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DESIGN AND DEVELOPMENT OF A SELF-PROPELLED SUGARCANE LEAF

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ABSTRACT

The development of a sugarcane leaf cutter machine with a size of 1.8×1.8×0.78 meters that uses power from a 13-hp gasoline engine to transmit power to the reduction gear to change the direction of rotation and transfer power to the ball pulley was conducted at Valaya Alongkorn Rajabhat University. The sugar cane leaf cutter is attached to the cardstock and works in a rotating manner. The blade is a grass cutter tendon. The blade set was placed on a trailer towed by a 13-horsepower agricultural multi-purpose vehicle. In the test, the area was used for an area of 0.80 × 50 meters (sugarcane leaf cutting width × distance) using the speed of the engine at 1,500, 2,000, 2,500, and 3,000 rpm, respectively. Expending forward gears while the car has speeds of 3 and 5 km/h and use the speed of the sugarcane pruning machine at 700, 840, 900, and 1,000 rpm. The test results at a vehicle speed of 3 km/h showed that the rotational speed of the sugarcane pruning machine gear shaft was 700 rpm and the engine speed was 1,500 rpm, which yielded a theoretical capacity of 1.5 rai per hour. The Acquired capacity to actually work was 1.1 rai per hour and achieved 73.3 percent field efficiency. When increasing the speed of the sugarcane pruning machine and the engine, the EFC (Actual Working Capacity) and EFF (Field Working Efficiency) values increased with the speed. The average fuel consumption of a tractor was 210 ml/50 m. and the average fuel

consumption of a sugarcane leaf cutter machine was 375 ml/50 m. Gasohol 91 was used as a test fuel.

KEYWORDS*:* Sugarcane leaf cutter; Tractor; Sa Kaeo Province.

INTRODUCTION

One of the most substantial industrialized crops in Thailand is sugarcane. Sa Kaeo province is located in the east of Thailand. It is a crucial source for sugarcane production in the country. Sugarcane output for the 2021-2022 crop years.[1] is expected to drop below 100 million tons as sugar millers are offering higher prices amid tough competition to buy crops. Both Thailand and other cane-growing countries are facing a drought, and this has caused some sugar millers in Thailand to announce they will purchase sugar cane from farmers at 1,300 baht per ton in 2021-22, up from the normal price of 1,000 baht per ton. In recent years, growth in sugar manufacture has come largely from area enlargement in the North and Northeast regions. In the future, superior prominence is anticipated to be given to the overview of developed yielding variabilities and the enlarged use of yield-enhancing production inputs. Demand for sugar in Asian markets is expected to remain strong. The major restraint to longer term growth could be the appearance of transferring and substructure bottlenecks, which would stall the flow of sugar to extend markets. Sugarcane cultivators in the Northeast province generally setting up their cane from October to November, and in the Eastern Middle Plains suburb, from November to February.[2] While the sugarcane crop calendar changes by region, the growing interval is about 10 to 14 months subject to the variety of cane. Farmers extensively grow only one or two ratoon products, and as a result, they can change the area planted almost quickly in response to world price changes. For example, the total sugarcane area enlarged sharply on the attend of the global price spikes of the mid-seventies, early eighties, and since the second-half of the eighties. Sa Kaeo Province is the No. 1 sugarcane growing area in the Eastern region. There are 12,837 domiciliary planting sugarcane and arrangement it to the factories, with a plantation area of 332,638 rai, yielding 3,558,412.34 tons, an average of 11,620 kg per rai (11.62 tons/rai) and a price of 79,669 baht per ton (Office of Agriculture and Cooperatives). Sa Kaeo Province has most of which is relevant for sugarcane cultivation, apart from Wang Nam Yen District, which has the most improper area for sugarcane planting, accounting for 31.61 percent (Bureau of the Cane and Sugar Board, 2019), but farmers still upgrade to grow factory sugarcane continuously. In particular, the communities in Villages 1, 3 and 8 in the limestone canal sub-district suffer from drought and production factors such as soil, water, nutrients, weather conditions and pests, including the burning of sugarcane leaves before harvesting, causing air pollution. The loss to the soil ecosystem and the cost of sugarcane fire were deducted from the initial sugar cane price. Therefore, the community was analyzed for production factors and the risks of sugarcane farming by specifying the farmer areas at Village 1, Ban Khai Charoen, Moo 3, Ban Wang Yao, and Village 8, Ban Khlong Pod Mee, which is an experimental area. The machinery of the sugar cane leaf cutter is essential for modern agriculture, as it enhances productivity and reduces the cost of cultivation. The cost of sugarcane leaf cutting by a mechanized process is almost one fourth of the complete manual process. Nevertheless, most of the smaller industries in Sakaeo, which now manufacture agricultural implements, lack design capabilities. For the manufacture of components, appropriate selection of materials and metallurgical treatment To guarantee durability and reliability in quality, proper tolerances for components and assembly methods are required for Additionally, these industries do not have quality R&D facilities and manpower to produce quality products. Considering the above points, the advancement of a tractor-mounted two-row sugarcane leaf cutter was carried out in agreement with the commitments of planters. It was decided to study transmission powered machines and to enhance their designs for aspect production of the present machine.

Many studies of sugarcane cutting machines,[3] have been conducted as follows. Zhang et al., 2017a,[4] conducted theoretic studies including investigation of the structural design and optimization of the blade, collaboration analysis between the blade roller and operating objects, simulation of the working process, etc. Zhang et al. (2017b),[5] premeditated the pulverizing device for a straw pulverization and throwing returning machine. The rotating speed of the cutter shaft, the structure and arrangement parameters of throwing and fixed blades, and the shape of the fan-shaped blade were explored. Zheng et al. (2017),[6] studied the soil cutting process of a rotary tillage blade under positive and negative rotation, and then obtained the relationship between the thickness of soil in the excavation and the height of the soil uplift at the bottom of the ditch after operation, so as to determine the structural parameters of rotary tillage blades. Matin, Fielke, and Desbiolles (2015),[7] carried out soil bin tests on the torque, power, and energy required by blades with three different geometric shapes of the rotary tiller when working at four different speeds, and obtained the best combination of parameters. Simulation methods have been widely used in agricultural machinery equipment, and can provide the basis for optimizing the design of the blade roller. Zhao et al. (2020),[8] conducted a simulation study on the influence of plain-straight blades with different edge curves and slide-cutting angles on soil disturbance and torque based on the discrete element method (DEM). Zhang, Zhang, Xiao, Bartos, and Bohata (2019)[9] performed the influence of bending angle, blade width, and working width of rotary tillage blades on working resistance and operating power consumption of soil cutting using a finite element method simulation and analyzed the results using a response surface method. Zhu et al. (2019)[10] compared using simulation different arrangements for spiral horizontal blades of blade rollers in the process of cutting soil, and found that the axial load stability and the cutting resistance of a herringbone arrangement were better than with serrated and interlaced cutters. However, most of the existing research in this area involves large and medium-sized agricultural machinery and equipment, and the research objects are mainly soil and straw residues. Xie, Wang, et al. (2020)[11] established a simulation model of the leaf stripping process for whole-stalk sugarcane harvesters to analyze the interaction between the stalk and the leaf stripping device. Dai and Wang (2020)[12] used an arbitrary Lagrange-Euler method to simulate the process of cutting sugarcane leaves with flexible blades in different working modes under the action of a self-excited wind field. Huang, Wang, Tang, Zhao, and Kong (2011)[13] computer-generated the cutting process of the miniature sugarcane cutter to find out the influence of the cutter inclination and cutting speed. These studies have provided the background for our simulation research, which examines the interaction between the blade roller and sugarcane leaves.

This research aims to design and develop a self-propelled sugar cane leaf cutter for a prototype being tested in Sa Kaeo Province for agricultural use in sugar cane leaf cutting to prevent the burning of leaves that cause global warming problems and particular matters as well.

MATERIALS AND METHODS

System Design

The sugar cane leaf cutter was designed to save on the cost of machinery production and reduce the cost of purchasing a prime mover tractor, which cost more than 300 thousand baht. The authors adapted a small 13-hp gasoline engine, in which the pulley ratio is 4 to 1, to transfer the revolution of the drive shaft to the gear box. The second transfer is to drive the pruning cylinder equipped with a grass cutting tendon with a pulley ratio of 1.5 to 1, so the total pulley ratio is $4 \times 1.5 = 6:1$. This ratio protects the engine from overload while working.

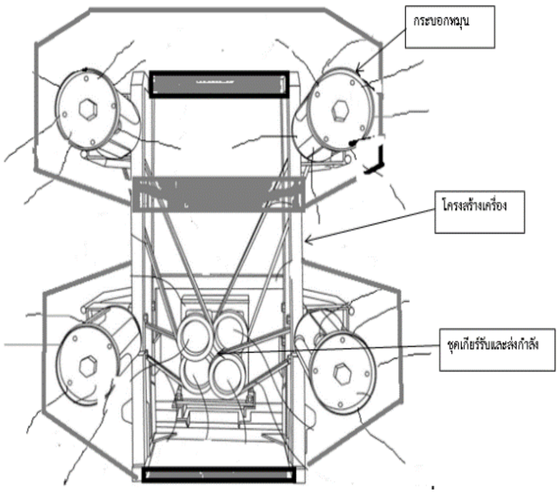

Figure 1: A sketch of a self-propelled sugar cane leaf cutter.

Fabrication

The fabrication of a self-propelled sugar cane leaf cutter

1. Create a sugar cane leaf cutter that can drive itself without the assistance of a tractor's PTO.
2. Construct a frame for a sugar cane leaf cutting machine out of steel bar with a 1.5 inch section area and 1.8 meter length, formed by cutting and welding together as shown in Figure 1-2 as a frame for several equipment configurations.
3. Power Supply.

The power transmission system is a transmission that transmits power from a 13-horsepower gasoline engine, which the engine shaft power is used to have a rotational speed of 540 to 800 rpm and is sent to the belt drive to change the direction axis. The rotation of the shaft is connected to the drive pulley. Then it is sent to the pulley along which it is attached to the sugar cane sprouts, as shown in Figure 1-2.

Figure 2: Fabrication of a self-propelled sugar cane leaf cutter.

Figure 3: The assembly of the sugar cane leaf cutter on a trailer.

The system was designed with the following specifications

800 mm field furrow depth

1.500 mm is the distance between sugarcane rows

Range of adjustment: 1,200 to 1,500 mm

Sugarcane cut length: 200-250 mm on average

Drive to machine: V-belt from engine to gearbox

The machine weighs approximately 400 kg

Field capacity ranges from 0.59 to 1 acre per day

13 hp gasoline engine as the prime mover

Significant Design of Sugarcane Cutter

The manufacturing drawings of the sugarcane leaf cutter, like general assembly, main frame, furrow opener, wheel, ground leveler, gearbox, and sugarcane container, were prepared, taking into consideration the design modifications and design refinements wherever necessary to make the machine more reliable. A high-strength, rust-proof, lightweight, weld able steel fabricated frame was used to support the machine. A compact bevel gear box has been designed which is connected to the gasoline engine. The multi-purpose agricultural tractor, as shown in figure 4, was used to tow sugarcane cutters for driving the various areas of the sugarcane farm. There was minimal damage to the sugarcane buds during the test.

Figure 4: Sugarcane cutter machine field test.

EXPERIMENTAL SET-UP

The operational testing of the sugarcane leaf cutter

A test of carding sugarcane leaves at a distance of 0.8 × 50 m (carding width × distance) using engine speeds of 1,500, 2,000, 2,500, and 3,000 rpm, using forward gears while the car is at 3 and 5 speeds km/h using the speed of the shotgun at 700, 840, 900, and 1,000 rpm, finds the operating time of the machine and the fuel consumption of the machine as shown in Fig. 4.

Testing work related to adjustment, sprout damage resolve, quality of cut, and superiority of cut was carried out as per the following procedure.

1. Adjustment

The adjustment was done by attaching the planter to the tractor by a three-point linkage system and powered by a gasoline engine. The tractor was operated in the first low gear at 1,600 engine rpm. The total number of setts cut per minute was recorded and tallied. This procedure was repeated three times and an average was calculated. Accordingly, the seed rate required per hectare was calculated.

2. Sprout Damage Resolution

A hundred sets of sugarcane were selected randomly and the number of sprouts damaged was observed and recorded. The average was computed.

3. Cut superiority

An average was calculated after randomly selecting 100 sets of sugarcane and observing the nature of the cut three times.

Field Test

1. Placement Depth[14]

The cutter was operated in the field without levellers. The depth of placement of setts in the furrows was evaluated. The depth was measured in three different locations, and the average was computed of placement of setts was controlled by the hydraulic system of the tractor.

2. Overlap/ Gap

A cutter was run in the field for 50 meters distance. All setts dropped were collected and the number of sets and length of each set were measured. The machine was operated in the speed range of 3 to 5 km/h at different towed speed.

$$\text{Average Overlap} = \frac{\text{Total length of setts} - \text{Distance}}{\text{Total no. of setts}} \quad (1)$$

$$\text{Average Gap} = \frac{\text{Distance} - \text{Total length of setts}}{\text{Total no. of setts}} \quad (2)$$

3. Speed of operation

The sugarcane leaf cutter was run at a fixed distance of 50 meters in the field and the time required to cover this distance was noted. Simultaneously, the time required for turning the planter was also noted. As such, three observations were required to get the accuracy.

4. Theoretical field capacity (TFC)

The speed of operation and theoretical width of the planter were noted as the following:

$$\text{Theoretical Field capacity} = \text{Theoretical Width (m)} \times \text{Speed of operation(km/h)}/10 \quad (3)$$

Actual field capacity (AFC)

The plot of 0.2 hectares was selected and the time taken to cover this area was noted. Time taken for turning, and other operational obstructions was also noted.

Field Efficiency

$$\text{Field efficiency} = \text{AFC} \times 100/\text{TFC} \quad (4)$$

RESULTS AND DISCUSSION

Subsequently, the prototype was tested in the sugarcane field to assess its performance. Laboratory performance was performed by connecting the prototype to a 13 hp. engine to verify the proper functioning of all components. All-important parameters of components such as pulleys, gears, belts, sugarcane cutting mechanisms, and chain gear mechanisms. Suspensions, etc., are checked for proper functioning according to the design. Study the cutting mechanism by feeding sugarcane of different diameters through it. The results of the laboratory experiments were found to be adequate and the unit was endorsed for field evaluation.

Test results of the design and development of a self-propelled sugar cane leaf cutter to test its performance. The results of the study were shown as follows:

Comparison of actual working capacity and farm performance was performed. When the engine speed is increased from 2,500 to 3,000 rpm, the capacity is increased, and when the ratchet speed is increased from 900 to 1,000 rpm, the capacity and efficiency are increased. Farm work has also increased, as shown in Figure 6 -7.

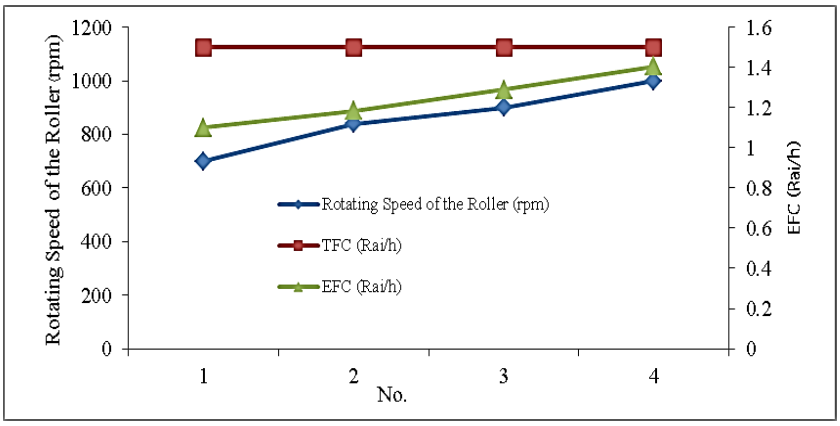

Figure 6: The relationship between the speed of the sprocket and the actual working capacity and theoretical performance.

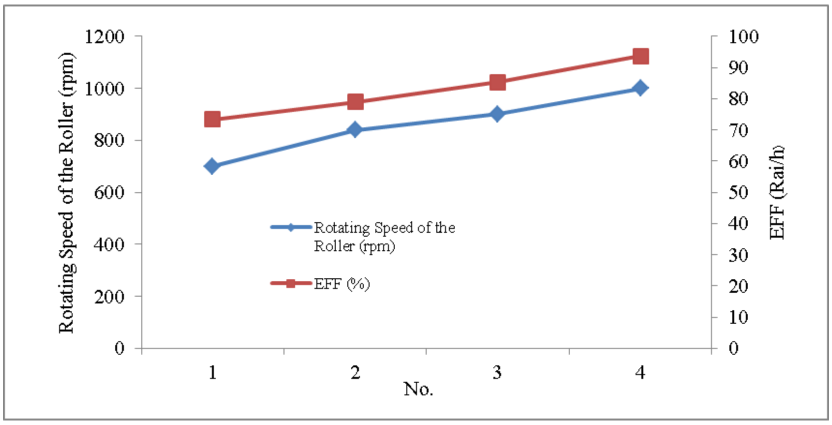

Figure 7: The relationship between the speed of the spout and the actual working capacity and efficiency of farm work.

CONCLUSION AND FUTURE SCOPE

The sugarcane leaf cutting area was about 0.8 x 50 m. Test results at low speed (3 km/h), the tests conducted by using a forward gear, with the speed of the picket at 700 rpm at an engine speed of 1,500 rpm, took an average time of 1.363 minutes to move and assessed its efficiency. The field was 73.33 percent, and at a speed of 2,000 rpm, the average moving time was 1.266 minutes. The farming efficiency was 79 percent. The appearance of the sugarcane leaf shedding was smooth, and there was a small amount of uncut sugarcane leaves. Sugarcane leaf carding test with forward gear, tow speed of 5 km/h, picket speed of 900 rpm at engine speed of 2,500 rpm, taking an average time of 1.163 minutes. The field efficiency was 85.337 percent, and at a speed of 3,000 rpm, the average travel time was 1.066 minutes. The farm efficiency was 93.733 percent. In leaf cutting, it is not as good as the lower tow speed. After conducting the study, the authors found that there are still issues that need attention and should be further studied for those interested in this study issue.

Suggestions for future studies are as follows

- The picker should be flexible enough to work in different areas and at different heights of sugarcane.
- It should be developed to be more compact and lightweight for ease of operation. For example, using a brushless DC motor will greatly reduce the size and weight of the machine and can also be powered by solar energy.

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