DESIGN AND DEVELOPMENT OF A NEW MECHANIZATION SYSTEM FOR SWEET POTATO PLANTING MATERIAL PRODUCTION

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ABSTRACT

Currently, sweet potato's vine cuttings for planting materials are manually conducted. This process is very tedious and causing low and inconsistent production. The process for obtaining the planting materials involves cutting the shoots from the matured existing sweet potato vines, which approximately 1.5 until 2.5 months after planting. Currently, the operations are done manually, where the cutting of the shoots is done by using a knife or secateurs. The selected shoots will be cut in size ranging from 30-35 cm long. One trained worker can process about 1300-1500 of cuttings per day and requires approximately 33,000 of cuttings for one hectare of planting area. In order to fulfil the cuttings requirement, more workers needed. Therefore, this paper reports on the development and evaluation of a new mechanization system for producing sweet potato planting materials as one of a solution to the arising issues. Implementation of mechanization for producing sweet potato cuttings has been essential to boost the sweet potato industries in Malaysia. The designed mechanization system consists of a new method for shoots production as well as machine development. Shoots from the tubers were selected due to the more significant numbers of shoots produced per square meter in comparison to vegetative cuttings which can produce approximately 429 cuttings/m2 and 140 cuttings/m2 respectively. Also, the shoots from the tubers are vertically propagated rather than sloping by vegetative cuttings which suit with the mechanism of machine's developed. This machine was designed to facilitate the cutting process of sweet potato shoots to be used as planting material. It is suitable to be used under a production shelter. While for the on-farm seedbed, a tractor-mounted cutter bar will be evaluated. This machine was divided into three main functional components, namely seedbed tray, cutter bar and cutter bar railing. This machine operates two simple steps. It begins with placing the tray of matured sweet potato shoots on the machine. Then the cutter bar will cut the shoots at the desired length throughout the railing.

Key words: Sweet potato, planting material, mechanization stage.

INTRODUCTION

Over 110 million tonnes of sweet potatoes are produced annually throughout the world. China by far is the largest producer of sweet potatoes with a production of 100 million tonnes per year which is 90% of world production (FAO Stat2014). Sweet potato is a common staple in many developing and low-income countries which accounts for 95% of total production, Tanzania, Nigeria, Ethiopia and Indonesia are in the top 5 world producers of sweet potatoes. Sweet potatoes ranked 7th in the list of essential food crops because it can be grown in a variety of arid to tropical conditions (Sweet Potato -Crop Trust2015).

Sweet potatoes are vegetatively propagated in the form of vine cuttings or sprouts (root slips) and are genetic clones of their parent material (Rao & Campilan 2002). The quality of propagation material is a significant contributor to the potential yield of a crop as well as agronomic factors such as irrigation, pest and disease management, weed control, nutrients and natural phenomenon such as climate (Atu 2014).

In Malaysia, sweet potato plantation is increasing rapidly year by year. Moreover, VitAto plantation is one of the flagship projects of Ministry of Agriculture with collaboration among government agencies such as Malaysian Agricultural Research and Development Institute (MARDI), Lembaga Pertubuhan Peladang (LPP) and Federal Agricultural Marketing Authority (FAMA). Moreover, sweet potato has become one of the major crops planted in BRIS soil especially in Kelantan and Terengganu because it has been recommended as an alternative industrial crop to replace the tobacco plantation (Zaharah, 2010). Thus, MARDI has announced quite a lot of sweet potato varieties such as Gendut, Telong and Jalomas and VitAto (Zaharah, 2010). Furthermore, in 2017, MARDI has declared a purple flesh sweet potato called Anggun variety. Usually, there are two planting seasons in a year for sweet potato cultivation, especially in Kelantan and Terengganu. The first and second season starts from January until May and July until November respectively. However, the second season is quite troublesome for the farmers due to heavy rainfalls (Tan S.L, 2006).

In 2019, the planting acreage in peninsular Malaysia was estimated at 3062 ha with 52,224 MT of total production. While in terms of cuttings demand, the farmer requires approximately 33,000 cutting for one hectare of planting area. Thus, planting materials production industries play an essential role in order to satisfy the demand as well as producing good quality cuttings in terms of virus-free.

Therefore, MARDI has developed a new mechanization system for producing sweet potato cuttings which purposely dedicated to increasing the production capacity compared to the current practice. Besides that, the quality of the cuttings also will be monitored, so that the farmers will get the maximum yield with the assistance of good plant management practices.

A current practice is done by manually using a knife. This method had to be done due to the creeping nature of the sweet potato plants, which difficult to be mechanized. In sweet potato cultivation, the planting materials required are approximately 33,000 cuttings per hectare. So, more workers are needed during planting materials preparation as one trained operator is only able to cut between 1300 until 1500 of cuttings per day.

The objective of this study is to evaluate the new mechanization system for cuttings production in the aspect of a machine's performance in which the production capacity will be assessed. The suitability of the shoots also was evaluated on the field in terms of yield production.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at a research plot in MARDI Bachok Research Station. The site is characterized by BRIS soil with annual precipitation and temperature between 2500-2800 mm and 24^{o}C – 32^{o}C respectively.

Sweet potato variety

Four varieties of sweet potato will be evaluated in this experiment, namely VitAto, Anggun 1, Anggun 2 and Anggun 3. These three varieties were selected due to the large-scale production, especially in Kelantan and Terengganu.

Preparation of seedbed tray

The cuttings production was evaluated in 2 different planting sources which are tuber's-based cuttings and vegetative cutting by using a vine. These cuttings were planted in a seedbed tray with the dimension of 1m (width) x 1m (length). The cuttings produced were cut in every three weeks to make sure the sprouts are matured and ready to be used as planting material. In this experiment, the cuttings were cut within two cutting intervals to compare the cuttings produced between the two planting sources.

Figure 1: Preparation of seedbed with high-density planting method

Figure 2: Sprouts from the tubers with uniform in size

Preparation of plant-bed

For the yield performance study, the selected cuttings were planted on the plant-bed according to the standard practices. The planting material from standard practice which cut from the matured sweet potato vines on the field also planted to compare the total yield. The plot was ploughed to a depth of 30cm using rotorvator after decomposed manure was broadcasted at a rate of 8-10 tonne per hectare. Seven plant-beds of 1.2m x 50m x 0.5m (width x length x height) were planted for each variety according to the planting material sources. On-farm crop management will be based on the standard sweet potato practices recommended by MARDI.

The mechanization system

This machine was designed to facilitate the cutting process of sweet potato shoots to be used as planting material. It is suitable to be used under a production shelter. It is divided into three main functional components, namely seedbed tray, cutter bar and cutter bar railing. This machine operates two simple steps. It begins with placing the tray of matured sweet potato shoots on the machine. Then the cutter bar will cuts the shoots at the desired length throughout the railing. Under a production shelter, a worker is required to replace the cuttings tray for continuous cuttings production. This machine can place up to four units of seedbed tray with a dimension of 1 meter square per tray.

Figure 3: 3D drawing of a new design of a mechanization system to cut the sweet potato cuttings

Figure 4: 3D drawing of a cutter bar that will be used to cut the sweet potato cuttings.

Data collection

During data collection, there are several evaluations measured consists of total cuttings produced (tubers sprout vs vegetative cutting), machine's performance and yield evaluation.

a. *Total cutting produced (Tubers sprout vs vegetative cutting)*

In this experiment, these two sources will be evaluated in terms of cuttings produces per square meter area. The cuttings were cut within two cutting intervals, which approximately three weeks. The most cuttings produced source was selected to be planted on the field to assess the total yield.

b. Machine's performance

In a machine's performance, it consists of evaluating the production capacity (production/hour) and cuttings quality. Cuttings/sprouts were assessed based on their length from the cut end of the sprout. The harvested cuttings from each plot were processed according to the following categories:

i. Optimal (28cm to 40cm)

ii. Short acceptable (20cm to 28cm)

iii. Undersized sprouts (<20cm)

iv. Damaged or diseased

c. Yield performance

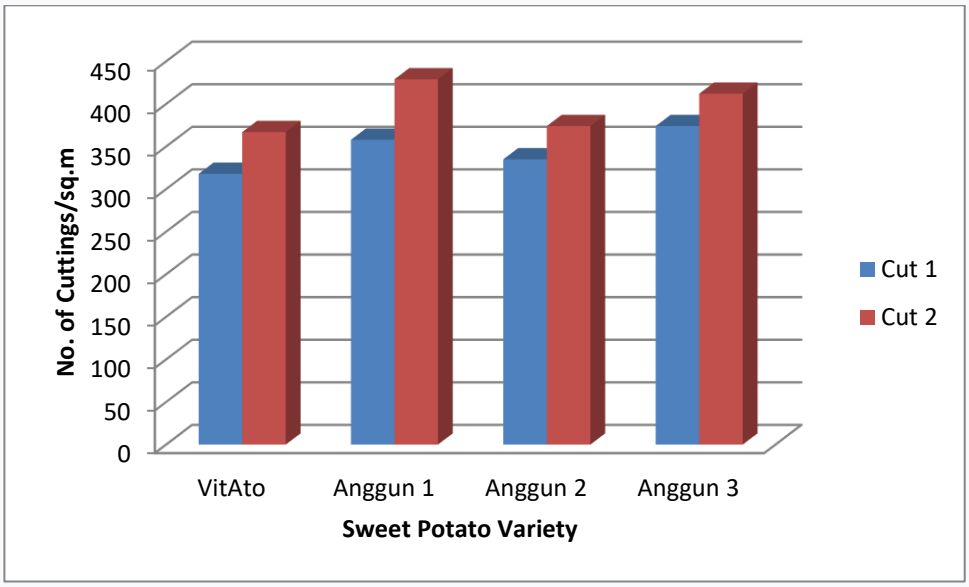
Yield for each plant-bed was recorded according to the varieties and planting material sources. The average yield was used to calculate and compare the total yield per hectare according to the planting material sources.

RESULTS AND DISCUSSIONS

Total cuttings production

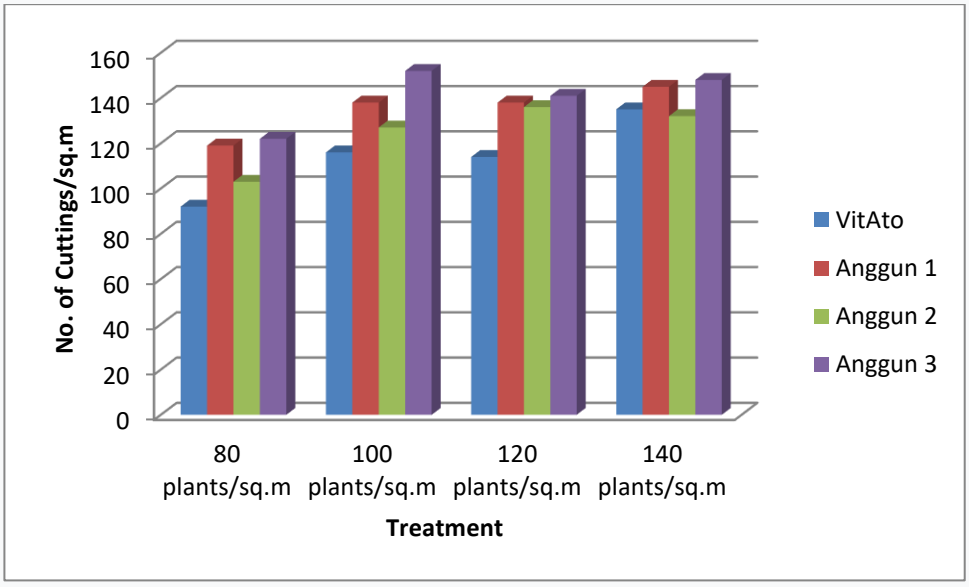
The averages of cuttings produced per square meter from two different cutting productions (tubers sprout and vegetative cutting) were shown in Figure 5 and Figure 6. It was found that the total cuttings produced from the tubers with the average of 342 cuttings per sq.m (VitAto), 393 cuttings per sq.m (Anggun 1 & Anggun 3) and 354 cutting per sq.m (Anggun 2).

Figure 5: Total number of marketable cuttings per square meter obtained from tuber's seedbed



In comparison, the cuttings produced from vegetative cuttings were measured according to different plant density ranging from 80 plants per sq.m to 140 plants per sq.m. The result shows that there is no significant difference in terms of cuttings produced between 100 plants per sq.m, 120 plants per sq.m and 140 plants per sq.m. The highest cuttings produced were 135 cuttings per sq.m (VitAto), 145 cuttings per sq.m (Anggun 1), 136 cuttings per sq.m (Anggun 2), and 152 cuttings per sq.m (Anggun 3).

Figure 6: Total number of slips at each density per square meter from vegetative cutting.



From the result, it was found that the tubers sprout shows significant numbers of cuttings produced compared to vegetative cutting per square meter area.

Machine's performance

The overall machine's performance was shown in Table 1 below. The data shows that the average time for each cut was 3.05 min or approximately 20,203 cuttings/hr.

Table 1: Overall machine's performance

Item	Cut 1	Cut 2	Cut 3	Average
Time is taken (min)	2.52	3.16	3.07	3.05
No. of cuttings	1007	1033	1041	1027
Quality				
Optimal (28cm to 40cm)	641 (63.7%)	655 (63.4%)	721 (69.3%)	672.3 (65.4%)
Short acceptable (20cm to 28cm)	184 (18.3%)	194 (18.8%)	176 (16.9%)	184.7 (18%)
Undersized sprouts (<20cm)	136 (13.5%)	152 (14.7%)	108 (10.4%)	132 (12.9%)
Damaged or diseased	46 (4.6%)	32 (3.1%)	36 (3.4%)	38 (3.7%)

Yield performance

Table 2 shows the comparison on the total yield of sweet potato between the cutting produced and standard practice which cut from the matured sweet potato vines on the field.

Table 2: Yield performance of sweet potato according to the varieties

Item	Data							
	Sweet Potato Variety							
	VitAto		Anggun 1		Anggun 2		Anggun 3	
Type of bed	New Method (Tubers)	Standard Practice	New Method (Tubers)	Standard Practice	New Method (Tubers)	Standard Practice	New Method (Tubers)	Standard Practice
Average yield per bed (50m)	143.50 Kg	151.20 Kg	105 Kg	110.20 Kg	126.20 Kg	124.30 Kg	148 Kg	159.2 Kg
Total yield per hectare	20,070 Kg	21,137 Kg	17,050 Kg	17,894 Kg	21,030 Kg	20,708 Kg	24,670 Kg	26,530 Kg

From the result, it was found that the yield shows no significant difference between both planting material. This is due to the same crop management in terms of fertilizer rate, pest and disease management and weed control. From the result, it shows that the planting material produced is as good as an existing method in terms of yield performance.

Indeed, this mechanization is improving the standard practices in terms of planting materials production time which can cut approximately 20,000 of cutting per hour compared to a manual method which can cut about 1300-1500 of cuttings per day per worker.

CONCLUSION

The production of cutting from the tubers will provide a new dimension to the sweet potato industries in Malaysia. It offers an alternative solution to the production of the current cutting which harvested from the existing farm in which the cuttings is uncontrolled and exposed to the on-farm pest and disease. Whereas, the new mechanization system offers a controlled quality of cuttings which will provide a new platform to produce a certified sweet potato planting material in Malaysia.

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