Cover crops associated with sugarcane to control weeds

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Abstract  In the tropical conditions of Réunion Island, weeds are the main bio-aggressors. Preventing weed infestation in crops is a challenge for a sugarcane industry that is seeking to improve its technical performance. If herbicides are the main technique to control weeds, reducing their use is a key environmental target, especially in terms of reducing the regional Treatment Frequency Index of Herbicide (TFIH). Alternative practices, such as soil mulching, mechanical weeding in plant cane, or false seedbeds, are examples of known techniques that are friendlier to the environment. In Réunion various methods are being assessed to control weeds and meet a European directive to reduce the TFIH by 50%. Two trials were conducted on Réunion Island during 2013 to 2015 to test the effectiveness of legume crops to control weeds. In these trials, Canavalia ensiformis and two varieties of Vigna unguiculata were sown in the inter-rows of ratoon cane. Results showed that weed coverage in the inter-row was maintained below 30%, except for V. unguiculata (early variety), and TFIH was reduced by 54-85%. However, the weed management strategy used in these trials was labor intensive. Even if the target to reduce pesticide use was achieved, inter-cropping is not risk-free and yield loss is to be considered. For inter-cropping to be viable, the risk of yield loss must be eliminated, technical issues related to mechanical sowing resolved, and cover-crop effectiveness in controlling weed infestations under severe weed pressure needs to be confirmed.

Key words  Sugarcane, Réunion Island, legume crops, weeding, TFIH, inter-row, ECOPHYTO

INTRODUCTION

Conditions in tropical environments are conducive to weed growth that can reduce sugarcane yields by as much as 400-500 kg/ha/day (Marion 1991; Marnotte 2008). Where herbicides are the main technique to control weeds, reducing their use is a key environmental target. In particular, the Treatment Frequency Index of Herbicide (TFIH) needs to be as low as possible. A TFIH value of 3.6 was reported by Martin et al. (2012), which is relatively low. However, it is still in the interest of the industry to determine ways of reducing this further. Alternative practices, such as soil mulching, mechanical weeding in plant cane, or false seedbeds, are examples of known techniques that are environmentally friendlier than the use of herbicides.

We conducted two trials as part of a program to reduce the use of pesticides in Europe by reducing the TFIH (ECOPHYTO Plan). The aims of these trials were to: 1) test the capacity of cover crops sown in the inter-rows of sugarcane to control weeds and thereby reduce the need to apply chemical weedicides; and 2) identify and overcome the limitations of cover crops to optimise their environmental, agronomic and economic benefits.

MATERIALS AND METHODS

Studies were conducted in a sugarcane field located on an experiment station in the northern area of Réunion Island in 2013 and 2015. Three legume crops, Canavalia ensiformis, Vigna unguiculata (red variety), and Vigna unguiculata (early variety), were included in our study due to their availability locally (Chabalier 2009; Chabalier and Marion 2013).

The treatments included the three cover crops (Table 1) sown at different dates after harvest of the preceding sugarcane crop - expressed as months after cut (MAC). In addition to these treatments that were replicated four times, there were two control plots in each case:

- a plot that was weeded by application of herbicides (reference), and
- a plot with weeds in the inter-row spaces, with the cane row weeded via herbicide treatments and manual removal.
Table 1. Trial treatments.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Cover crops grown in the inter-row spaces</th>
<th>Sowing date [months after cut (MAC)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td><em>Canavalia ensiformis</em></td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td><em>Vigna unguiculata</em> (early variety)</td>
<td>1.8</td>
</tr>
<tr>
<td>2015</td>
<td><em>Canavalia ensiformis</em></td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td><em>Vigna unguiculata</em> (red variety)</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Weed growth was assessed by visual inspection of the ground cover (Marnotte 2001) for the weed species present in the inter-row space. Weed cover within the sugarcane row was also assessed in the 2015 trial.

Pre-emergence herbicides were applied after harvest in the plot. The other weeding interventions were determined on the basis of the weeds present and were implemented once the ground cover reached 30%.

The Treatment Frequency Index of Herbicide (TFIH) (Billouet 2011) of each procedure was calculated as:

$$TFIH_{(plot)} = \frac{\text{Herbicide dose applied to the plot} \times \text{treated surface}}{\text{Recommended dose of the product} \times \text{surface of the plot}}$$

The yield and sugar content of the sugarcane were determined at harvest.

RESULTS

Establishment and growth of the cover crops

The legume crops were sown under mulch. *Canavalia ensiformis* rapidly attained 80% ground cover in the inter-row space by 4 MAC (Fig. 1) and its development continued until full leaf cover (Fig. 2). *Vigna unguiculata* (early variety) also developed rapidly (Fig. 3) with a maximum ground cover of 76% in the inter-row spaces at 3 MAC, but declined rapidly thereafter. *Vigna unguiculata* (red variety), sown at 3.3 MAC in more developed cane only achieved 25% cover at 5.5 MAC. From 6 months onwards, under the sugarcane foliage, the cover crops began to disappear (Fig. 1). This is well illustrated in Figure 4.

![Fig. 1. Ground cover of the cover crops in the inter-row spaces over time.](image-url)
Weed growth and pressure

Despite a mulch layer of 5-10 t dry matter/ha across the field, there was strong weed pressure in the inter-row spaces in the weed control plot: 95% ground cover at 3 MAC in the 2013 trial (Fig. 5), and 65% ground cover at 4.2 MAC in the 2015 trial (not shown here).
Very similar weed species occurred in both trials, with the five major species being *Typhonium trilobatum*, *Euphorbia heterophylla*, *Cyperus rotundus*, *Bidens pilosa* and *Centrosema pubescens*.

The presence of *V. unguiculata* (red variety) reduced weed growth in the inter-row spaces by more than 50% (Fig. 5). For the other two legume crops, the weed pressure remained much lower than the 30% threshold, a threshold at which intervention is required to avoid the harmful effects of the weeds.

![Ground cover of the weeds in the inter-row spaces for each treatment.](image)

**Fig. 5.** Ground cover of the weeds in the inter-row spaces for each treatment.

After the emergence of the cover crops, it was no longer possible to intervene with chemicals, whether in the inter-row spaces or the row of sugarcane. Manual weeding was then practised in the ‘weeded’ control.

**TFIH and sugar cane yields**

The average yields of sugarcane varied from 136 to 164 t/ha over the two seasons (Fig. 6), with the chemical control plots producing higher yields than the plots with cover crops. This is possibly due to the competition between the cover crops and the sugarcane. However, the marked intra-treatment variability (Fig. 5) should be noted. The TFIH was reduced by 54-85% according to the treatment and the year.

![TFHI (in red) and sugarcane yields (in blue) for each treatment.](image)

**Fig. 6.** TFHI (in red) and sugarcane yields (in blue) for each treatment.
DISCUSSION

Before almost completely disappearing beneath the leaf cover of the sugarcane, the legume crops planted at the start of the cycle in the inter-row spaces partly controlled the growth of weed species, reducing the TFIH by 54-85%.

However, the presence of legume crops in the inter-row spaces makes it difficult to maintain the rows of sugarcane weed-free using herbicides because of the effect on the legumes themselves. This may cause technical problems in the event of strong weed pressure.

Lower sugarcane yields occurred where legume cover-crops were grown. This reduced yield, compared to the chemical control plots, may have been due to competition for soil moisture and nutrients. The intra-treatment variability highlighted by large standard deviations is possibly due to the heterogeneity of the soil in the field, a constraint that should be removed by carrying out trials on other sites. Future trials will also be needed to compare the different duration times of the cover crops in the inter-row spaces.

CONCLUSIONS

The introduction of cover crops offers encouraging prospects for weed control and the reduction of the TFIH, at least when the weed pressure is not excessive. The treatments tested in the trials still have technical obstacles that require continued development:

- a mechanised sowing process under mulch;
- controlling weeds on the cane lines, particularly where weed pressure is severe;
- and the removal of the risk of yield loss.

However, other benefits arising from the use of legume crops include protection against soil erosion and improvement of soil fertility. These should also be considered when developing new and more agro-ecologically effective systems of cultivation.

REFERENCES


Les plantes de services associées à la canne à sucre pour maîtriser les adventices

Résumé. En conditions tropicales à La Réunion, les adventices sont les principaux bioagresseurs de la canne à sucre. La lutte contre l’enherbement représente un enjeu pour la filière dans l’atteinte des objectifs d’amélioration des performances techniques. Malgré diverses techniques de maîtrise des adventices alternatives au tout chimique (mulch, faux-semis, désherbage mécanique, etc.), la lutte chimique demeure importante, si bien que la réduction de l’utilisation des herbicides et donc de l’indice de Fréquence de Traitement (IFT) est un objectif primordial. A La Réunion, suite à la directive Européenne (plan ECOPHYTO), des expérimentations testant la maîtrise des adventices par l’utilisation de plantes de services intercalaires ont été mises en place afin de réduire l’IFT Herbicide de 50 %. Deux essais ont été conduits en 2013 et 2015, où trois légumineuses ont été semées sur l’interrang d’une repousse de canne à sucre : Canavalia ensiformis et deux variétés de Vigna unguiculata. Les résultats ont montré que le taux de recouvrement des adventices sur l’interrang a été maintenu en dessous de 30%, excepté pour le V. unguiculata var. 40j, et les IFTH ont été réduits de 54 à 85%. Mais ces itinéraires de désherbage sont consommateurs en main d’œuvre et ne sont pas non plus sans risque quant à des possibles pertes de rendements. Pour pérenniser la technique, ce risque demande à être levé de même que la mécanisation des semis et la confirmation de l’efficacité des couverts à maîtriser l’enherbement à de fortes pressions.
Cultivos de cobertura asociados con caña de azúcar para controlar malezas

Resumen. En las condiciones tropicales de la isla Reunión, las malezas son los principales bio-invasores en el cultivo de caña de azúcar. La prevención de la infestación de malezas en los cultivos es un desafío para la industria de la caña de azúcar que está tratando de mejorar su desempeño técnico. Si la aplicación de herbicidas es la técnica principal para controlar las malezas, la reducción de su uso es un objetivo clave ambiental, especialmente en términos de reducir a nivel regional el índice de frecuencia de tratamiento de herbicidas (IFTH). Prácticas alternativas, como dejar los residuos de la cosecha como cobertura (mulch), la escarda mecanizada de la caña planta y otros, son ejemplos de técnicas conocidas que son más amigables con el medio ambiente. En la isla Reunión se están evaluando diversos métodos para controlar las malezas y cumplir con una directriz europea de reducir el IFTH en un 50%. Durante los años 2013-2015 se realizaron dos ensayos en la isla Reunión para evaluar la efectividad de los cultivos de leguminosas para el control de las malas hierbas. Canavalia ensiformis y dos variedades de Vigna unguiculata fueron sembradas en los entre surcos de la caña de azúcar en soca. Los resultados mostraron que la cobertura de malezas en el entre surco se mantuvo por debajo del 30%, a excepción de V. unguiculata (variedad precoz), y el IFTH se redujo en un 54-85%. Sin embargo, esta forma de manejar la maleza utilizada en estos ensayos requiere del uso de mucha mano de obra. Aunque el objetivo de reducir el uso de pesticidas fue logrado, los cultivos intercalados no están libres de riesgo y la pérdida de rendimientos debe ser considerada. Para que los cultivos intercalados sean viables, el riesgo de pérdida de rendimiento deberá ser eliminado, aspectos técnicos relacionados con la siembra mecánica deberán ser resueltos, y la eficacia de los cultivos de cobertura en el control de la infestación bajo una fuerte presión de malezas debe ser confirmada.

Palabras clave: Caña de azúcar, isla Reunión, cultivo de leguminosas, deshierbe, IFTH, entre surcos, Ecophyto