

The Concept of Solid Fertilizer Dispensing Machine

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Abstract

Workers in the agricultural industry require more effort and prolonged amount of time to dispense fertilizers into the soil of the pineapple plants for several acres. Sometimes, it takes a few days to finish the fertilizing process. Hence, using bare hands to fertilize plants causes energy and time to be wasted. The aim of this project is to fabricate a portable solid-fertilizing machine that is able to dispense fertilizer pallets that will be used in the pineapple agriculture industry. This project consists of design mechanism, fabricating mechanism and testing of the dispensing mechanism of 20 grams of fertilizer. The designed dispenser consists of a cup which contains 20 grams of fertilizer pallets. The cup is attached to a mechanism below the storage tank, where a trigger is fabricated to perform the dispensing action of the fertilizer pallets. Hence, fertilizer pallets can be dispensed through a flexible hose and into a metal pipe. At the end of the metal pipe consists of a cone like sharp pointy edge which helps agricultural workers to pierce the soil with ease. With the aid of this project, it can minimize the time required to perform fertilizing of plants in the agricultural ecosystem and industry. Therefore, there is a huge market for this project being able to fertilize plants with limited time and force.

Keywords: Solid fertilizer dispensing machine, pineapple plantation, pallet

1.0 Introduction

The concept of this Solid Fertilizer Dispensing Machine is actually based on the current phenomenal in plantation system. Workers require a lot of forcing exerting during fertilizing plants and at the same moment a lot of time is being wasted. Workers prefer force and time saving mechanism that can eventually improve the output of plantation products solid fertilizer dispensing machine can play a big difference in the whole fertilizing process.

To be specific, this portable fertilizer which is under Public-Private Demand Drive Research Grant 2016 is concentrated on fertilizing pineapple plants. The planters require different amount of fertilizer depending of the size of the

pineapple plants. Therefore, some circumstances are taken in consideration when fertilizing them with this solid fertilizer dispensing machine such as:-

- i) The type of fertilizer require for the pineapple plants.
- ii) The amount of fertilizer required for them.

For this project the type of fertilizer that is used for pineapple plantations are pallet types. Pallet types of fertilizer are used is influenced by the duration of the repeatability for the fertilizing process. The pallet type of fertilizer takes quite long time to be broke down and for the plant to absorb the nutrients. So, based on the duration of the repeatability process, pallet type of fertilizer is the best fit for the current project with specific amount of fertilizer (Handreck and Black, 2005).

Amount of the fertilizer is the most important factor of all for the plant to grow healthy. High dosage or insufficient of fertilizers can even kill the plant. To avoid as such, pineapple plants require different amount of fertilizer depending on their size, which is 20 grams and 40 grams. 20 grams of fertilizers are used for the small size of plants whereas 40 grams of fertilizers are required for bigger size of plants. To avoid the over or insufficient amount of fertilizers, a specific mechanism is implanted to control the amount of fertilizers in solid fertilizer dispensing machine.

Similar concepts of dispensing fertilizers into the plant are available in the current market. Figure 1 shows the example of a Fertilizer Caddy which is designed to apply fertilizer proportionately and evenly throughout a drip and conventional sprinkler irrigation system on plants. Fertilizer Caddy injectors are ideal for residential, agriculture, commercial, and greenhouse application of fertilizer or additives. This product has been designed for use with any brand of liquid fertilizer on the market today, and can also be used with totally water-soluble dry fertilizers (Retrieved from: http://fertilizerdispensers.com/services/pdf/caddy_brochure.pdf). Another product available is the Seedovator, which is a mechanical seeder that is simple to use, requires little effort and can be used in small or large gardens. It is designed for commercial use so it is very durable, versatile and easy to use. In addition to the seed hopper, there is a fertilizer hopper that has an adjustment allowing the desired amount of fertilizer to be deposited several inches from the seed (The Online Home of Peaceful Valley, 2016).



Figure 1: Examples of Fertilizer Caddy and Seedovator

Basically, solid fertilizer dispensing machine is going to be a project that minimizes human force and also time saving, which could be a major upgrade from previous fertilizing mechanism. Certain circumstances are taken in consideration for solid fertilizer dispensing machine as a guideline throughout the project.

2.0 Design and Development

Equipment for the accurate dispensing of dry fertilizer materials is described in Figure 2. The dispenser consists of a cup which can contain pallet fertilizer depending on the amount 20 grams. The cup is attached to a mechanism below the storage tank which a trigger fabricated to perform dispensing of fertilizer. Hence, fertilizer which had been dispensed travel through a flexible hose and into a metal pipe which is made to pierce the soil to dispense the fertilizer. The end of the metal pipe, consist of cone like sharp point with sharp openings which helps agricultural workers to pierce the soil easily and fertilize the plants. The amount of material dispensed with this equipment, though less precise than obtained by weighing, is more precise than obtained by using hand-manipulated containers. The use of this equipment has reduced the time and labor required to perform agricultural work.

With the system described, either 20 grams of fertilizer can be dispensed using the same mechanism by changing/sliding the cup which is accessible through a separate compartment below the tank. Because of the modular design of the system, adaptations for specific needs can be constructed.

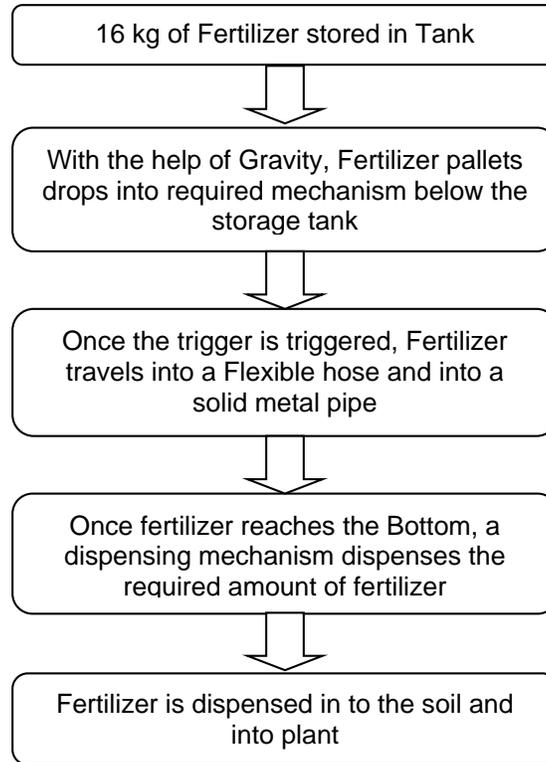


Figure 2: Solid fertilizer dispensing machine processes (Choong et al., 2018)

Figure 3 shows the prototype features of the final product. The basic steps of fertilizing processes are explained in Figure 4. The cylinder from the isolating mechanism plays a major role in dispensing fertilizers at exact amount. For instance, the diameter of cylinder which is used to isolate 20 grams of fertilizers from 20 kg is 2.6 cm whereas 3.1 cm for 40 grams. When the cylinder is static at its own position, the fertilizers starts filling up the cylinder. Then, a lever is pulled to bring the cylinder from left to right to transfer the fertilizers to hose and finally dispense.

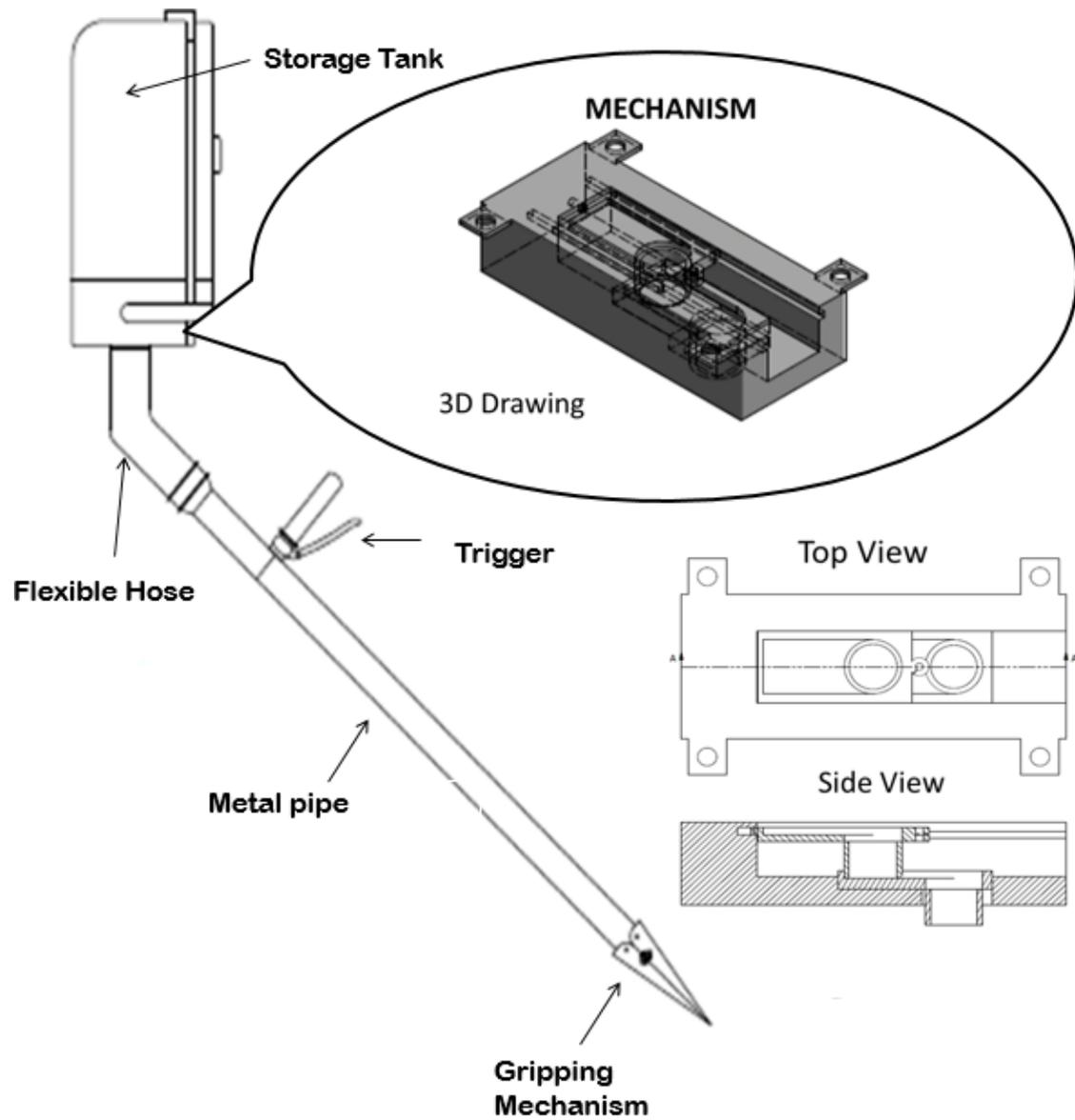


Figure 3: Prototype features (Choong et al., 2018)

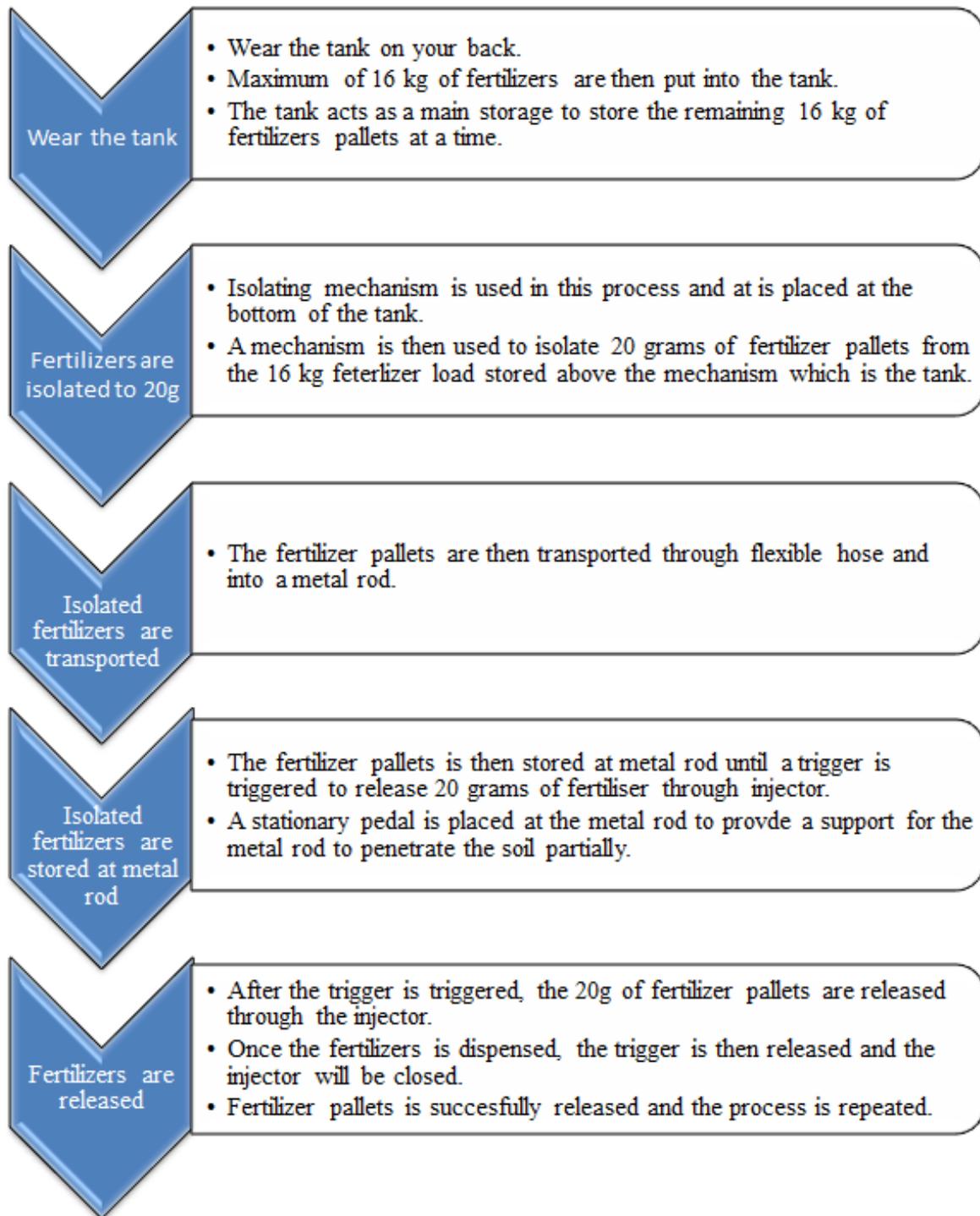


Figure 4: Basic steps of fertilizing processes (Choong et al., 2018)

3.0 Theory of Calculation

The solid fertilizer dispensing machine is used mainly for fertilizing pineapple plants. The tank is placed at the back and adjusted for comfort ability. Then, the lever is upon the reach of palms to trigger the openings at the injector while at the below of the tank there will be an isolating mechanism to isolate 20g from 16 kg of fertilizers. Referring to the mechanism, the trigger is needed around 10N of force to dispense the fertilizer. The 10N of force is needed because of the spring and cord tensions that are supporting the injector (dispensing mechanism). For a perfect fertilizing process for the plant, the metal rod and injector should be bent slightly between 15° to 20° angle and then inject them to the soil. This is because the injector will pierce the soil in ease (Baker et al., 2007). There is also a support (static pedal) provided to help the injector pierce the soil (Krishna, 2013).

4.0 Results and Discussions

There are three sets of data measured and for the current scenario, it is known that fertilizing process is done for many acres and it is never an easy job to fertilize long distance with manual method, which is using bare hands. The area covered for pineapple plantation land will be per 1 acre. In this section, it will be proven that fertilizing using solid fertilizer dispenser will be a much better option than fertilizing using manual method.

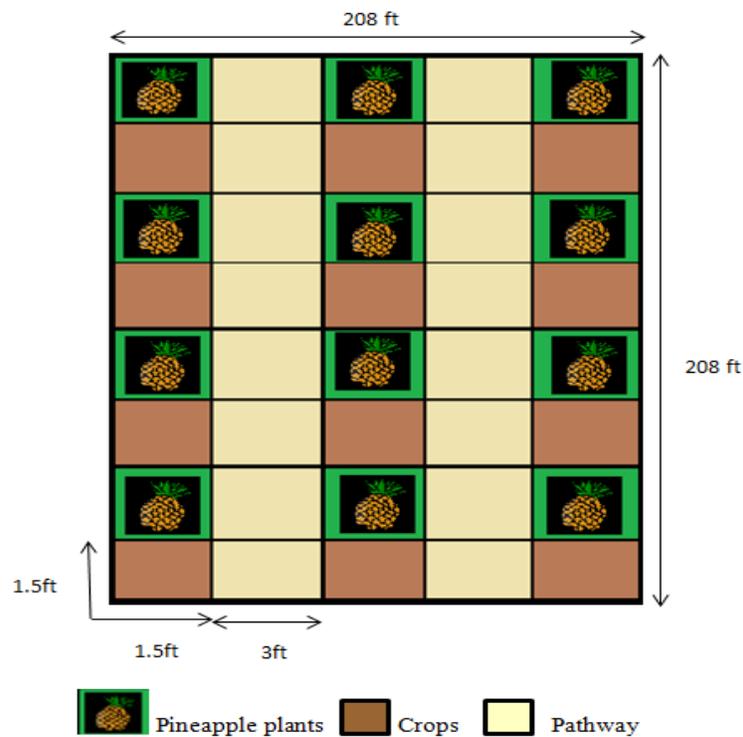


Figure 5: Plan of 1 acre of pineapple plantation (Choong et al., 2018)

Figure 5 shows a simple plan of 1 acre of plantation land. The gap between each pineapple plant is approximately around 3.0 ft. × 1.5 ft. which is equivalent to 10.33×10^{-5} acres. Thus, the covered area per plant is 2.25 ft.² or 5.1653×10^{-5} acres. The distance between crop to crop is around 3.0 ft., and distance between plant to plant is 1.5 ft. For, solid fertilizer dispenser, the storage for it is 16kg = 16000g and dispenses 20g every time fertilizing.

4.1 By Using Manual Fertilizing Method

Manual fertilizing method consumes more time and energy compared to solid fertilizer dispensing machine as more manpower is needed. This is because there will be 2 separate methods done by 2 people. The first man will be pocking the crop making a small compartment for the fertilizers followed by another man spreading fertilizers into the compartment. This method is done for many acres fertilizing more than ±10,000 pineapple plants.

4.1.1 First Method (Pocking the Soil)

A man will walk first through the crops pocking and making a compartment for the second man to spread fertilizers (separated process). The first man takes 13 seconds bending, making a compartment, standing back and walks to the next crop (repeated process).

$$\begin{aligned}1 \text{ acre} &= 43560 \text{ ft}^2, \\1 \text{ plot} &= 0.5 \text{ acre (21,780 ft}^2) \\1 \text{ acre} &= 10,000 \text{ plants} \\ \therefore 0.5 \text{ acre} &= 5,000 \text{ plants}\end{aligned}$$

Require 13 seconds to fertilize each plant using this method.

For 1 acre (10,000 plants) = 130,000 seconds = 2166.7 minutes = 36.1 hours

For 0.5 acre (5,000 plants) = 65,000 seconds = 1083.3 minutes = 18.1 hours

Thus, the first man requires 36.1 hours to fertilize 1 acre of pineapple plants (10,000 plants) and 18.1 hours to fertilize 0.5 acres of pineapple plants (5,000 plants) by only pocking and making a compartment for fertilizers which will be fertilized by the second worker following him at back through the crops.

The worker will be working 8 hours a day, 36.1 hours = 4 days and 5 hours.

The worker needs around 4 days and 5 hours to fertilize 1 acre of pineapple plants.

$$18.1 \text{ hours} = 2 \text{ days and } 3 \text{ hours}$$

The worker needs around 2 days and 3 hours to fertilize 1 plot of pineapple plants.

4.1.2 Second Method (Spreading Fertilizers into The Compartment)

The second man will be following behind the first man spreading fertilizers into the compartment prepared by the first man. The second man

requires 10 seconds bending, spreading fertilizers, standing back and walks to the next plant (repeated process).

Referring to the above calculation,

Require 10 seconds to fertilize each plant using this method.

For 1 acre (10,000 plants) = 100,000 seconds = 1,666.7 minutes = 27.8 hours

For 0.5 acre (5,000 plants) = 50,000 seconds = 833.33 minutes = 13.9 hours

Time trailing = 30 seconds

Thus, the second man requires 27.8 hours to fertilize 1 acre of pineapple plants (10,000 plants) and 13.9 hours to fertilize 0.5 acre of pineapple plants (5,000) by only spreading fertilizers into the compartment made by the first man. He will also be trailing the first man by 30 seconds (trailing time might change depending on the effort used by workers).

The time difference between the two workers,

$$36.1 \text{ hours} - 27.8 \text{ hours} = 9.3 \text{ hours}$$

$$18.1 \text{ hours} - 13.9 \text{ hours} = 4.2 \text{ hours}$$

∴ The workers are doing two different methods in order to fertilize certain acre of plants, The time difference between them is 9.3 hours for 1 acre and 4.2 hours for 1 plot and extra force is required.

4.1.3 By using Solid Fertilizer Dispensing Machine

As mentioned earlier, the storage for this machine will be 16kg and dispenses 20g every time fertilizing. The issue is how many plants can 16 kg of fertilizers cover?

$$1 \text{ acre} = 43560\text{ft}^2,$$

$$1 \text{ plot} = 0.5 \text{ acre} (21,780\text{ft}^2)$$

$$1 \text{ acre} = 10,000 \text{ plants}$$

$$\therefore 0.5 \text{ acre} = 5,000 \text{ plants}$$

$$20 \text{ g fertilizes } 1 \text{ plant}$$

$$16000 \text{ g fertilizes } 800 \text{ plants}$$

Approximately, how long does it take to fertilize 1 acre of plantation?

Require 6 seconds to fertilize each plant using this method.

For 1 acre (10,000 plants) = 60,000 seconds = 1000 minutes = 16.7 hours

For 0.5 acre (5,000 plants) = 30,000 seconds = 500 minutes = 8.3 hours

800 plants = 4,800 seconds = 80 minutes = 1.3 hours

16000 g of fertilizers can fertilize 800 plants in 1.3 hours. 1 acre (10,000 plants) will be fertilized in 16.7 hours whereas 0.5 acre (5,000 plants) can be fertilized in 8.3 hours.

What is the amount of fertilizers needed?

$$16000 \text{ g fertilizes } 800 \text{ plants}$$

$$1 \text{ acre} = 10,000 \text{ plants}$$

200,000 g fertilizers = 10,000 plants
 200,000 g = 200 kg of fertilizers needed to cover 1 acre of plantation

How many times the worker has to refill the tank to cover 1 acre of pineapple plants?

16,000 g fertilizers needed to fertilize 800 plants
 1 acre = 10,000 plants
 $10,000 \div 800 = 12.5$ times = 13 times

The tank should be refilled with fertilizers for 13 times to fertilize 1 acre of pineapple plants.

The worker will be working 8 hours a day, 16.7 hours = 2 days and 7 hours

The worker needs around 2 days and 7 hours only to fertilize 1 acre of pineapple plants.

8.3 hours = 1 day and 3 hours

The worker needs around 1 day and 3 hours only to fertilize 1 plot of pineapple plants. Table 1 presents the comparison between manual fertilizing method and using Solid Fertilizer Dispensing Machine.

Table 1: Comparison between manual fertilizing method and using Solid Fertilizer Dispensing Machine (Choong et al., 2018)

Methods	Manual fertilizing method	Solid Fertilizer Dispensing Machine
Differences		
Time	Consuming (36.1 hours per acre)	Saving (16.7 hours per acre)
Force	More force is required	Less force is required
Operation	Double	Single
Manpower	Needs more manpower	Less manpower
Fertilizer refill time	Numerous times (depending on worker's capability)	Only 13 times for 1 acre

Figure 6 is the bar chart shows the comparison of manual fertilizing method and fertilizing using solid fertilizer dispensing machine. Thus, it is proven that solid fertilizer dispenser has exceeded every expectation from every aspect.

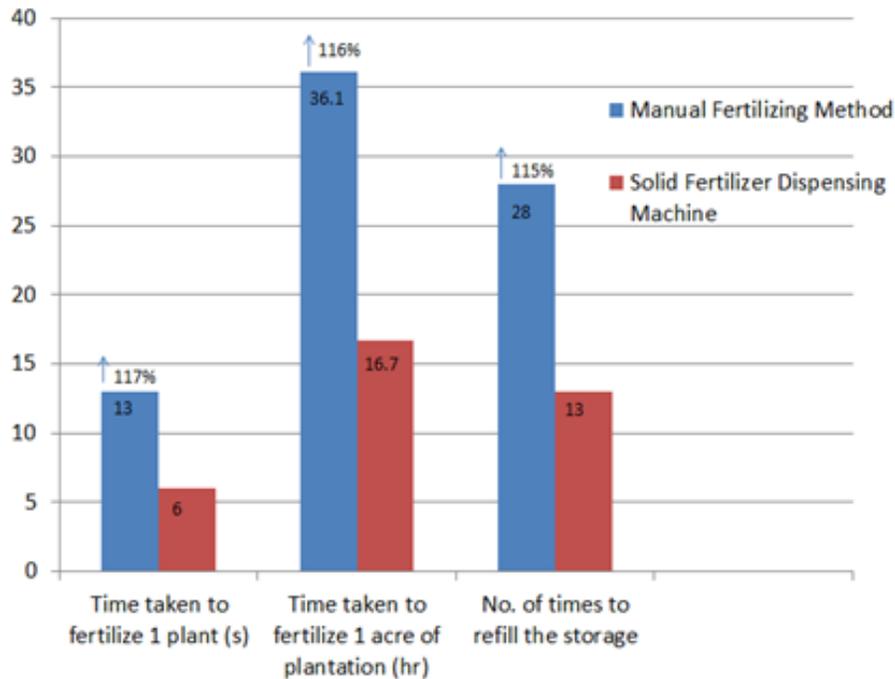


Figure 6: Comparison of manual fertilizing method and fertilizing using solid fertilizer dispensing machine

5.0 Conclusions

With this idea of solid fertilizer dispensing machine, a new type of fertilizing process is going to be introduced. Parallel to previous methods, fertilizing plants with this method is more efficient specifically on time and human effort. This project is pleasing in term of mobility because it enables workers to carry it around for acres. Covering many acres in a limited time is a core reason of this project, as the previous method which is handled manually takes up a lot of time.

This prototype could also be potentially commercialized as it has the potential to be marketed in the business industry. Not specifically on pineapple fruit fertilizing, but also many other plants as most of the agricultural industries uses manual ways for fertilizing in agricultural system. This solid fertilizer dispensing machine function is to simply dispense certain amount of fertilizers depending on type and size of plants. So, there is a huge market for this solid fertilizer dispensing machine when there is a need to fertilize plants for many acres of plants with limited time and force. This mechanically working project could also possibly be made as research or thesis project for upcoming undergraduates and students to develop this idea more. Plus, this prototype also contributes perfectly for people with the need of fertilizing plants for many

acres. Solid fertilizer dispensing machine could also be helpful for the government agricultural department to minimize hard labor and work force in the country.

Last but not least, solid fertilizer dispensing machine can be established as environmental friendly product and could be important for the future of fertilizing plants in agricultural industries.

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