Cutting sugarcane stumps with serrated cylindrical blades on ratoon cane

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Abstract. Cutting the sugarcane stump is one of the important activities in the ratoon sugarcane cultivation. Cutting the remaining sugarcane stump is done after harvest to grow new shoots. Cutting the sugarcane stump is usually done lower than the ground level. Cutting can be done manually or mechanically. The low productivity of ratoon cane can be caused by, among others, a lot of stumps that break, the time of cutting, shallow roots in the plants, and the lack of care in the plants. The cutting machine or stubble shaver used in sugar cane plantations have several disadvantages including imprecise blade design and the result of many stumps being broken so that productivity is low. The purpose of this study was to test the Serrated Cylindrical blades that rotate vertically to cut sugarcane stumps. As for the observations made the mound cutting profile, the percentage of stumps that broke, and the shoots productivity. The highest result of unbroken sugarcane stump in the second mound was 85.19%, then the first mound was 79.63% and then the third mound was 75.93%. The results of the growth of the number of shoots at 7 days after cutting in the first mound was 46 shoots, then the second mound was 43 shoots, and then the third mound was 34 shoots.

1. Introduction
Ratoon cane is a sugarcane plant that grows back from stem tissue that is still left in the soil after the sugarcane is cut and pressed. In this pressing process, the remains of the stump are cut at a flat position or lower than the mound surface. The garden to be pressed must be cleaned of the dirt from the previous felling. This is to make it easier to work on and so that the tools used can be more durable. Before pressing, for soil that is too dry, water should be first applied so that the former sugarcane plant that will be pressed is not easily uncovered [1]. Many types of cutting tools can cut underground with a depth of 5-10 cm, but the type of rotary cutting tool will provide several advantages, including lighter construction because it only consists of blades so that less energy is used to move it besides more economical when viewed from the use of materials. With these considerations, some of these studies used a cane crushed tool using a rotary type knife. In figure 1, The rotary blade design developed by Radite.

In the case of cutting from the bottom of the sugar cane stump, not only the cane stalks are cut, but the soil around the sugar cane stump at that depth will also be cut, for that we need a rotary type knife that is strong in construction and is also material strong. Thus, the material used for the blade is steel with a standard tool iron which is hardened on the part that is in direct contact with the ground and sugarcane trees, this is so that the knife does not dull quickly.

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1.1. The sharpness of the blade effect
Cutting is the process of dividing a solid object mechanically along the desired line using a cutting tool. In some cases, cutting has other terms depending on the tool and how the cut is done. These terms include chopping, cutting (Mowing), sawing (sawing), splitting (spliting), slicing (slicing) and so on.

Figure 1. Sketch of a cutting knife [3].

Figure 2. Blade (a), sharp and blunt (b), fine and blunt [2].
Sharpness and finess are two different properties of a blade (Figure 2). A knife is said to be sharp if it has a small radius and thickness of the blade, while it is said to be finess if the knife has a small blade angle. The opposite of sharpness is dullness, while the opposite of kink is not sharp (bluntness).

The sharpness of the blade is an important factor in cutting material. Sharpness has a significant effect on the cutting force, the sharper the knife used, the lower the required cutting force. Meanwhile, the angle of the blade has an effect on the maximum specific cutting force. Blades having a small blade angle (finess) require a lower maximum specific cutting force.

1.2. Characteristics of sugarcane stems

Sugarcane stalks have a cylindrical shape and consist of several parts (Figure 3). These parts include the eye or bud, the node, the internode, the wax band and the root band. The root band is the hardest part of a ripe sugarcane segment, while the middle section has the second hardness level (Hutasoit 1978). Furthermore, the Uba (hard sugarcane) type showed that the smaller the diameter of the sugarcane, the harder the sugarcane was, while the hardness of sugarcane planted in gardens without irrigation increased by about 20.39% compared to sugarcane planted in irrigated gardens.

Figure 3. Shape and parts of sugarcane stalks [1].

Figure 4 shows that the hard sugarcane (type Q-2) has sclerenchyma and parenchyma with thicker walls compared to soft sugarcane (type Badila). The thick walls in these cells increase the lignin content as a fiber binding, so that the cell wall bonds are stronger. In connection with this, the types and varieties of sugarcane affect the hardness of the sugarcane stalks, so that the amount of cutting force required is also not the same. Hutasoit's research (1978) shows that the Bz 134 variety has a
relatively high hardness compared to the other five varieties, namely Ps 41, Ps 30, POJ 3016, POJ 3067, and Bz 62. The Bz 134 variety has a hardness of 6.9 kg cm$^{-2}$ or equivalent, with 676 200 N m$^{-2}$.

1.3. Mound cutting profile

According to [5] that comparing the shape of the ridge profile is only viewed from the slope angle of the blade, because with different slope angles it will change the position of the blade holder in the process of cutting. Figure 3 can be seen in the form of the average profile of two type the knife treatment, the forward speed of 0.3 m/s, the blade rotation of 850 rpm with angles of 45° and 60°. At the position of the cutting angle 45° produces the shape of the result tend to be evenly distributed, not concave in and wider with a depth of thickness of 8.07 cm and width of result 39.17 cm, compared to the position of cutting angle 60° which profile shape is somewhat concave with a depth of 9.77 cm and width of the result 38.33 cm. This corresponds to the trajectory pattern of the blade tip when rotated forward, where the cutting angle is 60° concave compared to the cutting angle of 45°.

![Figure 5. Shape of cutting result](image)

In Figure 5. The results of the test with a 45° cutting angle it produces an average depth of 8.92 cm and a width of 37.50 cm, while the cutting angle 60° produces an average depth of 8.13 cm and a width of 36.46 cm. The 45° cutting angle results in a greater depth of depth on the cutting angle of the 60° cutting angle because there are several treatments at an angle of 45° which produce depths of more than 10 cm. In applications on the ground to adjust the depth of the hard it is difficult because there is no pan depth control unit on the engine. To adjust the depth of the mat, only rely on the hydraulic on the tractor to lower and raise the blade of the pressing machine.

1.4. The sooth of sugarcane

Generally sugar cane breeds vegetatively, namely by way of sprouting. Growth starts from the development of roots in the root band (root band) found in the cuttings or sugarcane seedlings (original cutting) that have been planted. Furthermore, the first shoot (primary shoot) followed by the second shoot (secondary shoot) grows from the eye bud (eye or bud) contained in the sugarcane seedlings, while the roots of the shoots develop in the root band found in the first shoots and shoots second (Figure 6).

Food reserves for new shoots are initially supplied by the sugar cane seed root system, so that the sugar cane cultivation depends on the root system of the seeds for 3-6 weeks or how long the new roots in the shoot can meet the needs of water, oxygen, and nutrition needed [1]
2. Materials and methods
The equipment used in this study include: 1 unit modified two wheel tractor machine with serrated cylindrical blade to cut stumps (figure 7), tachometer, digital camera, stopwatch, computer, and other supporting devices. The material used in this study is sugarcane mounds that have been harvested so that the remaining sugar cane stumps will be carried out. Observation of the quality of the ratoon cane and growth of shoots is the result of ratoon cane stumps that include unbroken sugar cane stumps, broken sugarcane stumps, and sugarcane stumps were uncovered. Shoot growth was observed starting from first week after the cutting treatment until the 4th week, including: Calculating the number of tillers growing after cutting, measuring plant height (cm) by measuring plant height from the base of the shoot to the highest end of the leaf, and measuring plant diameter (mm) from first week after treatment until the 4th week.

Figure 6. Cane shoots that grow from the buds of sugar cane seedlings and new shoot roots from the root band [1].

Figure 7. (a) Cutting stumps machine (b) Serrated cylindrical blade.
3. Results and discussion

3.1. Profile of mound

According to practitioners in the field, a good treatment is if you can cut the stump below the surface of the ground and the results of the shape like "V or W". There are two forms of cutting, namely the shape of the U or V shape which is carried out on soil containing sand and the form of W which is carried out on heavy soils which are easily broken during the dry season. Extension is carried out at a depth of 5-10 cm from the surface of mound [4].

The results of the cutting shape observed include the mound profile which the height and width of the shape after the cutting process. The study was carried out with 3 treatments of the mound. The shape of the cutting produced from the first mound, the second mound and the third mound can be shown in Figure 8, Figure 9 and Figure 10.

![Figure 8](image-url)

**Figure 8.** Results of cutting the first mound.

In Figure 8, shows the height of the mounds before cutting which is 17.93 cm, whereas after cutting it is 10.15 cm, so that it can be seen the depth of cutting produced at the first mound that is 7.8 cm cm obtained from the difference in the top of the mound before being cut with a mound base after cutting, and the result of the cutting width is 45 cm.
Figure 9. Results of cutting the second mound.

In Figure 9, shows the height of the mounds before cutting which is 17.90 cm, whereas after cutting it is 11.00 cm, so that it can be seen the depth of cutting produced at the second mound that is 8.9 cm obtained from the difference in the top of the mound before being cut with a mound base after cutting, and the result of the cutting width is 43 cm.

Figure 10. Results of cutting the third mound.

In Figure 10, shows the height of the mounds before cutting which is 13.38 cm, whereas after cutting it is 8.25 cm, so that it can be seen the depth of cutting produced at the third mound that is 5.3 cm obtained from the difference in the top of the mound before being cut with a mound base after cutting, and the result of the cutting width is 45 cm.
3.2. Quality of the results
The results of the cut of sugarcane stump are good, namely the cane stalks are neatly cut and there are no breakages and the surface of the sugarcane stump is flat (whole) as shown in Figure 11(a). The result of broken stump cut is the result of sugarcane stump whose surface is not intact and looks broken as shown in Figure 11(b).

![Figure 11](image_url)

(a) Unbroken stumps, (b) Broken stumps.

The results of the calculation of unbroken stumps on the first mound were 43 stumps and the percentage of unbroken sugarcane was 79.63%. The second mound was 46 stumps with a percentage of unbroken sugarcane as much as 85.19%. and the last mound or the third mound as many as 41 stumps with a percentage of 75.93% intact sugarcane. The average percentage of the total cutting of unbroken stumps was 80.25%.

![Figure 12](image_url)

Figure 12. The quality of the results of the cutting (%).

In Figure 12, The number of stumps that were cut into pieces was not too much, namely 11 stumps cut into pieces with a percentage of 20.37%, and 8 stumps for the second mound with a percentage of
14.81% and the last mound or the third mound was 13 stump with a percentage of 24.07%. The average percentage of the broken cut cane stump is 19.75%.

In this study, the results of uncovered sugarcane stumps from 54 stumps with a percentage of 0%, this shows that the serrated type of sugarcane stump cutting machine works well and is able to cut more intact sugarcane stumps.

3.3. Results of growth sugarcane plant

The parameters of the growth of sugar cane plants which were observed subsequently consisted of the number of shoot growth, shoots height (cm), shoots diameter (mm), growth observations made are 7, 14, 21 and 28 days after treatment.

3.3.1. Growth of shoots (%). There are differences in the percentage growth in the number of shoots grown from the results of cutting in each treatment from the angle of cutting the blade. The observation of the number of shoots is done once a week.

Based on the shoot growth data, the first mounds produced 46 shoots from 54 waiting ones that were cut or about 85.19%. Then the second mound produced 43 shoots from the 54 cut shoots or about 79.93%. Furthermore, the third mound produced 34 shoots or about 62.96%. So that the average growth of the treatment mounds on the seventh day after cutting was 75.93%.

On the 14th day after cutting, there was an increase in shoot growth in the second mound, namely 61 shoots or around 112.96%. Then the third mound was 60 shoots or about 111.11% and finally the first mound was 53 buds or about 98.15%. Whereas on day 21th, the highest shoot growth in the second mound was 85 shoots or 157.41% and then the first mound was 80 shoots or 148.15% and then on the third mound 66 shoots or 122.22%. While on day 28 th, the highest shoot growth was in the first mound 76 shoots or 140.74% and then 72 shoots or 133.33% in the second mound and then 77 shoots or 142.59% in the third mound.

3.3.2. Growth of shoots height (cm). The average plant height observed after cutting on days 7 th, 14 th, 21th, and 28 th days after cutting is shown in Figure 16. Based on data of observations that have been done in Figure 12 shows that the average growth rate of shoot height at the age of 7 days after treatment is highest in the first mound which is equal to 35.43 cm from 3 treatment of mounds, while the average value of growth shoot height at the third mound and the second mound is 16.61 cm and
At the age of 14 days the highest average growth value of shoots at the first mound is 74.43 cm, then the third mound is 72.23 cm and the second mound is 67.05 cm. At the age of 21 days after treatment shoots height growth began to increase where the highest growth rate of shoots was found at the third mound, which amounted to 101.33 cm while the other mounds. At the age of 28 days after treatment the growth of shoot height began to increase significantly where the highest average growth rate of shoots was found at the first mound which was equal to 127.40 cm.

4. Conclusions
From the data from the observations and discussion in this study, some conclusions were obtained, namely:
1. The resulting cutting form is in the form of U with depth of 5.3 to 8.9 cm and a cutting width of 43 to 45 cm.
2. The average percentage of the total cutting of unbroken stumps was 80.25%.
3. The highest shoot growth in 28 days was in the first mound 76 shoots or 140.74% and then 72 shoots or 133.33% in the second mound and then 77 shoots or 142.59% in the third mound.

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