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El Uso de Abonos Verdes Como Alternativa para Mejorar la Productividad y Sostenibilidad del Cultivo de la Caña de Azúcar

Introducción

Por abono verde se entiende a la utilización de cultivos de vegetación rápida, que se cortan y dejan en el mismo lugar donde fueron sembrados y que están destinados a mejorar las propiedades físicas del suelo, al aporte de nutrientes minerales así como activar y restaurar la vida microbiana del suelo, proteger al suelo de la erosión y limitar el desarrollo de malezas.

Aunque hay varias especies que pueden ser utilizados como abonos verdes, las leguminosas son las más empleadas debido a su capacidad de fijar grandes cantidades de nitrógeno de la atmósfera a través de la simbiosis leguminosa-bacteria fijadora de nitrógeno (*Rhizobium*).

En países como Australia, Sudáfrica y Fiji se ha determinado que uno de los factores responsables de la perdida de productividad del cultivo de caña de azúcar en el tiempo se debe al monocultivo (Bell, 2001; Wiseman and Morrison, 2005). Los factores asociados correspoponden al declinamiento de la materia orgánica del suelo acelerado por el tráfico pesado y la excesiva labranza del suelo, al desarrollo de plagas especificas del cultivo y enfermedades de la raíz principalmente.

De la misma manera, en Guatemala la caña de azúcar se basa en un sistema de monocultivo y hay áreas con mas de 100 años cultivadas bajo este sistema.

La Dra. Wiseman (2005) indica que para revertir la degradación y promover la salud del suelo se aconsejan tres prácticas complementarias: conservar los rastrojos, labranza mínima y el empleo de abonos verdes.

En Australia se han logrado incrementar los rendimientos de caña siguiente con la rotación y buen manejo de soya y maní obteniendo incrementos de 20 y 30 por ciento más con respecto al manejo convencional sin rotación.

En Brasil se han evaluado especies como *Crotalaria juncea, Canavalia ensiformis* y *Mucuna deringiana* en rotación con el cultivo de caña determinando que estas especies pueden fijar hasta un 50 por ciento de N total de la atmósfera que pueden ser aprovechados por el cultivo de caña de azúcar (Resende, 2000). De la misma manera en la Florida, EE.UU. se ha encontrado que *Crotalaria juncea* puede incorporar de 180-200 kg de nitrógeno al suelo (Muchovej, 1995).

A partir del año 2005 CENGICAÑA a estado motivando y promoviendo en los ingenios la investigación en abonos verdes y su incorporación al sistema de cultivo de caña de azúcar. De tal manera que en el presente informe se presentan los avances, experiencias obtenidas y el futuro que podrían tener los abonos verdes en el cultivo de caña de azúcar en Guatemala.

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The Use of Green Manures as an Alternative to Improve Productivity and Sustainability of the Sugarcane Crop

Introduction

Green manures refer to the use of quick vegetation crops that are cut and left on the same surface where they were grown. They improve the physical properties of the soil, add minerals, activate and restore microbial life in the soil. They also protect soil from erosion and prevent the growth of weeds.

Although there are many species that can be used as green manures, leguminous plants are the most used due to its capacity of fixing nitrogen from the atmosphere through symbiosis with nitrogen-fixing bacteria (*Rhizobium*).

In countries such as Australia, South Africa and Fiji it has been determined that one of the factors responsible for productivity losses in time, is sugarcane monoculture system (Bell, 2001; Wiseman and Morrison, 2005). The factors related to this are mainly the accelerated decline of soil organic matter content due to heavy transport and soil excessive tillage, the development of specific pests and root diseases.

In Guatemala, as well, sugarcane is produced under a monoculture system and there are areas with more than 100 years under this kind of system.

Wiseman (2005) indicates that reverting degradation and improving soil health requires three complementary practices: conservation of weed-residues, minimum tillage and green manure usage.

In Australia, yields have been improved by rotation and good management of soy and peanuts, obtaining 20-30 percent increase compared to conventional management, without rotation.

Species such as *Crotalaria juncea, Canavalia ensiformis* and *Mucuna deringiana* have been evaluated in Brazil in rotation systems with sugarcane. It has been determined that these species can fix up to 50% from total nitrogen in the atmosphere and that can be used by sugarcane (Resende, 2000). Likewise in Florida, USA it has been found that *Crotalaria juncea* can incorporate 180-200 kg of nitrogen to the soil (Muchovej, 1995).

Since 2005, CENGICAÑA has promoted green manure research in sugarmills and their incorporation to the sugarcane crop system. This article presents the advances, experiences and possible future for green manures in Guatemalan sugarcane crop.

Evaluation of Two Species of Intercropped Leguminosae

In 2005, a study started with the aim of learning about the potential for adaptation and the behavior of two species used as green manures: *Crotalaria juncea* and *Canavalia ensiformis.* These two species of Leguminosae were evaluated in an intercropped system in plant cane-crop and in the first ratoon-

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crop with variety CP72-2086 in a superficial Andisol at Pantaleón sugarmill.

None of the plots planted with the leguminous species in plant cane-crop, as well as in the first ratoon-crop was fertilized with nitrogen, thus the only plot fertilized both years was the check plot, where no leguminous species were planted. The dosage of fertilizer for this plot was 50 kg N/ha for plant cane-crop and 100 kg N/ha for first ratoon-crop. Eighty kilograms of P_2O_5/ha were applied uniformly on all plots at sugarcane planting. Therefore no fertilizer was directly applied to the leguminous plants.

Adaptation and Growth of Leguminous Species

Both leguminous species showed a very good adaptation and both presented a fast and vigorous growth, as observed on Figures 1 (*Crotalaria juncea*) and 2 (*Canavalia ensiformis*). *Crotalaria juncea* grows erectly and produces a high amount of biomass. In Figure 1, sugarcane appears to be less developed compared to *C. juncea*, although they were simultaneously planted. On the other side, *Canavalia ensiformis* (Figure 2) has a Type II indeterminate growth habit, lower in size, with wider and vigorous leaves, thus, more adapted to intercropping.

Biomass Yield and N Contribution Under an Intercropped System

Table 1 presents data for fresh biomass production, humidity content, N content in biomass and N contribution to the system, 65 after planting. It can be observed that *Canavalia ensiformis* produced 19.2 MT/ha of fresh biomass, while *Crotalaria juncea* produced 23.4 MT/ha. Nevertheless, *Canavalia* had a higher nitrogen concentration in its biomass: 3.52% versus 3.29% in *Crotalaria*. Humidity content was similar for both of them. In total, *Crotalaria* accumulated 157 kg N/ha and *Canavalia* 117 kg N/ha, 65 days after planting under an intercropping system.

Figures 3 and 4 show the type and growth of roots from *Canavalia ensiformis* and *Crotalaria juncea*, respectively, previous to biomass harvest. The two types of roots allow exploring different levels of the soil profile with different and varied types of pores, thus improving ventilation, water infiltration and, in general, a better physical condition of the soil. Both roots present nodules where *Rhizobium* bacteria carry out the process of nitrogen fixation from the atmosphere.

Effect of Intercropping on Sugarcane Yield

Table 2 shows means for sugarcane yield in cane plant-crop and first ratoon-crop from the intercropped system with *Crotalaria juncea* and *Canavalia ensiformis*.

As an average, it was observed that intercropping either of the two leguminous species did not have a negative effect on cane yield, in spite of their aggressive growth. On the contrary, intercropping and subsequent incorporation of *Canavalia ensiformis* to the soil, enhanced cane yield in cane plant-crop, as well as in first ratoon-crop with an average increase for the two crop cycles, of 8.1 MT/ha over the check plot planted without leguminous intercropped, showing the benefits provided to sugarcane by the association with these species.

The results indicate that intercropping and incorporation to the soil of *Canavalia ensiformis* and *Crotalaria juncea* supplied nitrogen needs for sugarcane. According to the data presented on Table 1, leguminous species contributed with more than 115 kg N/ha when the whole biomass was incorporated to the soil 65 days after planting.

Comparing the two species, *Canavalia ensiformis* showed better adaptation to the intercropping system, since sugarcane stalk population and height was slightly lower in plots planted with *Crotalaria juncea* than in those planted with *Canavalia ensiformis*.

In a similar experiment, but on a more fertile soil at CENGICAÑA's experiment station, a consistently lower population, height and stalk diameter of the sugarcane stalks harvested from plots planted with *Crotalaria juncea* that those harvested from plots with *Canavalia*, and even lower compared to plots without leguminous species, indicating that there is competition between *Crotalaria* and sugarcane in a fertile soil (field-trial observations at CENGICAÑA, 2007).

Fresh Biomass and N Contribution of Green Manures Under a Monoculture System (Rotation System)

Table 3 shows estimates for fresh biomass and amount of nitrogen accumulated in 65 days by *Canavalia ensiformis* and *Crotalaria juncea* planted as a monoculture on a superficial Andisol at Pantaleón sugar mill.

Crotalaria juncea produced 35.1 MT/ha of green biomass and accumulated 235 kg of N/ha in aerial biomass. Meanwhile *Canavalia ensiformis* produced 28.8 MT/ha of fresh matter with 175 kg of N/ha accumulated in the biomass. This biomass will vary according to soil and climatic conditions where they are planted.

The high nitrogen quantities accumulated in these leguminous species' biomass will be returned to the soil at the time of their incorporation to the soil and a good part of it will be available for sugarcane crops reducing or even eliminating the need to apply chemical fertilizers containing nitrogen.

Additionally these leguminous species provide good weed control. In sandy soils from Magdalena sugarmill weed pressure was reduced by 62 and 42 percent with the planting of *Crotalaria Juncea* and

Table 1. Fresh biomass, humidity content, N concentration and N accumulation in two leguminous species under an intercropped system, 65 days after planting.				
Green manure	Fresh biomass (MT/ha)	Humidity (%)	N concentration (dry base) (%)	N accumulation in biomass (kg N/ha)
Canavalia ensiformis	19.2	82	3.52	117.1
Crotalaria juncea	23.4	79	3.29	157.0

Two rows of *Canavalia ensiformis* after every sugarcane row (0.50 m between rows and 0.20 m between plants)
Two rows of *Crotalaria juncea* after every sugarcane row (0.50 m between rows and 0.10 m between plants)

Table 2. Sugarcane yield for plant cane-crop and first ratoon-crop and the average for the two crop cycles under an intercropped system with two green manures

TRIAL	Plant cane-crop 2006 (Tm/ha)	First ratoon-crop 2007 (Tm/ha)	Average (MT/ha)
Canavalia ensiformis + sugarcane	82.87	111.20	97.0
Crotalaria juncea + sugarcane	74.74	109.30	92.0
Sugarcane + Fertilizer	74.14	103.7	88.9

Table 3. Fresh Biomass, N concentration, humidity, and accumulated N in biomass per area in leguminous species under a monoculture system 65 days after planting

Green manure	Fresh biomass (MT/ha)	Humidity (%)	N Concentration (dry basis) (%)	Kg N/ha
Canavalia ensiformis	28.8	82	3.52	175.6
Crotalaria juncea	35.1	79	3.29	235.5

Canavalia: 0.50 m between rows by 0.20 m between plants.
Crotalaria: 0.50 m between rows by 0.10 m between plants.

Canavalia ensiformis respectively in comparison with soils where nothing was planted and weeds grew freely.

Figures 5 and 6 show the growth and development of *Crotalaria juncea* and *Canavalia ensiformis* in sugarcane nurseries from San Diego and Pantaleón sugarmills respectively, and figure 7 shows the behavior of another leguminous species, *Mucuna sp.*, with potential for a rotation system.

Leguminous Seed Production

Crotalaria juncea and *Canavalia ensiformis* produce seeds all year around. Despite this, it is preferable to plant them in August/September to obtain quantity and quality seeds in the dry season (December-January).

For *Canavalia ensiformis* the recommended distance between rows is 0.50 m, and 0.20 m between planting spots (1 grain/planting spot), and for *Crotalaria juncea*, 0.50 m between rows and 0.10 m between planting spots (2 grains/planting spot).

To plant a hectare with those distances around 165 kg/ha of *Canavalia ensiformis* seed, and 17 kg/ha of *Crotalaria juncea* seed are needed.

Leguminous species do not require any type of fertilizer and if the planting is performed in August-September no irrigation will be required either.

Future Use of Green Manures in Guatemala

According to the characteristics and dynamics of the Guatemalan sugar industry and related experience of other countries, the most immediate and adequate way for the industry to accept and adopt the use of green manures in the existing system is to use them as rotation crops in sugarcane nurseries. In Guatemalan agro industry more than 5,000 ha of sugarcane nurseries are planted yearly to provide commercial seeds to around 38,000 ha of annual renovations.

Sugarcane nurseries are generally planted from May onwards depending on the variety and the time when the seed is required, this means that land destined to sugarcane nurseries can spend 3 to 4 months without any productive use, which provides enough time to have a green manure harvest with all the advantages this would represent.

Acquiring knowledge and experience in the handling of these leguminous species will make it possible to think about their utilization in renovation areas, where pressure between harvesting and planting of the new crops is greater. Later on, green manure plantation can be justified in marginal areas where sugarcane growth is slower due to limiting climatic conditions, plague problems and diseases, and erosion susceptible areas. SJ