A study of stalk shape for designing the operational mechanism of gripping equipment for cassava tuber cut preparation process.

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Abstract. The objective of this research was to study the geometry of cassava plants such as number of stalks and branches, which will be useful for designing stalk gripping equipment which is a part of cassava tuber cutting process. Eight fields of cassavas planted with Kasetsart 50 variety, which is the most popular variety in Khon Kaen, were used to obtain samples for this study. The results indicated that cassavas can be clearly and easily categorized by number of stalks and branches. Moreover, they can be grouped into 6 types which are S11, S12, S13, S2, S3 and X. The number of samples of each type in each field were unequal with the maximum number of samples S11, S12, S13, S2, S3 and X type in fields were 3, 5, 5, 6, 2, and 7, and with percentage of 36, 75, 11, 42, 26 and 22, respectively. According to results above, gripping part can be designed by following plier shape concept.

1. Introduction

Cassavas is an important economic crop in Thailand and Thailand is also ranked as a top cassava exporter. The products that are processed from cassava are cassava chip, cassava pellet and cassava starch for animal feed, food, pharmaceutical, paper, monosodium glutamate, sweeter, garment and ethanol industry [1]. The cassava production was planted to 9.06 million rai in Thailand in 2559-2560 BE producing a yield 31.16 million ton [2]. The most popular varieties planted in Thailand are Kasetsart 50, Rayong 90, Rayong 5 and Huaybong 60 [3].

Cassava harvesting processes affects quality and quantity of products. The current popular harvesting method consists of 3 main steps such as pulling the roots out of the ground, cutting tubers, and then gathering and transporting tubers by human labor. These steps require large amount of labor and the labor supply is inadequate currently. [4-5] Nowadays, many machines such as digging, gathering transportation and tuber cutting machines have been developed by several researchers to solve problem of labor and time limitations. Pulling and tuber transportation machines are well- developed and widely utilized but development of cassava tuber cutting machine is still underdeveloped, so it needs further
advancement to produce a complete automatic harvest machine. The summary results of previous related researches are shown in table 1.

**Table 1 Result of previous cassava tuber cutter researches.**

| Result                     | Jaturong (2555) | Payungsak (2557) | Kiatsuda (2558) | Sakchai (2559)  |
|---------------------------|-----------------|-------------------|------------------|-----------------|
| Cutting mechanism         | Cylinder saw and pressing unit | Cylinder saw | Square tube blade | Circular saw 4 position |
| Cassava Variety           | Kasetsart 50    | N/A               | Kasetsart 50     | Rayong 9        |
| Capacity of machine (kg/hr)| 380             | 270               | 150              | 830             |

Therefore this research aims to study the physical characteristic of cassava which will be fundamental data in designing and developing a gripping part. Furthermore, the experimental data from this study produce the key information for developing practical harvesting machines in the future.

2. Materials and methods

2.1. Study site
Eight cassava fields planted to Kasetsart 50 variety in Mueang district Khon Kaen province Thailand, were randomly selected. Then a plot of 400 m² in each field was randomly chosen to study. All fields were planted in April-May by human labor. The distance between each row was 0.8 m and each stalk was 0.8 m and the height of planting ridge was in the range of 0.2 – 0.3 m. They were planted in clay; roam or sticky soil field.

2.2. Study of cassava shapes
Cassavas were classified into group by number of stalks and branches, and total number of each type was recorded in each field. Moreover, percentage of each type was also calculated in each experimental field.

3. Results and discussion

3.1. Cassava shape study
The study results showed that shapes of cassava samples are diverse, but they consist of 2 main similar parts. First is stalk that grow from soil level called 1st range of stalk, and second is stalk which separate form 1st range of stalk called 2nd range of stalk. Hence, cassava can be categorized into 6 types by number of 1st range and 2nd range of stalk as indicated in table 2.

The percentage of each type of cassava samples in 400 m² area of 8 fields were calculated are shown in table 3, and then pictured in figure 1.

Furthermore, the results illustrated that cassava populations in each row compose of many types and are randomly distributed as shown in figure 2.
Table 2. The cassava type description.

| No. | Cassava Type | Description                                      | Photo |
|-----|--------------|--------------------------------------------------|-------|
| 1   | S 11         | One 1st range of stalk.                          |       |
| 2   | S 12         | Two 2nd range of stalk separate from One 1st range of stalk. |       |
| 3   | S 13         | Three 2nd range of stalk separate from One 1st range of stalk. |       |
| 4   | S 2          | Two 1st range of stalk.                          |       |
| 5   | S 3          | Three 1st range of stalk.                        |       |
| 6   | X            | Cannot be characterized into 1 – 5 types above.   |       |

Table 3. The Percentage of cassava samples in each types.

| Fields | Number of samples | Percentage of each types. |   |   |   |   | Total |
|--------|-------------------|---------------------------|---|---|---|---|-------|
|        |                   | S 11 | S 12 | S 13 | S 2 | S 3 | X   |       |
| 1.     | 414               | 7    | 58   | 8    | 18  | 7   | 2   | 100  |
| 2.     | 488               | 12   | 9    | 6    | 28  | 26  | 19  | 100  |
| 3.     | 410               | 36   | 10   | 6    | 28  | 9   | 11  | 100  |
| 4.     | 380               | 11   | 9    | 9    | 30  | 20  | 21  | 100  |
| 5.     | 318               | 5    | 75   | 11   | 4   | 1   | 4   | 100  |
| 6.     | 506               | 30   | 2    | 1    | 41  | 10  | 16  | 100  |
| 7.     | 400               | 32   | 0    | 0    | 33  | 13  | 22  | 100  |
| 8.     | 400               | 23   | 15   | 5    | 31  | 15  | 11  | 100  |

Figure 1. The comparison of cassava sample percentage in each types of every fields.

Figure 2. The Position of each cassavas types in field.
3.2. Related Works
From the review of previous researches about cassava tuber cutting, those previously developed machines can be categorized into 3 groups as follows:

3.2.1. Combined set of cylinder saw, cutting unit and gripping unit.
1) A Cassava root picking machine.
This combined set consists of 3 main parts which are pressing unit, cutting unit and feeding unit [6]. It operates by putting cassava into gripping unit and then pushes pressing unit towards cassava so that cassava and gripping unit move downward until reach the cutting unit, cylinder saw, which rotating below as shown in figure 3.

2) Cassava harvester for cutting cassava tubers from rhizome.
This machine requires workers use their hands to hold cassava stalk and then insert stalks into cutting unit by facing tuber side to cutting saw of cylinder. After that, workers have to use other hands to grab the other side of stalk (after tubers are cut) and then pull that stalk out (figure 4) [5].

![Figure 3](image1.png)
**Figure 3.** The operation diagram of a cassava root picking machine.

![Figure 4](image2.png)
**Figure 4.** The operation diagram of cassava harvester for cutting cassava tuber from rhizome.

![Figure 5](image3.png)
**Figure 5.** The operation diagram of cutting machine in subject 3.2.2.

![Figure 6](image4.png)
**Figure 6.** The operation diagram of cutting machine described in 3.2.3.
3.2.2. Cutting and gripping unit are separate from each other. This machine consists of 2 main parts which are cutting unit and gripping unit. The cutting unit is a square tube blade and edge of blade upside down. The gripping unit is cylinder tube which is placed below the cutting unit. Cutting process starts by putting cassava stalk in gripping unit and setting cassava tuber on upward position, then cutting unit will move downward to cut cassava tuber as shown in figure 5.

3.2.3. The gripper unit is a conveyor chain. A conveyor chain was used to make gripping unit like a conveyor of cassava digging machine. It was used to grip a cassava stalk and conveyed cassava into cutting unit. The cutting unit consists of 4 pieces of circular saw which are located in top, bottom, right and left as shown in figure 6.

3.3 Gripping Equipment Design Concept
In case of harvest in fields that have a lot of S2, S3, and X type population, it is unsuitable to use automatic combine harvester (combine set of tuber pulling from ground and tuber cutting equipment) because currently pulling equipment is conveyer chain, although it is easy to pull tubers from the ground but it is difficult to grip stalk in these types in tuber cutting process. So, the proper machine should be a semi-automatic machine, which it needs a man to feed stalk to cutting machine.

From review of designs discussed in topic above, cutting methods in group 1 and 2 require raw material preparations for cutting excessive stalks so that only one main stalk remains, then that remaining stalk can be inserted into gripping unit. However, if there are a lot of S2, S3 and X type populations in operation fields, it will consume much time to prepare raw materials. This research foresees the need for reducing time in preparing process, by changing the gripping technics, so that it can grip any type of cassava stalk. Gripping idea comes from pliers and clamps concept, which is used to grip objects or any materials, because its diameter can be adjusted to the desire point. So, mechanism of plier is suitable to be used as gripper since it can grip various shapes and diameters of cassava stalk. Furthermore there is no requirements to cut excessive stalks. This machine consists of two main parts which are gripping unit and cutting unit and they are attached behind the tractor and cassava digging machine. The cutting machine operation needs one man to feed a cassava stalk to cutting machine as shown in figure 7. This machine can work in fields that have any shapes of cassava, and it can continuously cut cassava tuber and save time from cutting stalk before cutting the tuber.
4. Conclusion
Results of this study indicate that cassavas can be characterized into 1st and 2nd range of stalk which can be classified into 6 groups and the population of each types are very random. Therefore, the same variety of cassava planted at the same time in the same field leads to different types of randomly distributed plant structure. Therefore, cassava tuber cutter must be designed to have the gripper that can grab any shapes and sizes of cassava. So, this research proposes the plier-like mechanism design which can to grip the various characters of cassava than current or previously developed machines. Moreover, such machine can save time.

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