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Original Research Article

Design and Development of Double Rotor Drum Shredding Machine for Managing Pineapple Residue in Peat Soil

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Abstract: In Malaysia, Pineapple is a one of tropical crop that contributes in generating Malaysian economy. Pineapple is mostly planted on mineral and peat soils, where each has different practices and approaches. In peat soil condition, nowadays farmers normally manage the pineapple residues by using a chemical to kill and fire to burn before it been replanting. This is common practice to remove the pineapple residues. With this method soil fertility can be affected and open burning will be polluting the environment, as the government nowadays recommending toward green approach. For pineapple farm in mineral soil, MARDI has come out with a machine to shred and plough pineapple plant residues back into the soil which are practiced for mineral soil. The machine is adopt a rotovator concept. Unfortunately, the machine had the unsatisfied result because the plants were not chopped into small pieces but only separated into a few large parts. In the 11th Malaysian plan (RMK-11), the development of a new concept and prototype with a double rotor drum, design type blade, special blade arrangement and speed gave a promising result in a way to manage the residues of pineapple plants easily without chemical or fire. The purpose of the paper is to discuss the design and development of the machined for management of pineapple plant residues on peat soil, including the functionality test. Special arrangement of the blade and type of blade is a focus part that been consider before it been attach to the double rotor drum. The machine capable working rate is 0.28 ha/hr and the machine efficiency is 92 %. Maximum machined operation is 7–8 hours per day. As a result the machine chop smooth with fine and easy manage disposal pineapple residue.

Keywords: shredding machine; pineapple residue; prototype; pineapples crops

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1. Introduction

Pineapple is one of the tropical fruits that has a bright future in supporting the Malaysian export market economy. Currently, 95 % of the domestic canned pineapple production is the exported market while the rest is for domestic market. Fresh pineapple contributes only 30 % of the export market and 70 % for domestic market (MPIB, 2012). In Malaysia, pineapple is generally grown on two main areas, peat and mineral soil, each of which has different practices and approaches. The management of pineapple residues which mainly consist of the leaves and stems is always a matter of environmental concern. In common practice, pineapple residues are managed by using of a chemical to kill and fire for burning (Ahmed *et al.*, 2003). This is not a green approach, because frequently use of chemical can affect the soil fertility and open burning will pollute the environment (Liu *et al.*, 2013). In the 9th Malaysian plan (RMK-9), MARDI has come out with a machine to shred and plough pineapple plant residues for mineral soil as shown in Figure 1 below. This machine was design to be operating in mineral soil. The depth soil penetration is 12" (30 cm) The machine has adopted a motivator concept. Unfortunately, the machine had the unsatisfied result because the plants were not chopped into small pieces but only separated in a few large parts. In the 11th Malaysian plan (RMK-11), the development of a new concept and prototype with a double rotor drum, design type blade, special blade arrangement give a promising result in a way to manage the residues of pineapple plants easily without chemical and fire to burn. For peat soil condition, the machine have maximum of 2" (5.08 cm) for depth soil penetration because if the blade dig more depth it might disturb the hardpan surface. The purpose of the paper is to discuss the design and development of the machined for management of pineapple plant residues on peat soil, including the functionality test.

Figure 1. Existing machine pineapple mulched.

2. Materials and Methods

2.1. Machine Design

Main focus of the study was is to be operate the machine in the peat soil area. Which means that the design of the machine must have the appropriate amount of weight that allowed it to be carried out under the conditions of the peat soil. The machine was designed for a small power tractor with a minimum power of 38 HP and mounted implement with high PTO driven. The general specification is 980 mm in length, 1480 mm in width and 400 mm in height as shown in Figure 2 and Table 1. The machine was driven by a PTO 1:1 ratio gearbox connected to a long shaft and been attached using triple pulley and belting. There are many types of rotovator blades available in market. Those are C shape, L shape and J shape. This machine was designed with two rotors drum and fixed with a swinging L shape of blade as shown in Figure 3 and the blade composition is shown in Figure 4. The blades are arranged in helical form with 4 blade L-shape fully covered side by side between the rotors. L-shaped blades are better compared to C or J type blades in trashy conditions as they are more effective in killing and they do not pulverize the soil as much shown in Figure 5. The complete prototype is shown in Figure 6.

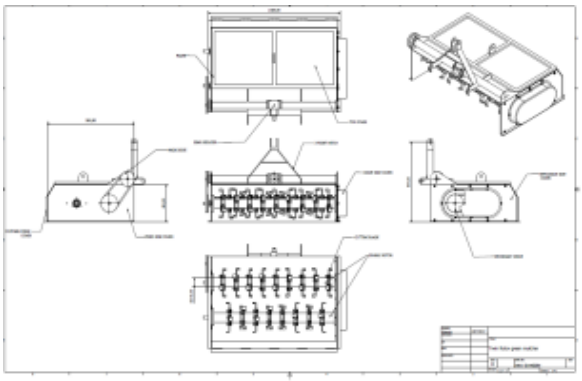

Figure 2. Technical drawing of the machine.

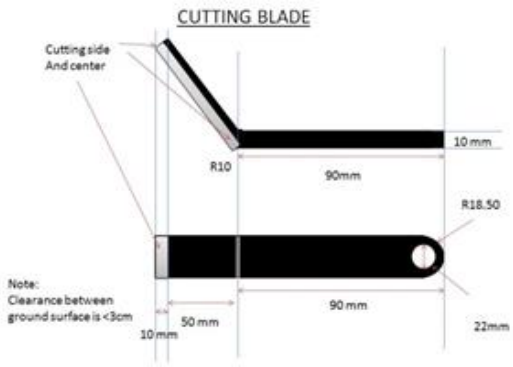

Figure 3. Design of the cutting blade.

Table 1. Technical design specification.

Parameter	Value
Length	980cm
Width	1480cm
Height	400cm
Weight	200kg
Working rate	0.25 ha/hr
Minimum tractor power	38hp
Power	PTO Driven

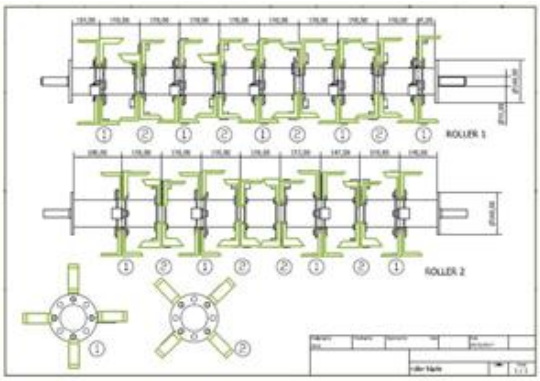

Figure 4. Blade arrangement.

Figure 5. Composition of blades at the drum in actual view.

Figure 6. Prototype double rotor shredding machine.

2.2. Fabrication

The prototype machine was fabricated by the local fabricator according to given technical drawing. Some of the components were changed due to the availability in a local market. The machine has been developed in small scale sizes which are to be operated in a peat soil condition. The designed of the machine is basically normal like existing rotovator except for the 2 rotor drums and the arrangement of the blades were arranged in special composition. The special feature of this blade arrangement is that it covers every row of crops throughout in straight line. Each row of crop passed will be exposed to the blades of this machine allowing no crop to be left behind from being hit by the blade.

2.3. Test and evaluation

The machine prototype was tested and evaluated for the functionality mounted by Kubota 38 hp high clearance tractor at pineapple testing plot station MARDI Pontian, Johor shown in Figure 7. Using 2 different speed rate of 1.1 km/hr and 1.3 km/hr with 3nd gears low and high and the speed of the PTO is 540 rpm driven for same gear. Fixed 2000 rpm tractor speed in the same gear, distance of 12 m × 16 m with 8 replicates and total area of 0.0192 hectares show in Figure 8 and time had been taken and recorded for analysis.The main aim is to ensure that plant residues are produced as fine material using 2 different gears but the same PTO speed.

Figure 7. Test and evaluation of the prototype.

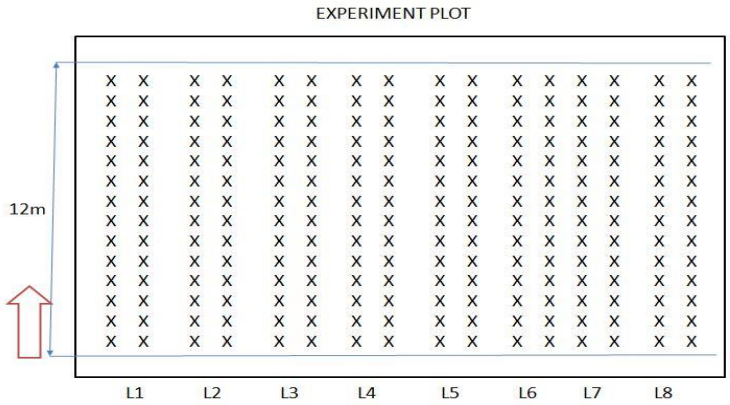

Figure 8. Experiment plot.

3. Results

The first prototype of the shredding machine was successfully fabricated in 8 weeks of fabrication works. The machine was then tested and evaluated for functionality.

3.1. Machine Capacity and Machine Efficiency

Table 2 shows the results obtained from the experiment. The speed of 1.1 km/hr and 1.3 km/hr were used in this experiment was approximately using maximum PTO speed of 540 rpm to shred the crop. Using 38 hp tractor speed of 2000 rpm speed of tractor in 2 gear low and 3 gear low, the average time taken was 28 seconds and 36 seconds for 12 m distance. Table 2 show that after the machine was tested and data was analyzed. It has been shown that the working rate is 0.28 ha/hr. Therefore, the result is fine and easy disposal pineapple plant residues without using chemical and fire to burn that can polluting the environment.

Table 2. The summary of results performance evaluation for new design prototype and existing machine.

Performance Evaluation	**New prototype**	
Sub-Plot (12m X 16m)	L1, L2, L3, L4	L5, L6, L7, L8
Tractor speed (Km/hr)	1.1 km/hr	1.3 km/hr
Machine capacity (hr/perday)	7-8	7-8
Field work rate (ha/hr)	0.25	0.28
Power take off (PTO)(Rpm)	540(Max)	540(Max)
Machine efficiency (%)	89%	92%
Tractor speed (Gear&Rpm)	2 Low (2000rpm)	3 Low (2000rpm)

4. Discussion

The machined efficiency depends on the speed of the PTO to chop the crop into small pieces show in Figure 9. The speed of the tractor must also be in slow motion because the crop is in different sizes. If the speed of the tractor is fast, the crop will pass through without chopping the crop. This prototype seem to have higher force impact in chopping the crop because it have two drum, special blade arrangement and very sharp blade compare to the existing machine which were like normal rotovator. The result for existing machine was unsatisfied because the plants were not chopped into small pieces but only separated into a few large parts shown in Figure 10. Table 3 show the performance evaluation for both machine in different soil condition. This machine is using the same concept and purpose as rotovator machine which are to use to plough by series of blade that cut, pulverizes mixer and level the soil before replanting. Using rotovator concept added with double rotor drum full with special arrangement of bladed seem easily chop the pineapple crop easily based on actual view.

Table 3. The summary of results performance evaluation for new design prototype and existing machine.

Performance Evaluation	**Result**	
Machine	**New prototype (Peat soil)**	**Existing machine (Mineral soil)**
Machine capacity (hr/perday)	7–8	7–8
Field work rate (ha/hr)	0.27	0.108
Machine efficiency (%)	92	43
Power take off (PTO)(Rpm)	540(Max)	540(Max)
Tractor speed (Gear&Rpm)	2 Low (2000 rpm)	2 Low (2500 rpm)

Figure 9. Fine and fibrous material pineapple residues pineapple residues management.

Figure 10. Chopped into small pieces but only separated into a few large parts.

5. Conclusions

According based on functionality observation, second gear low and third gear low speed of the tractor and 2000 rpm with maximum PTO driven has resulted in fine and easy disposal pineapple plant residues. Re-rotor after a week using normal rotavator machine or

this prototype can be done before the replanting show in Figure 9. As conclusion, by using this machine, it will reduce negative impact of environment and also prevent the use of chemical and open burns. This machine has a great potential to solve pineapple residue and is widely implemented. It has been designed and fabricated locally, making it easier to adapt to Malaysia's environment and conditions.

Figure 9. The pineapple residue rotting after 1 week and it been shred once more time before replanted.

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