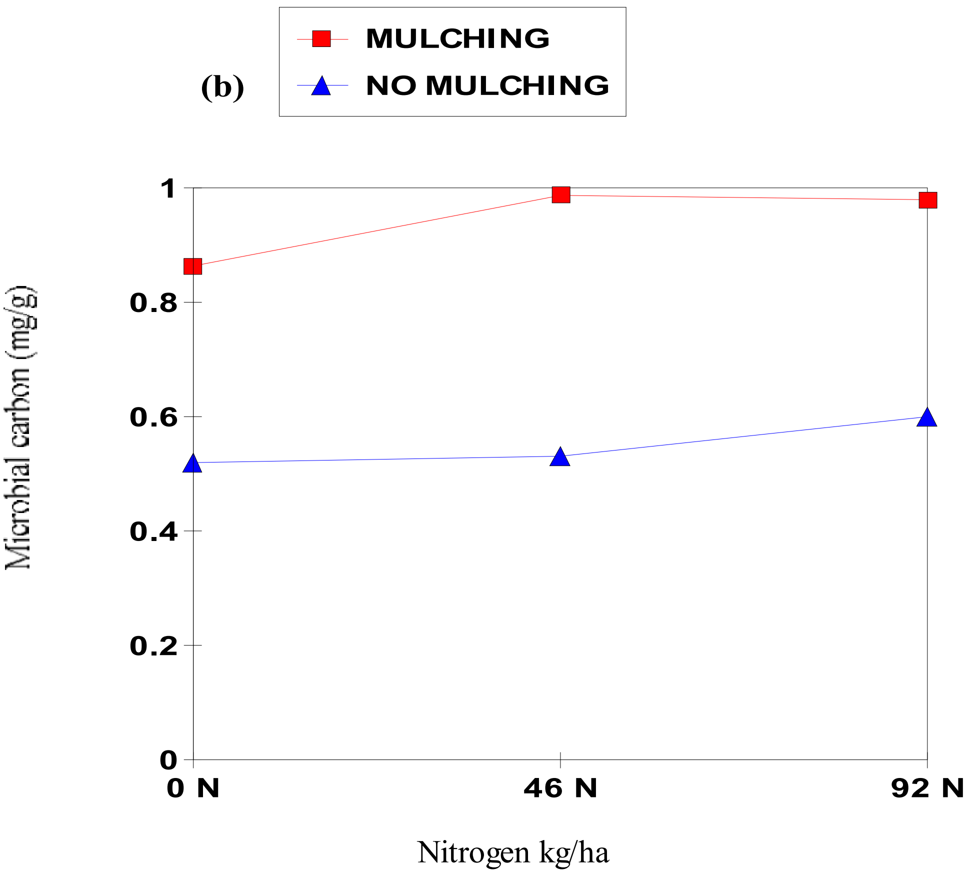


Figure 4: Grain yield as affected by ridging, mulching and nitrogen (a) and microbial carbon (b) as affected by mulching and nitrogen application at Chitedze

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