AESA 2009

ISBN 978-602-95924-0-5

International Symposium
AGRICULTURAL ENGINEERING TOWARDS SUSTAINABLE AGRICULTURE IN ASIA

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DESIGN OF A DITCHER EQUIPPED WITH SCRAPERS FOR MAKING DRAINAGE CHANNEL ON DRY LAND SUGAR CANE PLANTATION

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ABSTRACT

The objective of the research was to design a ditcher equipped with a pair of scrapers and pulled by a four-wheel tractor. The ditcher was designed to produce drainage channel with trapezoidal shape for dry land sugar cane plantation. The ditcher should be operated without using the PTO of the tractor, and be able to scrape the dug soil and place it on the top of initial ridges. A prototype of the ditcher has been designed and developed. The ditcher was consisted of two main components: 1) a ditcher and 2) scrapers. The ditcher was designed to cut-across the ridge and throw the soil to the right and left side of the ditcher in making the drainage channel across the planting ridges. A pair of scrapper was set to the ditcher for scrapping the soil in between the ridges and put it on the top of the ridges. Scraping mechanism was driven by an additional wheel that rolls on the ridge's profile. By the mechanism, the ditcher could make drainage channel across the ridge without using the PTO of the tractor. The test result conducted at the Experimental Field of IPB and Jatitujuh Sugar Cane Plantation, showed that the prototype operated well for making the desired drainage channel with the field capacity of 6.85 ha/hour. The cross section of the resulted ditches was trapezoid with the dimension of 38.7 cm depth, 37.9 cm lower side, and 100.2 cm upper side.

INTRODUCTION

One of the main factors determining the sugar cane production is a good drainage system. Drainage channels that cross the planting rows are used to drain the excess water from sugar cane plantation. The drainage channels at Jatitujuh Sugar Cane Plantation have been being formed by using a rotary ditcher. Shape and size of the drainage channel were good enough as expected, but the rotary ditcher itself had some disadvantages such as: its blades became dull and worn quickly, it tend to break the tractor PTO system. On the other hand, the utilization of a furrower in the ditch forming is preferred. But, by using the furrower, shape and dimension of resulted channel were not fulfill the requirement (Figure 1). In addition, the soil dug out by the furrower from the channel covered both sides of the planting ditch along the channel and blocked the drain water to flow out from the planting rows. To solve the problem, it is necessary to develop a new type of ditcher which is operated without using tractor PTO, and can scrape up the blocking soil from both sides of the planting ditch along the channel.

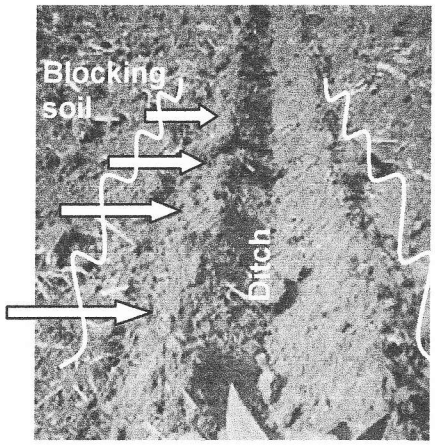


Figure 1. A ditch produced by a furrower.

The objective of the research was to design a ditcher equipped with a pair of scrappers pulled by a four-wheel tractor. The ditcher operated without using PTO. It is requested that the prototype can produce drainage channel with trapezoidal shape [1] with the lower side of 35 cm, upper side of 90 cm, and depth of 40 cm. It is also able to scrape and place the dug soil on the top of initial ridges.

RESEARCH METHOD

Field and tractor identification

As fundamental information for designing the ditcher, field characteristic of sugar cane planting area in Jatitujuh Sugar Cane Plantation was identified. Shape and dimension of the profile of planting ridges were measured, and the result is presented in Figure 2 (plant cane ridges) and Figure 3 (ratoon cane ridges).

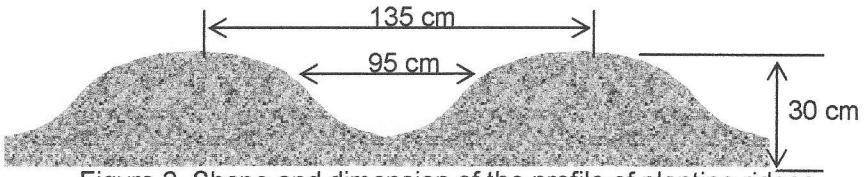


Figure 2. Shape and dimension of the profile of planting ridges.

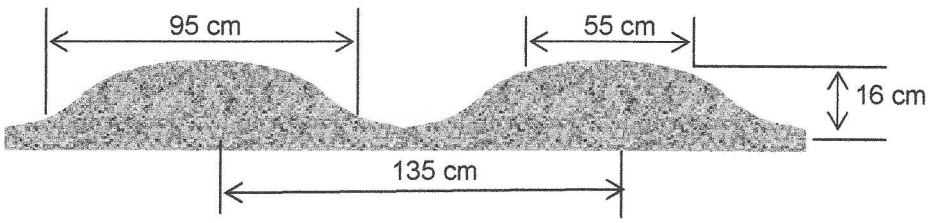


Figure 3. Shape and dimension of the profile of ratoon planting ridges

Physical properties and mechanical properties (cone penetration resistance, plate penetration resistance, shear resistance, etc.) of the soil were also measured. Furthermore, three point hitch specification and general dimension of the tractors used for pulling the ridger were identified and measured.

Drainage channel produced by a rotary ditcher at the planting area was identified and measured as presented in Figure 3. This ditch dimension was preferred to be produced by the new type of ditcher.

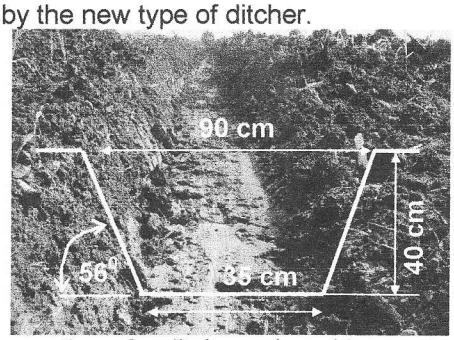


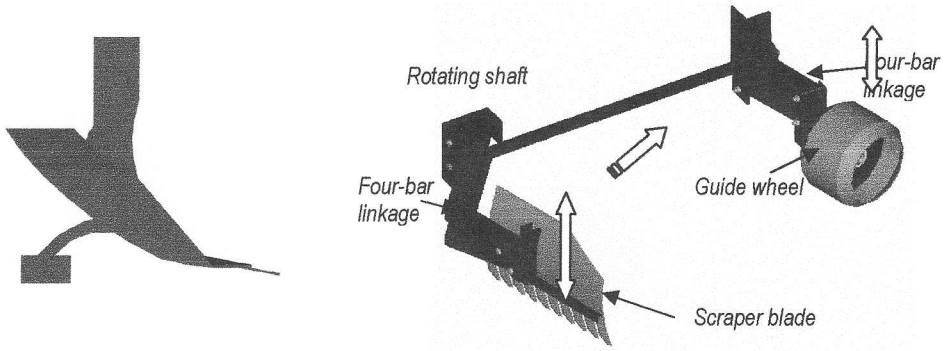
Figure 4. Cross section of a ditch produced by a rotary ditcher.

Conceptual design

There were two main processes that should be performed by the ditcher:

1) cutting-across the ridge and throw the soil to the right and left side of the ditcher in making the drainage channel across the planting ridges,
2) scraping the dug up soil in between the planting ridges and put it on the top of the ridges.

There were several concepts for performing these processes and making the preferred ditch, and following is the best concept selected on evaluation process. For the first process, a conventional furrower design as introduced by several authors [4, 5] as shown in Figure 5 (a) is selected for simpler construction. The cutting section should be able to cut the soil as the bottom of the ditch at 35 cm width. The moldboard shaped wing section should be able to lift up and throw the dug up soil to the left and right sides of the ditcher. For the second process, a scraping mechanism is designed, which consists of two main parts: a) scraper blade, and b) motion mechanism for the scraper blade. Since the scraper blade at the right and left sides of the ditcher should scrape up the soil in between the planting ridges and put the soil in the top of the ridges, the motion mechanism should be able to move the scraper blade as required. Furthermore, since the scraper blade should move up and down without using any power resource, the motion is performed by utilizing the ridge profile and a guide wheel which rolls on the ridges and move the scraper blade. The up-down motion of the wheel is utilized and connected to the scraper behind the wheel by a rotating shaft (see Figure 5(b)). By using the mechanism, the scraper moves up-down simultaneously with the guide wheel.



(a) (b)

Figure 5. Design concepts of ditcher (a) and scraper (b).

The mechanism was designed by analyzing the motion path of the scraper as resulted by the guide wheel movement, as shown in Figure 7. Since the required moving amplitude of the scraper is bigger than the wheel amplitude, the four-bar linkage of the scraper should be longer than the four-bar linkage of the wheel.

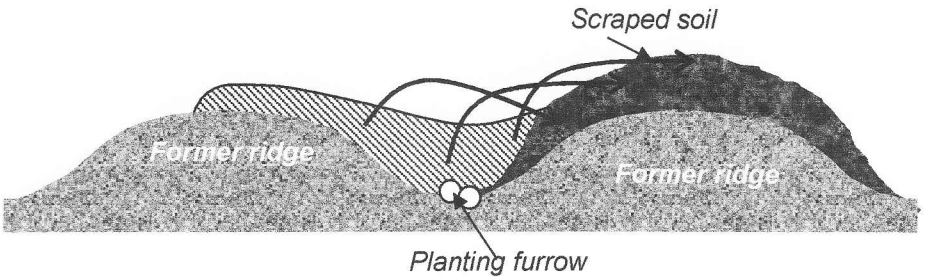


Figure 6. Scheme of scraping up process of soil from planting furrow to the top of the ridges

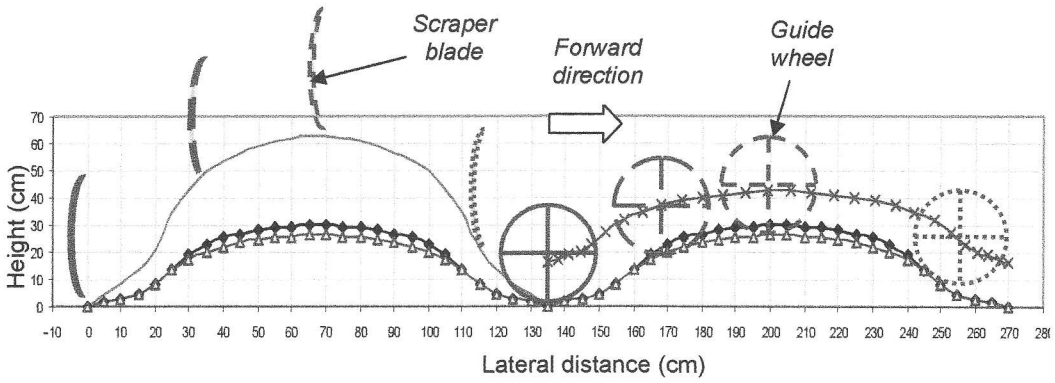


Figure 7. Scraper motion path as generated by the guide wheel movement.

For installing all parts of the ditcher and hitching to the tractor, a frame was designed at a proper strength and function. The concept is shown in Figure 8.

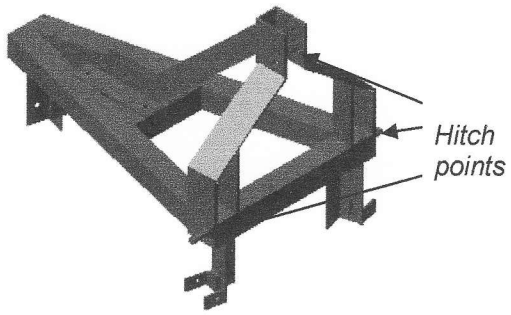


Figure 8. Design concept of the frame.

Performance testing method

A prototype of the ditcher was fabricated based on the design result. Furthermore, performance tests were conducted at the Experimental Field of Agricultural Engineering Department, IPB and Jatitujuh Sugar Cane Plantation. Testing plots was prepared at the same condition as the sugar cane planting condition, including similar size of planting furrows. Soil condition on the ridge was measured before the test, comprised soil bulk density, water content, and cone penetration resistance.

The prototype was hitched to a four-wheel tractor and set at a proper operation depth. During the operation, average forward speed was measured to get the field capacity of the ditcher. Ditches resulted by the ditcher were observed, and their cross sections dimension were measured using a relief-meter. The profile of planting row was also observed and un-scraped soil on the furrow bottom was measured.

To identify the power required for pulling the ditcher, a set of measurement was conducted. In the measurement, the ditcher was hitched to a tractor (Tractor-2) which was pulled by another tractor (Tractor-1) and a load-cell was set on the steel towing cable between the two tractors to measure the pull force (Figure 9). The draft force of the ditcher was determined by subtracting pull force in pulling un-worked ditcher from the pull force in pulling the worked ditcher.

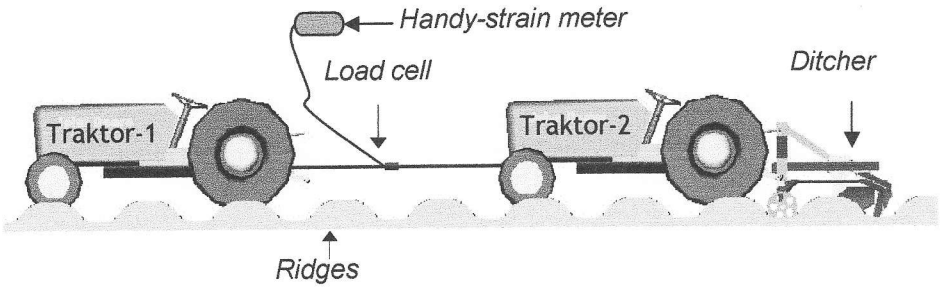


Figure 9. Ditcher draft force measuring method.

RESULTS AND DISCUSSION

The prototype of the ditcher

Based on design analysis and several adjustments, a prototype of the ditcher equipped with scrapers was fabricated as shown in Figure 10.

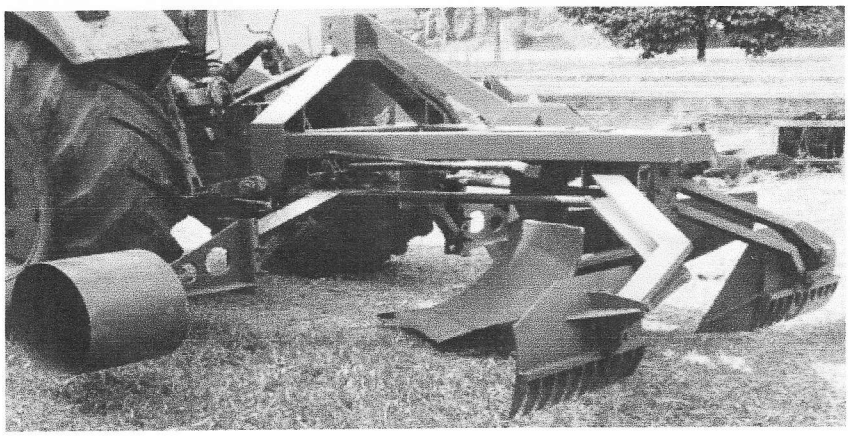


Figure 10. Prototype of the ditcher.

The prototype of the ditcher was equipped by a pair of soil scrappers. The function of the ditcher is to make the drainage channel, whereas function of the scrapper is to scrap up the soil in between the ridges and put it on the top of the ridges. Scraping mechanism was driven by a guide wheel that rolled on the ridge's profile. The drive force then was transmitted through a transmission shaft to drive the scrapper. The structure of the scraper ditcher consisted of a frame, a ditcher, and a pair of scrapers. The frame had a triangular shape and equipped with three standardized hitching points. The ditcher had share cutting angle of 70°, 60 cm cutting width, share intersection angle of 15°, and the concaveness radius of the moldboard of 65 cm. The construction of the scraper driver consisted of a pair of guide wheels (41 cm in diameter), wheel arm (28 cm in length) and a pair of scraper

blades (40 cm x 55 cm in size), scraper arm (68 cm in length). The dimension of the prototype was 173 cm in length, 293 cm in width, and 138 cm in height, and the weight is 435 kg.

Field performance of the ditcher

The result of performance tests showed that the ditcher operated successfully. The ditcher produced the expected trapezoidal cross section drainage channel with a proper size as expected. The test result at Experimental Field of Agricultural Engineering Department, IPB showed that the average length of lower side, upper side and the depth of the ditch were 39.1 cm, 113.1 cm and 33.1 cm respectively. Whereas, the test result at Jatitujuh Sugar Cane Plantation showed that the average length of lower side, upper side and the depth of the ditch were 37.9 cm, 100.2 cm and 38.7 cm respectively (Figure 11). The cross section and size of the ditch produced by the ditcher were sufficient for drainage purpose [1, 2].

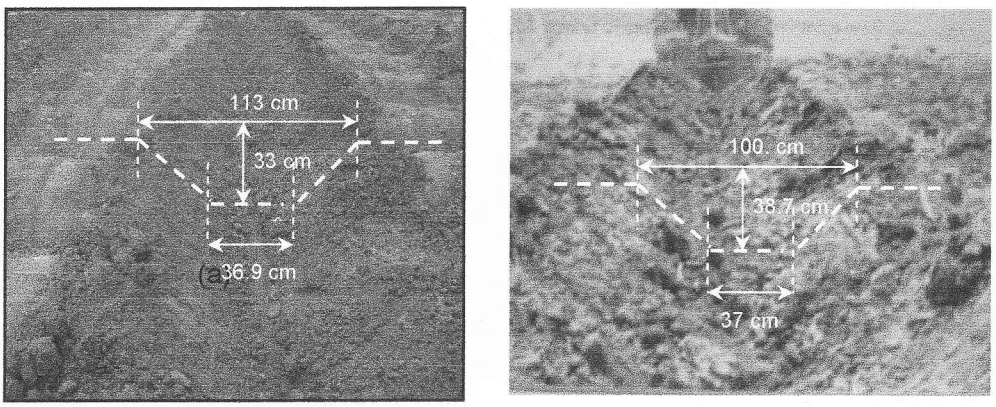


Figure 11. Profile of ditches produced by the dither: (a) at Experimental Field of Agricultural Engineering Department, IPB, and (b) at Jatitujuh Sugar Cane Plantation (b).

As observed on the field tests, the scrapper could scrap up the discharged soil and then placed the soil on the ridges. However, there was un-scraped soil in between the ridges which has 6 cm in height (at Experimental Field), and 15.8 cm in height (at Jatitujuh Sugar Cane Plantation).

The draft force of the ditcher operated at Experimental Field was 2.84 kN at the average speed of 0.31 m/s. The average wheel slip of the tractor was 37.6%. Test result at Jatitujuh Sugar Cane Plantation showed that the average draft was 6.49 kN, which was bigger than that of the Experimental Field. It was due to the heavier soil of the Jatitujuh Sugar Cane Plantation, and deeper working operation of the ditcher [3]. The soil condition and working condition caused the high draft and forced the tractor to have a high wheel slip. As measured at the test, the average wheel slip was 63.4%. The average working speed was 0.57 m/s. Actually, this

speed was higher than the average speed of the rotary dither (0.34 m/s), but it was lower than the average working speed of the tractor pulling a furrower (0.87 m/s).

CONCLUSIONS

1. A prototype of a ditcher equipped with scrapers for making drainage channel on sugar cane plantation has been designed and fabricated.
2. The ditcher worked well in making the drainage channel at a proper cross section size with the field capacity of 6.85 ha/hour. The cross section of the resulted ditches was trapezoid with the dimension of 38.7 cm depth, 37.9 cm lower side, and 100.2 cm upper side.
3. The scraper could scrap up the discharged soil and then placed the soil on the ridges.

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