Performance Test of Vertical Rotary Blade to Cut Sugarcane Stumps with Two Wheel Tractors

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Abstract. Many efforts have been carried out to boost sugarcane production through increased productivity, namely land preparation, seed repairs, fertilization, irrigation, plant maintenance and pest control. Thus, performance is very important because it will determine the quality of sugar cane. To date, sugarcane crabs is still performed manually with co-added of hoe equipment. Cutting with hoes in addition to low capacity and expensive costs, the yield is also less than expected. According to practitioners in the field, a good cutting stump requires the stump below the surface of the ground and shaped like "U, V or W". The purpose of this study was to examine the cutting angle of the sugarcane cutting tool using 3 cutting angles of the blade that rotates vertically with two-wheeled tractor power. The highest percentage growth of shoots in each week after treatment is in the cut angle of 0° which is equal to 17.78% at 7 days after treatment to 86.67%, yet, the growth in height and diameter of shoots is the lowest treatment.

1. Introduction
To date, sugarcane crabs is still performed manually with co-added of hoe equipment. Cutting with hoes in addition to low capacity and expensive costs, the yield is also less than expected. According to practitioners, a good treatment requires stump below the surface of the ground and the results of the shape like "U, V or W". There are two forms of cutting as shown in Figure 1, namely the shape of the U or V shape carried out on soil containing sand whilst W shape 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 [3]

![Shape of mound](image)

(a) shape U/ V  (b) Shape W

**Figure 1. Shape of mound [3]**

The exploitation of sugarcane by ratoon is performed on sugarcane because it can save production costs. Ratoon cane which is good is done by cutting the remaining plant flat or below the surface of the soil. The tools used are generally hoes using manpower and a stubble shaver machine. The problem that arises related to manual construction is the availability of labor both in terms of quantity and quality. [4] suggest that the labor available to manage sugarcane land is only one third of the workforce in the period before 1975. Another thing to think about in relation to manual construction is the quality problem of the results of ratoon cane to complete manual finishing work or hoes need 10-14 people per hectare. This ratoon cane process to produce sugar cane plants that have deep roots, so that the plants will not easily collapse after adulthood. This ratoon cane has a lower yield compared to the first plant. This results in sugar cane can only be pressed several times, usually only up to three
times, where the cultivation process and environmental factors are very influential in determining how many times this plant can be cutting.

1.1. Mound Cutting Profile
According to [2] that sugarcane mounds for the first (R1), second (R2) and third cutting (R3) in the land of PG Jatitujuh have different shapes and sizes. The difference lies only in the size of the width of the ridge, the mound for R3 has 85 cm, while for R1 and R2 80 cm. The distance of the mound to the mound to three mounds 135 cm, the height of the ridge and the surface of 20 cm and the width of the stump area which must be cutting 40 cm. While the position of the sugarcane groove is not always straight in the middle, the deviation ranges from 0-25 cm from the center. The average number of stumps is 5-12 stumps.

![Mound Cutting Profile](image)

**Figure 2.** Mound Cutting Profile R3 (a), R1 dan R2 (b) di PG Jatitujuh [2]

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°.

![Shape of Cutting Result](image)

**Figure 3.** Shape of Cutting Result (a) Cutting Angle 45° (b) Cutting Angle 60°
In Figure 3. 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.

1.2. The sooth of Sugarcane
Generally, sugar cane breeds vegetatively, namely by means 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 4).

![Figure 4](image)

**Figure 4.** Cane shoots that grow from the buds of sugar cane seedlings and new shoot roots from the root band [1]

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 (Humbert 1968). The base of the sugar cane stem below the ground (ground level) has an increasingly short and tapered stem segment (Figure 5). The buds found at the base of the first stem (primary stalk) grow into the second stem (secondary stalk) and the buds at the base of the second stem develop into the third stem (tertiary stalk). The growth takes place sequentially, continuously, and has alternating positions according to the position of the buds at the base of the sugarcane stem.
Sugarcane stalks that remain below the soil surface after logging can grow back as sugar cane. Food reserves for new shoots from sugar cane are initially supplied by the previous sugar cane root system. After the shoots grow into sugarcane stems that have their own root system, the old root function is taken over by the new sugar cane root system. The old roots then change color to dark (blackish) and are no longer effective in making food supplies, so the roots eventually die and break down in the soil.

2. Material and Methods
The equipment used in this study include: 1 unit modified stubble shaver machine with two wheel tractor unit, 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. Variables varied in performance testing were cutting angle 0°, 15°, and 30°. 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.

3. Result and Discussion
3.1. Profile of Mound
Before the cutting process is carried out, measurements are also taken to determine the shape of the mound. 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 cutting angles namely 0°, 15°, and 30°. The shape of the cutting produced from the cutting angle 0°, 15° and 30° can be shown in Figure 6, Figure 7 and Figure 8.

**Figure 5.** Sequence of growth of sugarcane stems from cut sugar cane found below the ground [1]
In Figure 6. shows the height of the mounds before cutting which is 16.7 cm, whereas after cutting it is 7.7 cm, so that it can be seen the depth of cutting produced at an angle of 0° that is 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 35.5 cm.

In Figure 7. shows the height of the mounds before cutting which is 16.8 cm, whereas after cutting it is 8.0 cm, so that it can be seen the depth of cutting produced at an angle of 15° that is 8.8 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 33.5 cm.

In Figure 8. shows the height of the mounds before cutting which is 16.9 cm, whereas after cutting it is 8.2 cm, so that it can be seen the depth of cutting produced at an angle of 30° that is 8.7 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 33.5 cm.
In Figure 8. shows the height of the mounds before cutting which is 15.7 cm, whereas after cutting it is 9.4 cm, so that it can be seen the depth of cutting produced at an angle of 30° that is 6.3 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 31.5 cm.

3.2. Quality of The Results

The quality of the results of the cutting is the result obtained directly from the field process, then the results of the cutting quality are divided into several parameters, namely: Unbroken stumps, broken stumps and uncovered stumps, then the results of the three types of stumps are included in the average percentage.

In Figure 9. The quality of the unbroken stump is the form of an intact piece of cutting, where the sugarcane stump is completely cut from all three clumps. The quality of broken stumps is categorized where the stumps of sugarcane look broken at the time of cutting (not perfectly cut), while the quality of uncovered sugarcane stumps is a form of stump that is not cut by a blade but the stump of sugarcane is lifted out of the ground.

![Figure 9](image)

**Figure 9.** (a). Unbroken stumps, (b). Broken Stumps, (c). Uncovered stumps.

![Figure 10](image)

**Figure 10.** The quality of the results of the cutting (%).

Based on the figure 10, Percentage of the quality of sugarcane stump cutting results shows that for the highest average percentage of intact stumps themselves are found at an angle of 0° with a depth of 9 cm which is 86.67% at a cutting angle of 15° the percentage of whole stumps is 68.89% with a cutting depth of 8.8 cm, while the lowest cutting value is at an angle of 30° with a depth of 6.3 cm that is equal to 60%.

Based on data on the percentage of quality cut results of sugarcane stumps for the average percentage of the highest broken stumps was found at a cutting angle of 30° with a cutting depth of 6.3 cm that is equal to 22.22%, at an angle of 150 the percentage of broken stumps is 15.56% with a cutting depth of 8.8 cm, while the lowest percentage of broken stumps at an angle of 0° which is 11.11% with a depth of 9 cm. Based on data on the percentage of the quality of sugarcane stump
results for the highest percentage of uncovered stumps found at 30° angles with a depth of 6.3 cm, which is equal to 17.78%, at an angle of 15° percent the stump is exposed reaching 15.56% with depth of 8, 8 cm, while the lowest percentage of uncovered stumps is at the angle of 0° with a depth of 9 cm which is equal to 2.22%.

The difference in value of each parameter is influenced by the shape of the cutting angle and position of the blade when cutting process, so that there are types of stump pieces that are not evenly intact. At an angle of 0° it can be said that the best cutting angle of the 3 types of stump pieces is due to the position the blade as a whole is fixed (without changes in position or addition of angles) and spin flat and cut without breaking down more sugar cane stumps, so as to produce intact stump pieces of 86.67%, and produce diameters of cutting on the mound profile of 35.5 cm and depth of mound by 9 cm. At a cutting angle of 15° it can be said that the type of cutting angle is good because it still produces intact pieces on the sugar cane stump of 68.89%. In contrast to the previous angle the position of the blade at this angle is not completely in contact with the sugarcane stump, and results in a cut diameter of the ridge profile of 33.5 cm and a cutting depth of 8.8 cm. While at an angle of 30° is a type of cutting angle that is quite good because it still produces stump pieces on sugarcane stumps by 60% but at this angle more produce the type of broken and uncovered stumps than the other treatment, this occurs due to the position of the blade that is too tilted so that when operating causing the stump to be raised so as to produce uncovered and broken stump, this treatment resulted in a smaller diameter of cut in mound profiles that was 31.5 cm and depth of mound cuts was 6.3 cm

3.3. Results of Growth Sugar Cane 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 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

![Figure 11. Percentage of Growth in Number of Shoots (%).](image)

In Figure 11. The results of each percentage graph, it can be shown that the highest percentage of shoot growth in each week after cutting is in the cut angle of 0° which is equal to 17.78% in 7 days after treatment and reach to 86.67% in 28 days after treatment. This is because at this angle it is the cut angle form that produces the most intact pieces on the sugar cane stump. according to some studies the unbroken stump will produce good shoots growth
3.3.2. Growth of shoots height (cm)
The average plant height observed after cutting on days 7, 14, 21, and 28 days after cutting is shown in Figure 12.

![Figure 12. Shoot height (cm).](image)

Based on data of observations that have been done in Figure 10 shows that the average growth rate of shoot height at the age of 7 days after treatment is highest in the 15° cutting angle which is equal to 17.9 cm from the 3 treatments, while the average value of growth shoot height at 0° and 30° cutting angles is 16.61 cm and 16.42 cm. At the age of 14 days the highest average growth value of shoots at 0° and 30° cutting angles was 35.09 cm, whereas at an angle of 15° only 34.13 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 15° cutting angles, which amounted to 55.37 cm while in the cut angle of 0° and 30° that was equal to 54.91 cm and 54.75 cm. 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 30° cutting angles which was equal to 74.40 cm and at 15° angles at 73.34 cm while the lowest value was at the 0° cut angle which was 67.01 cm.

3.3.3. Growth of Shoots Diameter
The average plant diameter observed after cutting on days 7, 14, 21, and 28 days after cutting is shown in Figure 13.

![Figure 13. Growth of Shoots Diameter (mm).](image)

In Figure 13 shows that the average growth rate of shoots diameter at the age of 7 days after treatment is found at 30° cut angle, which is equal to 4.73 mm from the 3 treatments, while the average
value of shoot diameter growth at 0° and 15° cutting angles is equal to 4.52 mm and 4.63 mm. At the age of 14 days after treatment, the results can be shown that the average value of growth of large shoot diameter is at the cutting angle of 0° and 15° which is equal to 5.63 mm while at an angle of 30° only 5.55 mm. At the age of 21 days after treatment the growth of shoot diameter began to increase where the average growth rate of the largest shoots was found at the cut angle of 0° which was equal to 6.63 mm while in the cutting angle 15° and 30° that was equal to 6.52 mm and 6.49 mm. At week 4 or 28 days after treatment, the growth of shoot diameter began to increase significantly, where the average growth rate of the largest shoots was at the 30° cutting angle of 8.43 mm and at an angle of 15° at 8.32 mm while the lowest value was at the angle cut 0° which is equal to 8.20 mm.

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 / V, on mounds at 0° cutting angle produces a depth of 9 cm and a cutting width of 35 cm, deeper and wider than other treatments.
2. The best cut angle of the 3 types that have been done in this study is the 0° cut angle which produces intact piece of 86.67%. The highest quality of broken and uncovered stumps was obtained at 30° cutting angles, which amounted to 22.22% for broken stumps and 17.78% for quality uncovered stumps
3. The highest percentage growth of shoots in each week after treatment is in the cut corner of 0° which is equal to 17.78% at 7 days after treatment 86.67% at 28 days after treatment. But at the growth of the height and diameter of the shoots to be the lowest treatment, this is due to the growing number of tillers resulting in competition for food.

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