THE EFFECTS OF GREEN-CANE TRASH BLANKET ON SOIL TEMPERATURE, SOIL MOISTURE AND SUGARCANE GROWTH

By

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Abstract

GREEN cane harvesting and trash blanketing (GCTB) is being increasingly adopted in the sugarcane area of Tucumán Argentina. These practices result in lower environmental impacts, cost reduction in weed control, and an improvement in soil moisture conservation. The effects of a trash blanket on the soil temperature and soil moisture regimes were studied in a field trial by comparing burning of post-harvest residues (BC) and GCTB systems under irrigated and rainfed conditions during four growing periods. The impact on stalk population, stalk growth, number of leaves and weight of millable cane was evaluated. Soil temperature was 1.5°C higher at emergence and tillering where the residue was burned as compared to the GCTB system. After these periods, the differences were no longer significant. In all cases, the temperature remained above the 10.5°C base temperature for Tuc 77-42 growth. The trash blanket also modified the soil moisture regime, and variations in soil moisture were closely related to rainfall distribution. Periods with moisture contents above 40% of the available water in the top 45 cm were 40 days during dry springs and 80 days during humid springs for the GCTB whereas, in the burnt residue plots, they were 20 days and 50 days, respectively. Differences in the number of stalks at harvest were not obtained for the two systems; however, there were more shoots where the residue was burned at the tillering phase. Changes in the temperature and moisture regimes in the top 45 cm caused by the trash blanket had no adverse effect on cane yield. This information can be used by the growers of Tucumán to justify the adoption of green cane trash blanketing in their farming operations.

Introduction

Sugarcane production without burning, i.e. green cane harvesting, is being increasingly adopted by growers of Tucumán. One of the main reasons for the adoption of green cane systems is the significant reduction in trash levels in cane delivered to the factories under various field conditions caused by the incorporation of new technologies in the mechanical harvesters.

The Tucumán sugarcane area has a moderate to severe soil water deficit in the spring when a low level of available water is a limiting factor for shoot-emergence and tillering (Torres Bruchman, 1979; Fogliata, 1995; Romero, 2000). Cane grown on alluvial sandy loam and loamy sand soils represents 50% to 62% of the area and is severely affected by low moisture levels. Furthermore, the area lies between latitudes 26°30’ and 27°00’ south, and the temperature remains below the sugarcane growing threshold for at least three months. Low temperature is also a limiting factor during the early stage of growth (Torres Bruchman, 1979; Fogliata, 1995).

Changes in the soil temperature regime caused by the GCTB system are mentioned in several research works. Thompson (1966) found that the temperature measured at 8:00 am at a depth of 2.5 cm was 4°C lower in the GCTB system as compared to BC system. Page et al. (1986) registered a temperature that was 3°C higher at a depth of 15 cm in BC. Wood (1991) showed that maximum and minimum temperatures were higher and lower respectively at the 5 cm depth in BC. These researchers agreed that differences disappear when the cane canopy shadows the soil surface.

Several researchers have studied the effect of GCTB on soil water regimes (Mourombo et al., 1997; Prove et al., 1989; Wood, 1986). All of them concluded that the trash blanket reduces evaporation losses. Prove et al. (1989) found that the water content was 3% to 4% higher in the top 30 cm under the
trash blanket. Wood (1986) showed that water content was 15% higher under a GCTB during the three months following harvest, but differences disappeared as soon as the rainy season began. Mourombo et al. (1997) also found that the trash blanket reduced water losses by 288 mm and this reduction was as high as 47% of the cane water consumption under BC.

Changes in soil temperature and moisture regimes influence tillering and growth to different extents, depending on the growing conditions of the area. Page et al. (1986) points out that the cane canopy is comparatively greater from September to early November in BC, but differences tend to disappear from late November onward. Torres and Vallegas (1995), working with ratoon crops, found that the GCTB reduced shoot growth after harvest, but there were no differences between systems six months later. The latter was confirmed by Chapman (2001) who showed that growth differences between BC and GCTB systems in crops harvested early, and at the end of the season, were no longer noticeable after 100 days and 40 days, respectively.

With respect to cane and sugar production, research work carried out in various sugarcane areas of the world have produced different results. Studying soil losses caused by water erosion in Queensland, Prove et al. (1989) did not find differences in cane production between BC and GCTB systems in fields where weeds were controlled by herbicides. Wood (1991) found cane yields to be 10 t/ha higher under the GCTB compared to the BC system. He also pointed out that cane yields were 1.6 t/ha higher in BC than GCTB in poorly drained soils. Finally, Murombo et al. (1997), in Zimbabwe, found a 14.4 t/ha difference (30%) in favour of GCTB when both systems were compared.

Since several references stress that low temperatures and low moisture contents during early spring in Tucumán negatively affect emergence and tillering and that the trash blanket modifies soil moisture and soil temperature regimes, this research work was carried out to determine the GCTB effects on the sugarcane crop’s initial growth and yield production.

Material and methods

To evaluate the effect of crop residues on soil temperature, soil water regimes and sugarcane growth rates and yields, a field trial was carried out in Tucumán, Argentina from September 1996–2000, over 4 harvest seasons (Table 1). Two crop residue management practices, BC and GCTB, were compared under irrigated and rainfed conditions.

The treatments were replicated four times in a randomised block design. The plot size was 112 m² and the evaluations were carried out in 80 m² corresponding to 5 central rows. The variety was TUC 77–42 (Mariotti et al., 1987) and was planted in September, 1996.

Cane was manually harvested green, and cane residues (leaves and tops) were spread over the soil surface to simulate mechanical harvesting. Crop residues were burnt 2 to 3 days after harvest in the BC plots. In the irrigated plots, 50 mm of water was applied when the moisture content in the soil went below 40% of available water.

Soil temperature was measured at 9:00 am twice per week at a 12 cm depth. Two measurements were carried out in each plot on both sides of the cane rows, in the soil volume where maximum root growth takes place. Every week and in every plot, the soil water content was determined gravimetrically in the 0–15 cm and 15–45 cm layers on both sides of the rows. Soil temperature and humidity were determined under irrigated and rainfed conditions.

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>pH</th>
<th>Texture</th>
<th>Organic matter %</th>
<th>Soil salinity ohms (15.6 °C)</th>
<th>P Bray II (ppm)</th>
<th>K Cmol+/kg</th>
<th>Wcc %</th>
<th>Wpm %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–25</td>
<td>6.4</td>
<td>Loam</td>
<td>2.8</td>
<td>1200</td>
<td>40</td>
<td>1.0</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>25–50</td>
<td>6.5</td>
<td>Clay loam</td>
<td>1.6</td>
<td>1145</td>
<td>38</td>
<td>1.1</td>
<td>28</td>
<td>14</td>
</tr>
</tbody>
</table>

Sugarcane growth rates were determined bi-weekly during the early stages of growth by counting the number of shoots per plot and taking representative stalks to determine stalk height from the soil surface to the youngest visible dewlap on 15 shoots per plot, and counting the number of green leaves on 15 shoots per plot. The number and the weight of millable stalks in each plot were determined at harvest.
Statistical analyses of the soil temperature, soil moisture, and vegetative parameters (stalk number and length and number of green leaves) data were made using ANOVA. Differences between means were tested using Tukey's test (0.05). In Figures 1 to 5, horizontal lines and dotted lines indicate the periods in which differences between treatments were statistically significant and not significant, respectively.

Results and discussion

Soil temperature

A reduction in soil temperature, ranging from 0.6°C to 3.6°C (average 1.5°C) was recorded under the GCTB compared to BC (Figure 1). Differences occurred at emergence and tillering, but disappeared when the cane canopy closed the inter-row. These results are in agreement with those reported by Thompson (1966), Page et al. (1986) and Wood (1991). Differences between treatments in soil temperature were lower in irrigated plots.

Soil Moisture

The soil moisture regime was affected by the GCTB system and these effects were closely related to the amount and sequence of rainfall.

Available soil water content in the top 45 cm remained over 40% for 5 days in dry and 35 days in wet springs in the GCTB system while this occurred during 4 and 20 days, respectively, in the BC system.

The 40% available water threshold was taken as the minimum water content below which sugarcane growth decreases (Fogliata, 1972).

The presence of crop residues in irrigated plots reduced water requirements to only two applications; both brought a total amount of 90 mm of water to the soil.

This was enough to keep the moisture content above 40% of the available water. Water requirements were higher in BC plots with 170 mm being needed to keep soil moisture at a similar level of available water. These results confirmed those obtained by Mourombo (1997).
Fig. 2—Moisture regime of the top 45 cm soil under green cane trash blanket (GCTB) and burnt cane (BC) residue management systems. Averages of moisture contents were determined during 2 wet (A) and 2 dry growing seasons (B).

- Period during which differences were statistically significant at 5%.
- Period during which differences were not statistically significant at 5%.

Stalk height and number of green leaves
There were no differences in stalk height (Figure 3) and number of green leaves (Figure 4) between the BC and GCTB systems both in irrigated and non-irrigated plots.

Fig. 3—Changes in cane stalk height during the growing period under green cane trash blanket (GCTB) and burnt cane (BC) residue management systems. Averages of 4 growing seasons.

- Period during which differences were not statistically significant at 5%.
In this study, the positive effect was reduced to a great extent due to severe water stress in both treatments, during the early stages of crop growth in the 96/97 and 97/98 growing seasons from August through November. From this period onward, moisture contents were high under both residue management systems.

**Number of stalks**

During the early stages, the number of stalks per metre of row was higher in the BC treatment (Figure 5). This treatment had 3.8 more stalks per metre than the GCTB treatment at the beginning of the tillering stage, but this difference disappeared at canopy closure.

**Sugarcane yield**

Cane yields ranged from 81 t/ha to 101 t/ha and differences were not statistically significant between treatments for any of the 4-harvests (data not presented). The GCTB system has been shown to produce higher yields under rainfed conditions as a result of a more efficient utilization of soil moisture (Wood, 1991; Mourombo, 1997).

In this study, the positive effect was reduced to a great extent due to severe water stress in both treatments, during the early stages of crop growth in the 96/97 and 97/98 growing seasons from August through November. From this period onward, moisture contents were high under both residue management systems.

Figure 2 (B) shows the variations in available moisture during these growing seasons (average values of both periods) in which water content was very low after harvest, and there was almost no rainfall.
during the following 60 days. On the other hand, the 1998-1999 and 1999-2000 campaigns showed small water deficits, at the beginning of the season lasting only for short periods (Figure 2 A). At the same time, they coincided with the period of the year when temperatures are low (Figure 1).

Conclusions

The GCTB management system produced changes in the soil moisture and soil temperature regimes when compared to the BC residue management system. These changes were highly dependent on the amount and sequence of rainfall. However, changes in soil moisture and soil temperature had no effect on cane yield under Tucumán conditions when compared to the BC system.

The number of stalks was higher at the beginning of each period of growth in BC; but this difference also was no longer present at harvest. Stalks length and number of green leaves did not show differences between the residue management systems.

Though differences in crop yield were not obtained, the GCTB system may have several advantages when compared to the BC system. Crop residues on the soil surface may reduce weed populations and weed control costs (McIntyre, 1996; Richard, 1999); reduce water losses by evaporation and water requirements in the area under irrigation as evidenced in this study; and reduce soil erosion in sloping areas (Prove et al., 1989).

Finally, a green-cane harvest/GTCB residue management system may also improve environmental conditions, since burning cane prior to harvest or burning crop residues after harvest contribute significantly to the contamination of the atmosphere. These results suggest that GCTB does not reduce cane yields and can be adopted by local cane growers in Tucumán.

REFERENCES


LES EFFETS DU PAILLIS COMPLET SUR LA TEMPÉRATURE ET L'HUMIDITÉ DU SOL ET SUR LA CROISSANCE DE LA CANNE À SUCRE
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MOT-CLES: Tallage, Rejet (Spurning), Rendement.
Résumé
Le paillis complet après une récolte en vert est de plus en plus adopté dans la région cannière de Tucumán en Argentine. Cette pratique a pour effet de réduire les coûts encourus pour le contrôle des mauvaises herbes - avec une incidence moindre sur l'environnement - et d'améliorer la conservation de l'humidité du sol. Les effets du paillis complet sur la température et sur l'humidité du sol ont été étudiés dans un essai au champ en comparant les parcelles où le paillis était brûlé après la récolte à celles où le paillis complet était pratiqué, sous des conditions pluviales et irriguées, pendant quatre périodes de croissance. L'impact sur le nombre et la croissance des tiges, le nombre de feuilles et le poids de cannes usinables a été évalué. Dans le cas où le brûlis serait pratiqué, la température du sol était de 1.5°C supérieure durant les périodes de germination et de tallage par rapport au traitement avec un paillis complet. Par la suite, les différences n'étaient plus significatives. Dans tous les cas, la température est demeurée au-dessus de la température de base de 10.5°C pour la croissance de Tuc 77-42. Le paillis complet a également modifié le régime d'humidité du sol et les variations étaient étroitement liées à la distribution de la pluie. Les périodes durant lesquelles le taux d'humidité était supérieur à 40% de l'eau disponible dans la couche arable de 45 cm ont été de 40 jours pendant la période sèche du printemps et de 80 jours pendant les périodes humides pour le paillis complet, alors que dans les parcelles où les résidus étaient brûlés, elles étaient de 20 jours et de 50 jours, respectivement. Aucune différence dans le nombre de tiges à la récolte n'a été obtenue entre les deux pratiques ; cependant, il y avait plus de tiges à la phase de tallage là où le résidu avait été brûlé. Les changements de régime de température et d'humidité de la couche supérieure de 45 cm provoqués par le paillis complet n'ont eu aucun effet dépressif sur le rendement de la canne. Cette information peut être utilisée par les cultivateurs de Tucumán pour justifier l'adoption de la récolte en vert suivie du paillis complet.

VARIACIÓN DE LA TEMPERATURA Y HUMEDAD DEL SUELO BAJO RESIDUOS DE COSECHA, Y SU IMPACTO EN EL CRECIMIENTO Y RENDIMIENTO DE LA CAÑA DE AZÚCAR
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KEYWORDS; Brotación, Rendimientos de Caña.
Resumen
La cosecha en verde y el manejo del Cultivo con Residuos de Cosecha en Superficie (GCBT) han experimentado una gran difusión dentro del área cafetera de Tucumán, Argentina. Estas prácticas producen un bajo impacto ambiental, una reducción en los costos de control de malezas y favorecen la conservación del agua. Con el objetivo de evaluar el efecto de la conservación de los residuos de cosecha sobre la temperatura y humedad del suelo, se compararon los sistemas de manejo con quema y GCTB durante 4 años en un campo experimental, en un suelo Argiudol Típico bajo condiciones de riego y secano. Se evaluó además el impacto en la población de tallos, altura de tallos, número de hojas y rendimiento cultural de la caña. Se utilizó un diseño experimental en bloques aleatorizados con 4 réplicas, con un tamaño de parcela de 112 m², las determinaciones se llevaron a cabo en 80 m² correspondientes a los 5 surcos centrales. La temperatura del suelo fue 1.5°C mayor durante la brotación y el macollaje en los tratamientos con quema comparados con GCTB. Luego de este período las diferencias no fueron significativas. En todos los casos la temperatura permaneció por encima de la temperatura base para el crecimiento de la caña de azúcar. GCTB produjo modificaciones en el régimen hídrico del suelo, asociadas con la distribución de las lluvias. Los períodos con contenidos de humedad superior al 40% de agua útil en los 45 cm superiores del suelo fueron de 40 días durante las primaveras secas y 80 días en las primaveras húmedas en los sistemas de GCTB, mientras que en los sistemas con quema los mismos fueron de 20 y 50 días respectivamente. El GCTB y la quema no produjeron diferencias en el número de tallos a cosecha, sin embargo en las parcelas con quema el mismo fue mayor durante el macollaje. Las modificaciones en la temperatura y la humedad del suelo producidas por la conservación de los residuos de cosecha no indujeron variaciones en los rendimientos de caña.