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Effect of variety and cane yield on sugarcane potential trash

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ABSTRACT

Low environmental impact production systems are a major concern in agroindustry and society, with food and sugarcane production being one of the areas where sustainability is a high priority. Green cane harvesting emerges as an important alternative for a cleaner production system, since it excludes the burning of residues, conserves soil and insolves the possibility of energy generation. An estimation of potential sugarcane available trash is very important in order to define management strategies. A research was carried out to determine the amount of dry trash available in cane fields before (SPT) and after green cane harvesting (SFT). Also, the relationship between SPT and SFT was studied in order to validate the precision of SPT as an SFT predictor using green cane combine harvesting for the main cultivated varieties in the sugarcane-growing area of Tucumán (LCP 85-384, TUCCP 77-42, CP 65-357 and RA 87-3). An increase in SPT was associated to cane yielding/ha, ranging from 6.9 to 16.0 t/ha of SPT for 32 to 104 t/ha of cane yielding. LCP 85-384 and CP 65-357 produced the highest amount of dry trash before harvest, while TUCCP 77-42 produced the least for similar cane yielding. Simultaneously the DT/CY ratio decreased with a mean value around 16% of cane yield and its use for estimating SPT was limited, as low coefficients of determination highlight. SPT appropriately predicted SFT under green cane combine harvesting conditions and the former one could be estimated using cane yielding/ha.

Key words: sugarcane production, dry trash, green cane, combine harvesting.

RESUMEN

Efecto de las variedades y su rendimiento cultural en la biomasa residual potencial

La implementación de sistemas productivos con bajo impacto ambiental es una preocupación tanto para la agroindustria como para la sociedad, resultando la producción de azúcar una de las áreas donde la sustentabilidad es un objetivo prioritario y alcanzable. La cosecha en verde de la caña de azúcar aparece como una importante alternativa para conformar sistemas de producción más limpios, prescindiendo de la quema de material vegetal y residuos de cosecha, conservando el suelo y ofreciendo una posibilidad para la generación de energía. Una estimación del potencial de residuos disponible de la caña de azúcar cobra gran relevancia en el momento de definir estrategias de manejo. Se realizó un estudio para determinar la cantidad de biomasa residual disponible en los cañaverales en forma previa (SPT) y posterior (SFT) a la cosecha mecanizada en verde para las principales variedades cultivadas en la provincia de Tucumán (LCP 85-384, TUCCP 77-42, CP 65-357 y RA 87-3). Además, se estudió la relación entre SPT y SFT a fin de validar la precisión de SPT como predictor de SFT en el caso de la cosecha integral en verde. El incremento del SPT estuvo asociado al mayor rendimiento cultural/ha, registrándose valores del 6,9 a 16,0 t/ha de biomasa residual para rendimientos culturales de 32 a 104 t/ha. LCP 85-384 y CP 65-357 produjeron el mayor SPT, mientras que TUCCP 77-42 generó la menor cantidad para niveles similares de rendimiento cultural. La relación SPT/CY disminuyó y el promedio general fue del 16% del rendimiento cultural, aunque su uso para estimar SPT fue limitado, como señalan los bajos coeficientes de determinación. SPT predijo adecuadamente SFT para el caso de la cosecha integral en verde, y el primero puede ser estimado adecuadamente empleando el rendimiento cultural/ha.

Palabras clave: producción de caña, biomasa residual seca, caña verde, cosecha mecanizada.

** Partial results showed at XXVI ISSCT Congress, South Africa 2007.*

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INTRODUCTION

There is a clear tendency nowadays to develop products taking into consideration their impact on the environment and this trend will undoubtedly become more important in the near future. This statement is particularly true for food products such as sugar, given the rising interest and expansion of markets for natural and organic products. These are obtained through procedures, both on agricultural and industrial stages, in which the use of chemicals and damage to local and global environment are avoided or reduced to a minimum.

Further, cane agriculture can be practised with a minimum consumption of chemical products and can be made highly compatible with environment and soil conservation. An issue of the utmost importance, from both ecological and economic standpoints, is the harvest of green cane (Cordovés Herrera, 1999).

Green cane harvesting is a widespread practice in many countries and the sugar industry in Argentina is not an exception. Our country is facing changes and progressively moving from the burning of sugarcane plantations (prior to harvest and after harvest) towards green cane management. Nowadays, green cane harvesting is reaching almost 80% of the cultivated area in Tucumán.

Sugarcane growers have begun to notice that trash can play an important role in improving soil conditions (such as organic matter and moisture content), energy production and other uses, such as animal feed. Eliminating cane burning in management systems entails harvesting green cane mechanically, developing and implementing technological alternatives for vegetal residues utilization.

An estimation of sugarcane potential trash (SPT) available for use as soil mulch and as biofuel is very important in order to define management strategies that ensure the sustainable development of both agriculture and energy generation. Thus, there has been an increasing interest in reliable data about trash quantities left in the fields.

Residual biomass shows a high variability influenced by several factors: varieties, production levels, crop age, management variability and differences in harvesting systems and operation efficiency (Rípoli *et al*., 2000; Robertson, 2003). Many authors cited by Dias Paes and Oliveira (2005) published data about the ratio between the amount of trash left in the field and sugar cane yield. The values varied considerably, from 10% to 60% in Colombia, from 20% to 35% in South Africa, 30.5% in Cuba and 14% in Brazil (Rípoli *et al*., 2000). According to these authors, green leaves, dry leaves and tops left unburned in the field have an average moisture content of 50%.

In this way, the volume of trash remaining in fields (SFT) after green harvesting would be considered as a function of the amount of available trash prior to cane harvesting and the harvesting process itself.

Research was carried out to determine the amount of dry trash available in canefields before harvesting (SPT) excluding the effect of harvesting conditions. The main cultivated varieties in the sugarcane-growing area of Tucumán were evaluated: LCP 85-384, TUCCP 77-42, CP 65-357 and RA 87-3, at different production levels. Furthermore, the relation between SPT and SFT was studied in order to validate the precision of SPT as an SFT predictor using green cane combine harvesting.

MATERIALS AND METHOD

Trials for potential dry trash (SPT) determination (tops, dry and green leaves) prior to harvest was performed using four sugar cane varieties with different yield levels (LCP 85-384, TUCCP 77-42, CP 65-357 and RA 87-3) during 2005 and 2006 harvesting seasons (May to October).

Many cases were analyzed for each cultivar and yield level (Table 1) using from three to five replicated samples in each case. Cane yield was estimated by counting millable stalks in three ten meter long rows, taking from three to five random samples of 15 successive stalks in order to determine average stalk weight, fresh trash weight, and composition (tops, dry and green leaves). As fresh trash weight showed large variations, it was not an useful parameter for trash quantity estimation (Robertson, 2003; Días Paes and Oliveira, 2005). Therefore, water content was determined by drying at 70°C until constant weight in order to estimate sugarcane potential trash (SPT), i.e. dry trash before harvest.

SPT/CY ratio versus CY (cane yield) and SPT versus CY relationships for each cultivar were studied using regression techniques (Días Paes and Oliveira, 2005; Robertson, 2003).

Table 1. Number of cases studied for the main varieties considered and cane yield levels.

Cultivar	Cane yield levels (t/ha)	Cases
LCP 85-384	101 - 109	8
	80 - 90	6
	60 - 75	11
	25 - 40	9
CP 65-357	67 - 73	5
	52 - 64	7
	38 - 50	5
TUCCP 77-42	99 - 107	4
	80 - 89	4
	61 - 71	4
	42 - 59	3
RA 87-3	66 - 74	5
	57 - 61	3
	< 60	5

In order to study sugarcane final trash (SFT), the first step was to determine SPT for 24 cases (12 cases evaluated in 2005 and 12 in 2006), in three random plots of 24 m2 per replicate. After green combine harvesting, residues deposited on soil were collected, classified as millable stalks or trash, and then weighed. Trash water content after harvest was determined using the mentioned procedure.

RESULTS AND DISCUSSION

Results in Table 2 in all varieties showed that rising SPT was related to increases in cane yield per ha, but simultaneously, the SPT/CY ratio decreased. SPT ranged from 6.9 to 16 t/ha for cane yielding from 36 to 104 t/ha. A variation among varieties, especially among yield levels, was registered. LCP 85-384 and CP 65-357 showed higher SPT at similar yield levels, while TUCCP 77-42 produced the least.

Total trash water content ranged from 38% to 55%, with an average of 43% showing a high variability, thus disqualifying fresh weight as an useful indication of trash quantity. This result is minor as compared with the one reported by Dias Paes and Oliveira (2005).

The variability in fresh trash before and after harvesting was very high, as reported by different authors (Ripoli *et al*. 2000), due to several factors related to the crop itself, such as variety, production level, crop age, harvesting dates and variability of crops. External factors, such as environmental conditions, irregular harvester feeding and differences in harvester set-up and operation, efficiency of the trash recovery system and the percentage of area under unburned sugarcane harvesting have to be taken into account as well.

The SPT/CY ratio varied from 12% to 23%, with an average value of approximately 16% of cane yield, registering the main variations among cane yield levels for all varieties. As presented in Figure 1, the SPT/CY ratio diminished with an increase in cane yield, but showed a very low determination coefficient, limiting the use of models to estimate potential trash availability in cane fields.

Accordingly, Días Paes and Oliveira (2005) reported a poor relationship between SPT/CY ratio versus cane yield for different cultivars in Brazil and proposed the use of an average ratio of 14% for general SPT estimations, which is within the range of results found in Tucumán.

As seen in Figure 2, SPT showed two different responses to cane yield. CP 65-357 and TUCCP 77-42 registered a significant linear response with an SPT increase rate of 162 and 154 kg per ton of cane yield, respectively. On the other hand, LCP 85-384 and RA 87-3 showed two response phases: first, a linear and significant increase in the amount of dry trash of 146 and 158 kg respectively per ton of cane yield until 80-85 t/ha, followed by a stabilization phase with a very low increase rate. Considering all varieties, mean dry trash increase rate was 151 kg per ton of cane yield until 100 t/ha and 155 kg for higher cane yields.

The positive relationship between SPT and cane yield for the evaluated varieties showed significant coefficients of determination, being thus possible to use equations to estimate SPT. Robertson (2003) reported that dry trash was fairly variable, but could be predicted approximately from cane yield, with an average rate of 100 kg of dry trash per ton of cane yield. On the other hand, Dias Paes and Oliveira (2005) suggested a rate of 140 kg/t of cane.

A linear relation was established between SPT and SFT (Figure 3), considering three varieties with between 40.5 and 108.8 t/ha yield under green cane combine harvesting conditions. It was determined that SPT estimated accurately the amount of dry matter trash after harvesting (SFT), although trash composition suffered some changes (decrease in leafy content and increase in millable stalk

Table 2. Dry trash availability prior to green harvesting and DT/CY ratio in four varieties with different cane yield levels.

Cultivar	Cane yield (t/ha)	Fresh trash before harvest (t/ha)	SPT (t/ha)	SPT / CY (%)
LCP 85-384	104.4 ± 2.9	27.8 ± 6.9	16.0 ± 3.1	15.4
	84.8 ± 2.9	25.9 ± 5.9	15.5 ± 3.2	18.2
	66.4 ± 7.2	23.1 ± 4.2	13.5 ± 3.3	20.3
	32.0 ± 4.7	12.7 ± 3.3	7.5 ± 1.9	23.4
CP 65-357	76.0 ± 7.9	29.3 ± 11.1	13.3 ± 4.7	17.5
	58.4 ± 4.0	21.8 ± 7.6	10.6 ± 2.9	18.1
	44.4 ± 4.5	16.4 ± 7.8	8.5 ± 2.9	19.1
TUCCP 77-42	103.0 ± 5.3	23.1 ± 1.4	12.5 ± 1.3	12.1
	84.5 ± 5.3	19.9 ± 2.7	10.9 ± 1.5	12.9
	66.2 ± 7.7	16.6 ± 4.3	8.9 ± 1,6	13.4
	50.2 ± 8.9	13.9 ± 3.9	6.9 ± 1.9	13.7
RA 87-3	71.9 ± 4.1	18.0 ± 3.3	10.3 ± 1.3	14.3
	65.3 ± 4.7	17.3 ± 2.8	9.6 ± 1.7	14.7
	59.4 ± 4.4	15.9 ± 3.1	8.9 ± 1.9	15.0

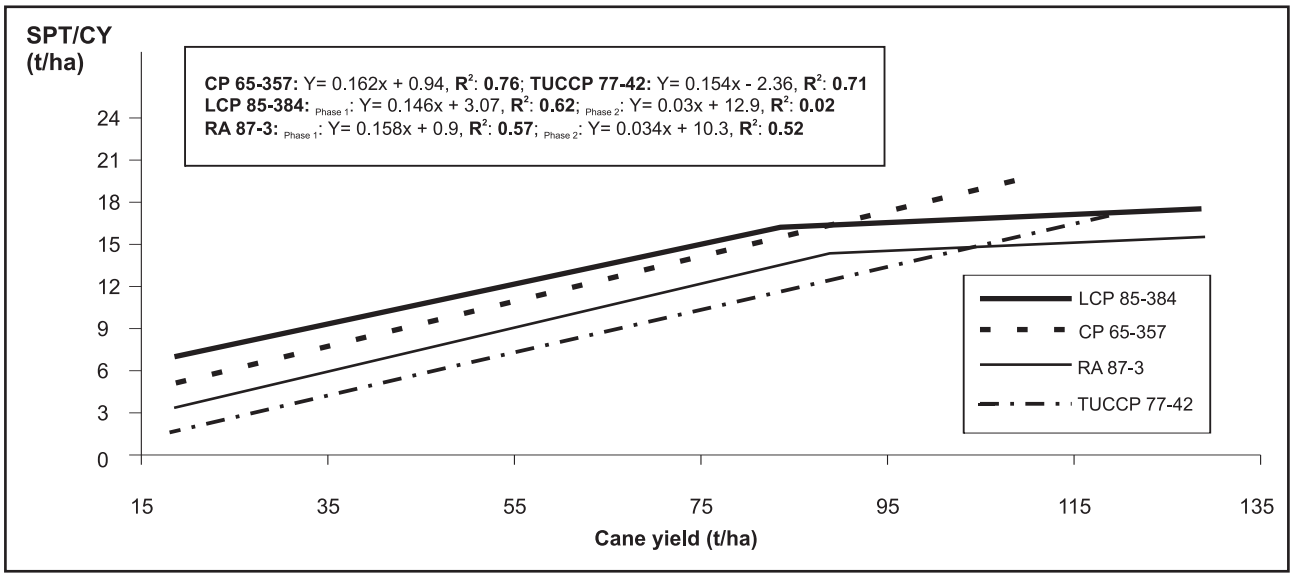

Figure 2. Relationship between sugarcane potential trash yield and cane yield for four sugarcane varieties.

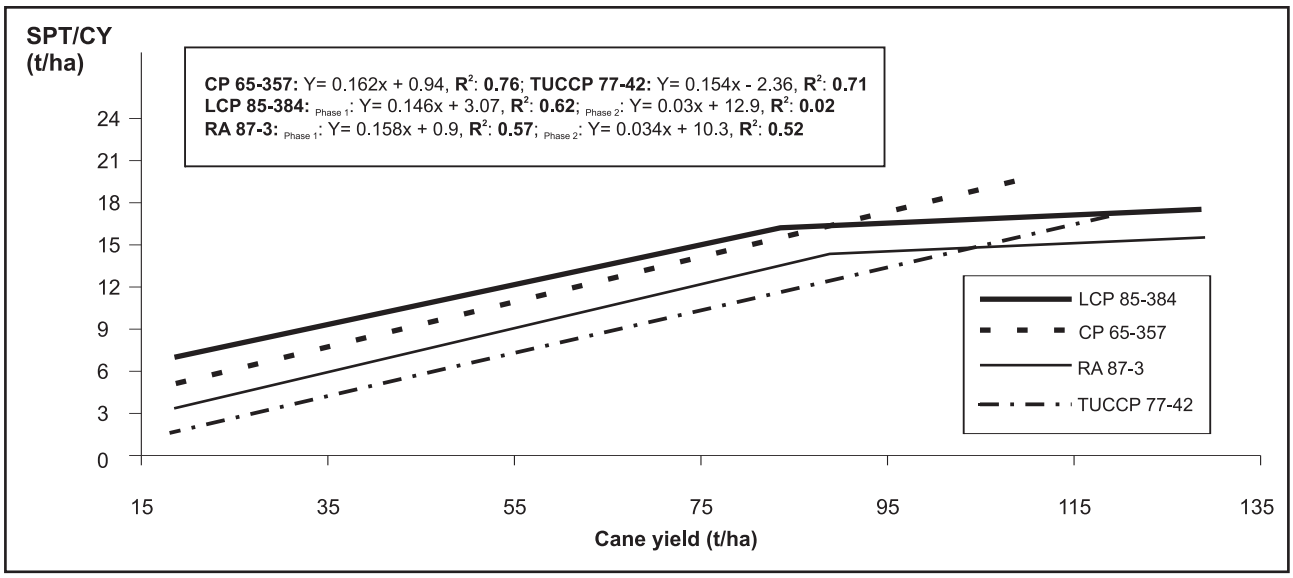

Figure 2. Relationship between sugarcane potential trash yield and cane yield for four sugarcane varieties.

share) (Table 3).

The result suggests that dry matter trash that will be returned per ha in commercial canefields after combine green harvesting (SFT) could be estimated from SPT, and the latter one is appropriately predicted by cane yield.

CONCLUSION

• SPT available in cane fields ranged from 6.9 to 16.0 t/ha for cane yielding between 32 and 104 t/ha, varying among varieties and especially with production levels. LCP 85-384 and CP 65-357 showed higher SPT for similar cane yield than the other varieties evaluated, including TUCCP 77-42, which recorded the lowest value.

• An increase in cane yield/ha was associated to increases in SPT, though the SPT/CY ratio decreased.

• Until 85-90 t/ha cane yield, all varieties increased their SPT between 146 and 162 kg per ton of cane. The average SPT, considering all the varieties, was 151 kg/t of cane yield.

• For the tested varieties, the SPT available in commercial cane fields can be predicted approximately using cane yield/ha, and SPT accurately predicted SFT under green cane combine harvesting.

Table 3. Cane yield, fresh and dry trash before harvesting and dry trash after harvest for three sugarcane varieties.

Cases		LCP 85-384 9'	TUCCP 77-42 9'	CP 65-357 6'
Cane yield (t/ha)	Range	52.3 - 108.8	40.5 - 88.1	48.0 - 80.9
	Mean	85.4 ± 16.7	62.7 ± 16.9	66.7 ± 11.2
Fresh trash before harvesting	Range	16.1 - 32.1	12.5 - 20.6	13.2 - 22.8
	Mean	26.5 ± 5.2	16.3 ± 3.3	18.3 ± 3.5
Dry trash before harvesting	Range	7.1 - 14.8	5.3 - 9.4	6.5 - 10.9
	Mean	11.8 ± 2.5	7.2 ± 1.5	9.2 ± 1.7
Dry trash after harvesting	Range	6.0 - 15.6	5.3 - 10.7	7.4 - 11.5
	Mean	11.3 ± 3.4	7.7 ± 1.5	9.4 ± 1.6

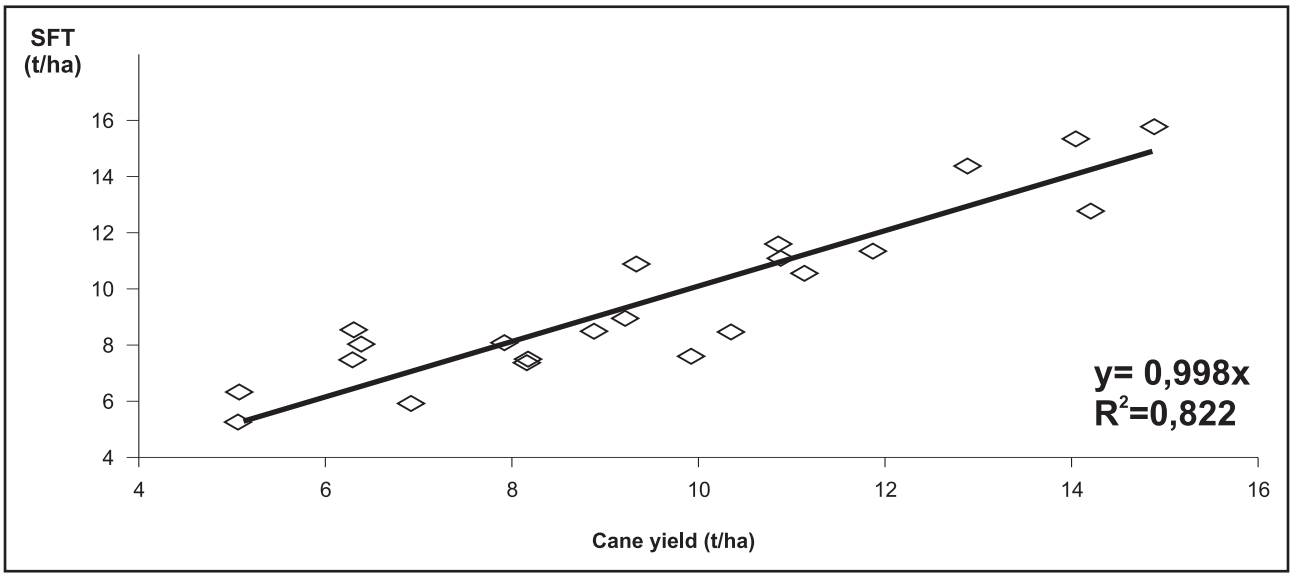

Figure 3. Relation between SPT and SFT, for 24 sugarcane plots of three varieties (LCP 85-384, TUCCP 77-42 and CP 65-357).

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