# Energy Requirements for Base Cutting of Selected Sugarcane Varieties in Sri Lanka

K. T. Ariyawansha* and K. H. D. Abeyrathna

*Sugarcane Research Institute, Uda Walawe, Sri Lanka*

*Corresponding Author: ktariyawansha@gmail.com*

**ABSTRACT**

Knowledge of energy requirement for sugarcane harvesting is an important requirement for designing mechanical harvesters suitable to local conditions. The objective of this study was to quantify and compare the mechanical energy requirements for base cutting of three selected sugarcane varieties under local conditions. Shear strength, specific shearing energy and energy requirement to cut sugarcane from the base for three commercial sugarcane varieties, namely, SL96 128, SL 96 328 and Co 775 were estimated. The results indicated that the shear strength of the varieties, SL 96 128, SL 96 328 and Co 775 was 1.69MPa, 2.42MPa, and 1.74MPa respectively. The variety SL 96 328 required significantly higher shear strength than the other two varieties. The specific shearing energy of the three varieties, SL 96 128, SL 96 328 and Co 775 was 27.77 mJ/mm$^2$, 39.30 mJ/mm$^2$, and 35.24 mJ/mm$^2$ respectively. The variety SL 96 128 showed a significantly lower energy requirement than the other two. The total energy requirement to cut 1 ha of sugarcane from the base was lower in SL 96 128, and it was 1510.4 kJ. This value was 1931.9 kJ and 1968.9 kJ for SL 96 328 and Co 775 respectively.

**Keywords**: Energy, Harvesting, Shear strength, Sri Lanka, Sugarcane

## INTRODUCTION

Because of the practice of manual harvesting, the shortage of labour during sugarcane harvesting has been one of major constraints for sugarcane production in Sri Lanka. This has led to increase the cost of both sugarcane and sugar production. Sugarcane harvesting is the highest cost component in sugarcane production. The cost of production of sugar has increased due to failures of sugar mills to run at their maximum capacities due to insufficient cane supplies. As a result most often the mills are running at under capacity sometimes even below 50%. Therefore, introduction of appropriate mechanised harvesting devises to local sugarcane field has become an urgent requirement in sugarcane and sugar production at a lower cost. Most of the mechanical harvesters developed in other countries are not suitable for local conditions. Therefore, it is essential to study local harvesting conditions before introduction of harvesters. In Sri Lanka, most of the sugarcane lands are less than 1ha in size. The use of imported harvesters is not recommended due to their high capacity and waste of energy and increased the emission air pollutants when operating on small lands. It will increase not only the cost of sugarcane harvesting, but also, pollution of the environment. The amount of energy required for harvesting a unit area is better indicator for selecting of appropriate harvesters for local conditions. Samaila (2012) has found that energy requirement for cutting top and base of the sugarcane was 15.71J and 23.83 J respectively. Taghijarah (2010) has reported that the shear strength and specific shearing energy of the sugarcane cultivated in Iran were 3.64MPa and 51.41 mJ/mm$^2$ respectively. The effect of cane stalk orientation for cutting energy was studied by Taghinezhad (2012). According to that sample orientation perpendicular to the cane stalk has been reported as to be using maximum energy to cut the cane. However, no any investigations have been carried out to study the energy requirement to harvest sugarcane under local conditions. The main objective of this study was quantification and comparison of mechanical energy requirement of cutting some selected sugarcane varieties from their base under local conditions.

## MATERIALS AND METHODS

This laboratory experiment was conducted at the Division of Mechanisation Technology, Sugarcane Research Institute (SRI), Uda Walawe. Samples were taken from three commercially-cultivated sugarcane varieties, namely, SL 96 128, SL 96 328 and Co 775 separately (each variety for each treatment). Ten sugarcane stalks from each farmer plot were collected as 3 replicates. Ten-centimetre long stalks from the base of the cane were separated from all collected stalks and average diameter of each separated stalk was recorded with 15 mm away from the lower node. The moisture contents of the test samples were measured on wet basis (w.b).

The shear force of each sample was measured subjecting to shearing action by using specific shearing instrument (Figure 1) developed by SRI. This instrument was operated according to the shearing principle given by Ramalingam (2009). The shearing action on the test materials was applied by the 10mm thick two sliding plates moving from each other (Figure 2). Those plates were consisted of different sized holes to accommodate different-sized test samples. The shearing force applied on the test samples was measured from load cell, and it was indicated by digital indicator. A constant loading rate of 10 mm/min was maintained throughout the testing because loading rate significantly affects the shear strength (Taghijarah *et al*., 2011). During shear force testing, the force applied was recorded with displacement of the sliding plates until specimen failure. The orientation of the force applied to the test sample was kept as perpendicular to the cane stalk since, the force applied to the stalk was maximum with sample in perpendicular to the cane stalk (Taghinezhad *et al*., 2012). The average values of the shear force of ten stalks taken from each plot were calculated for each variety in each replicate. The calculated average values of shear force of each replicate were graphed against the displacement of shearing force (Figure 3). The shear strength of the test material was calculated according to the following equation (Lina, 2009):

$$\tau = \frac{P}{A}$$

where: $\tau$ is Shear strength (MPa), P is the maximum shear force (N) and A is the area ($mm^2$) in which shear occurs.

Figure 1 Shear force testing instrument

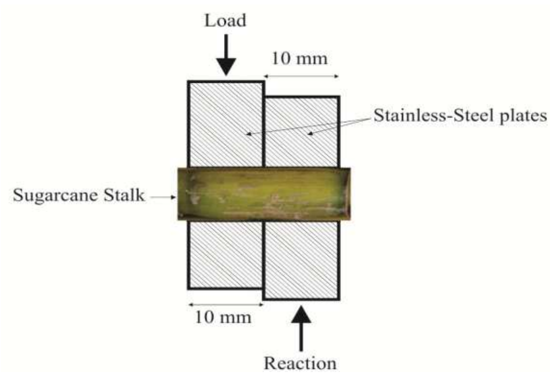


Figure 2 Application of shearing action on test sample

The best-fitted trend line with its equation for each replicate in each treatment was estimated using MS Excel 2013. Then shearing energy was calculated by integrating area under the curve (Curve equation) of the shear force displacement diagram. Taghijarah (2011) has calculated the specific shearing energy using the following equation:

$$E_{sc} = \frac{E_s}{A}$$

where: $E_s$ is shearing energy (mJ) and $E_{sc}$ is specific shearing energy.

Then average energy requirement for cutting of base for 1 ha was calculated using the following equation:

$$E_{ba} = \frac{E_{sc} N_c \, \pi \left(\frac{D}{2}\right)^2}{1000000}$$

where: $E_{ba}$ is average energy requirement (kJ) for cutting of base for 1 ha, $N_c$ is average number of cane stalks (Numbers) per ha according to the common planting practice adopted in Sri Lanka, and D is average diameter (mm) of cane base of the selected variety.

The means of the energy requirements of the three varieties were compared at 5% significance level using analysis of variance (ANOVA) using SAS statistical package.

## RESULTS AND DISCUSSION

The results showed that the moisture contents of the test samples were in the range of 75-78% w.b. The shear strength of the variety SL 96 328 (2.42MPa) was significantly higher than that of the other two varieties at 5% significance level. The shear strength of the variety SL 96 128 and Co 775 were 1.69MPa and 1.74MPa respectively. The mean value of the shear strength of the predominant variety in Iran (IRC99-01) was 3.64MPa (Taghijarah *et al.,* 2011) at the average moisture content on 75.25% w.b. Therefore, local varieties required lesser force to cut from their base than the variety IRC99-01 in Iran.

The specific shearing energy of the variety SL 96 328 (39.30mJ/mm$^2$) was not significantly different from that of the variety Co 775 (35.24 mJ/mm$^2$). The variety SL 96 128 showed the lowest specific shearing energy value of 27.77 mJ/mm$^2$. But according to Taghijarah (2010),

Table 1 Mean values of shear strength and specific shearing energy and energy requirements for base cutting of different sugarcane varieties

| Verity | Shear Strength (MPa) | Specific Shearing Energy (mJ/mm2) | D (mm) | Nc(No.) | $E_{ba}$(kJ/ha) |
|---|---|---|---|---|---|
| SL 96 128 | 1.69$^b$ | 27.77$^b$ | 24.0 | 120000 | 1510.4 |
| SL 96 328 | 2.42$^a$ | 39.30$^a$ | 22.8 | 120000 | 1931.9 |
| Co 775 | 1.74$^b$ | 35.24$^a$ | 26.7 | 100000 | 1968.9 |

Note: The mean values with the same letters in each columns are not significantly different at 5% probability.

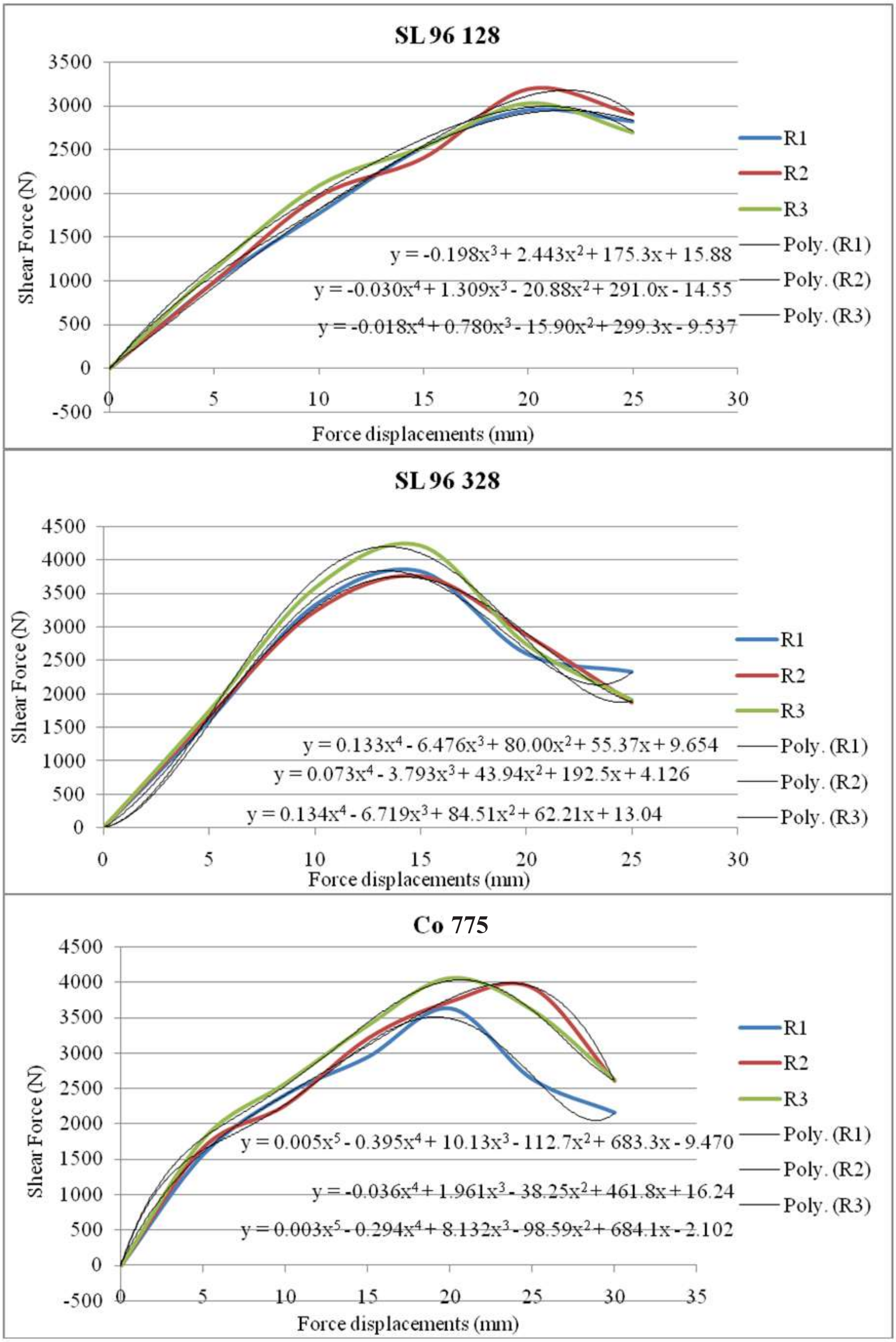


Figure 3 Average shear force versus shear force displacement in different varieties

the mean value of specific shearing energy of IRC99-01 was 51.41mJ/$mm^2$. Among the local three varieties, SL 96 128 recorded the lowest specific shearing energy.

However, further investigations on the specific shearing energy with different factors such as age of the crop, cultivated area, moisture content, soil type, conditions of growing, etc., and the energy requirement for different field practice in harvesting in-field conditions should be further studied.

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