

DESIGN ANALYSIS AND INVESTIGATION OF FABRICATED WEEDER FOR TAPIOCA FARM

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ABSTRACT

In the present-day agriculture, weed regulator in the farm lands is a tedious process that needs more money and human effort. There are a number of methods such as manually removing the unwanted plants by using traditional hand tools or by spraying chemical weedicides which will kill the weeds or using some mechanical equipment's. Of the above-mentioned methods, the mechanical weeding is mostly preferred due to its low operating cost and human effort. Moreover, the efficiency of the mechanical weeding process is high when compared with the other methods. In dry land tapioca farms, it is difficult to remove the unwanted weed plants by using the existing weeding equipment's. In the tapioca farms, the tubers of tapioca are located only few millimeters below the soil surface. The present -day weeding equipment's remove the weed plants by digging the soil surface and it is not favoured because the process will cause damage to the tubers. The use of chemical weedicides is not preferred due to the hazardous nature of the chemicals. The manual weeding process is also not preferred because of the high labour cost. So, in this project A mechanical equipment for carrying out the weeding process in the tapioca farms is designed and fabricated in a way such that it will not cause any damage to the crops. The weeder will only remove the unwanted weed crops in the farm. Apart from the weeding operation, the weeder can make the soil surface loose which will increase the porosity of the soil. Hence the water percolation will be more and the moisture content of the soil can also be maintained. Thus, the weeder will reduce the costs involved in the maintenance of the tapioca farm lands. It will also reduce the human effort involved in the weeding process.

Keywords: Weeding, traditional tools, water percolation, labour cost.

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1. INTRODUCTION

Tapioca plant, also known as Cassava is an annual crop that is grown for about one year. The time to cultivate the crop takes about one year. Due to this time, the costs involved in the cultivating process is also more. This crop is grown widely in tropical regions because it needs at least eight months of warm weather. The plant prefers well-drained soil and modest rainfall, but it can survive where soils are wet. The roots of tapioca do not tolerate freezing temperatures and the best growth is in the areas where the sunshine is more. This is a drought resistant crop and can grow in extremely dry lands also. Tapioca is also mostly unaffected by the pests, insects and other animals as the edible parts are below the ground surface. The plant is grown for its tubers which are rich in starch content. These tubers are the sources of the carbohydrate around the world and is also used to produce a number of medicinal products. This crop plays a major role in the economy of the developing countries of the world such as India, South Africa, etc., The reason behind this is this crop grows effectively even in the low fertile soils where the moisture content is low and the climate is also arid. Moreover, the tapioca is a major part of the staple food in the many regions of the world. It is also a major source for the food supplement of livestock. It is also used for deriving biofuels such as alcohol blended fuels and biodiesel. In India out of the thirty-two states in the country tapioca is grown in thirteen states. The south Indian states play a major part in the tapioca production as the climate in these regions is favorable for the cultivation.

Weeds are the plants that are designated as unwanted plants or not desired plants. These plants are in the form of small herbs that tend to reduce the productivity of the farm lands. These weeds or unwanted plants tend to absorb the nutrients that are supplied to the crops and thereby affecting the growth of the main crops drastically. So, it becomes the necessary activity to control the growth of these unwanted plants in the farm lands. Some examples of the weed plants are *Cynodon dactylon*, *Cenchrus ciliaris*, *Eleusine indica*, etc., In other words weeds are plants that grow at times when we want other plants or crops to grow in the desired place and at desired time. It is a common fact that all weed plants are unwanted plants but all the unwanted plants are not weeds. These plants are tending to curb the utilization of the farm lands and the water resources that would seriously affect the agricultural welfare.

Weed control is one of the most important aspects in the present agriculture. The control methods for weeds are mechanical, chemical, biological ways. Mechanical weeding is chosen as compared to chemical weeding because weedicides are generally expensive, hazardous and discriminating. Moreover, mechanical weeding keeps the soil surface loose which results in better aeration and moisture conservation. Weed control is becoming an expensive operation in crop production. Majority of farmers use hand-hoe for weeding which requires 40-60 labours for weeding one hectare of land. In the present-day intensive agriculture, even though high yielding varieties respond very well to inputs, weeds still exist as a major problem to hamper the productivity of crops. For sustainable agriculture we must develop and practice the concept of weed management in variance with the conventional weed control approach. Where weed control aims at putting down the weeds already present, by some kind of physical or chemical energy.

Hence it is important to use a weed killer in order to control weeds. Weeds if left unchecked may compete with other plants for nutrients, space, water and soil, thereby

restricting their growth. Weeds often insulate the soil surface by forming a layer and hence increase frost risk.

2. OVERVIEW OF THE PROJECT

Weeding is one of the tedious process in the agriculture. The weeds tend to reduce the productivity of the crops by 40 percent. There are many methods available for the control of weeds in the farm lands such as manual, chemical and mechanical methods. Of these the mechanical method is preferred because of its advantage over the other. The comparison between the three methods is illustrated in the Table 1.

The weeders should be designed according to the nature of the soil and the type of crops cultivated in the farm. In tapioca farms the crops are located at a distance of 30 centimeters and more. The tubers of tapioca plants are located only few millimeters below the soil surface and the existing weeders dig the soil. This will damage the tubers and an alternate type of weeder is designed such that it does not cause any damage to the crops. Apart from weeding process, the weeder also loosens the soil surface to enhance aeration and moisture content in the soil. The weeder is fabricated using the available materials to make it cost effective and affordable.

Table 1. Comparison between different methods

S.No	Parameters	Traditional methods	Chemical methods	Mechanical methods
1	Cost	High	Medium	Less
2	Time	High	Less	Less
3	Human effort	High	High	Less
4	Hazards	Nil	More	Nil

3. LITERATURE REVIEW

As the time period accessible for weeding is limited, enhanced mechanical weeders are to be used to complete the weeding operation in due time at less cost. At present, more than fifteen different designs of hoes and weeders are available in market. All these designs are region specific to meet the requirements of soil type, crop grown, cropping form and availability of resident possessions. Therefore, effort has been made to develop a weeder for dry land crops. Its performance was compared with other available weeders in the state namely wheel finger weeder, wheel hoe and traditional method of weeding by trench hoe for groundnut crop at different soil moisture content. The plant damage increased with decrease in moisture content. [1] This may be due to the reason that with decrease in moisture content soil hardness increased and as a result weeding element could not penetrate to desired depth and sometimes slide over hard surface and strikes the plant.

The force required to evacuate some weeds determined by using rope was by pulling through a spring balance and the force at the point of weed removal will be noted. The machine was designed based on the principle of weed stem failure due to shear, and soil or root failure due to impact and abrasion. The design process can be viewed as an optimization process to find structures, mechanical systems, and structural parts that fulfill certain expectations towards their economy, functionality, and appearance using simulation-based design process. [2]

Weeding is an important agricultural unit operation. Delay and carelessness in weeding operation affect the crop yield up to 30 to 60 percent. Various parameters such as speed of travel, time of operation, field capacity, weeding efficiency and horse power requirements were considered during the design of the weeder. Kharif crops are most affected due to weeds. Weeding accounts for about 25 % of the total labour requirement (900–1200 man-hours/hectare) during a cultivation season. Delay and negligence in weeding operation affect the crop yield up to 30 to 60 percent. Though many manually operated weeders are available they are not popular because farmers feel it to be heavy as compared to conventional hoes. For mechanical control of weeds, mostly human and animal powers are utilized. Mechanical weed control not only uproots the weeds between the crop rows but also keeps the soil surface loose, ensuring better soil ventilation and water intake capacity. Manual weeding can give a clean weeding, but it is a slow process. [3]

Manual weeders are not available for vegetables and other crops like tapioca planted at row layout of 30 cm to 50 cm. The control methods for weeds are mechanical, chemical, biological and cultural methods. Mechanical weeding is favored as compared to chemical weeding because weedicides are generally expensive, hazardous and selective. Moreover, mechanical weeding keeps the soil surface loose which results in better aeration and moisture conservation. Battling one of the major problems (weed control) in crop production, different types of weeder have been developed for weeding in wet and dry upland flat beds which will best suited to a specific soil type. The material for making the weeder can be mild steel. Mild steel is used in the production of agricultural tools for a long period. The mild steel is used because it has the sufficient strength to withstand the loads that act on the weeder in the working farm lands. [4]

The effectiveness or the efficiency with which the machine performs its envisioned function is considered in evaluating the performance of an implement. The machine should be adapted to the soil and environmental conditions of the farm. All machines are designed to perform a given task at a specified time. If this designed objective is not met it means that the machine and the power unit is not correct. The rotary blade was made of mild steel to withstand the wearing condition during its contact with the soil and other external material. [5]

4. METHODOLOGY

The project starts with the literature survey and ends with the result evaluation. The Figure 1 shows the methodology of the design and fabrication project.

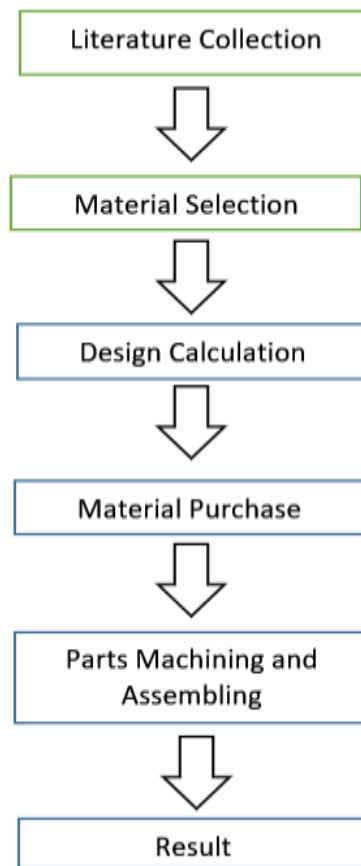


Figure 1. Methodology of the project

5. PROBLEM DEFINITION AND OBJECTIVES

In the tapioca farms the productivity of the crops is affected by the unwanted weed plants and it is tedious to control the weeds by the traditional and general weeding equipment's. There is a need of a specific design of a weeder for the tapioca farm causing only less or no damage to the crop.

- To reduce the costs involved in the process of weed control in the tapioca farm lands.
- To develop a mechanical equipment to remove the weed plants in the farms without causing any damage to the crop especially the tubers.
- To reduce the requirement of the additional or a greater number of labors needed for the weeding process in the job.
- To minimize the time involved in the weeding process.
- To design an equipment that reduce the human effort in the tapioca reducing the need of labors.
- To move the equipment as accost effective and affordable price.
- To make a weeder for the tapioca farm that will not only remove the unwanted plants but also losses the soil and increases the porosity to help the water percolation in order to maintain the moisture content.

6. SELECTION AND USAGE OF MATERIALS

In this project, for the purpose of making the equipment moveable a standard bicycle wheel available in the market is purchased and used. The bicycle wheel is chosen because it has a large diameter and it is less weight. As it has a large diameter only a small amount of effort is to be given by the worker to move the equipment. The light weight of the wheel also helps us to reduce the overall weight of the machine. The wheel is made up of stainless steel which is weightless and has the sufficient strength to withstand the stresses and loads induced during the working time.

The stainless steel is also corrosion resistant and it is very favorable to use it in the farm lands. The farm lands has enormous amount of moisture content in the environment and it favors the formation of rust in the equipments. In our equipment, the wheel will be in contact with the soil surface where there will be more amount of moisture. As the wheel is made up of stainless steel, it is corrosion resistant and can be used for a long time.

The wheel has spokes arrangement in the rim. The advantage of spokes wheel is that they are light weighted and can withstand high shock loads during working process. The spokes wheels are deformable and can regain its original shape after the loads are removed. They can be straightened easily with the available tools and this process does not require any special skills and tools. The reason why alloy wheel is not preferred is because the alloy wheel is heavy.

In this equipment for the assembling purpose of the all the parts of the frame with wheel and blade, standard metric 10 mm bolts and nuts are used. The bolts and nuts are made up of mild steel. The bolts and nuts are manufactured by hot rolling and are hardened using heat treatment process. The heat treatment process enhances the desired strength of the fasteners. The mild steel fasteners are chosen because the material has the sufficient strength to withstand the loads that act on them without any breaking.

The bolts and nuts are always mounted in the places where the two or more members join. These places are subjected to heavy shear loads and the chosen fastener material should withstand the heavy shear load that act in them. The material chosen for the fabrication of the fasteners have a shear strength of about $140 \text{ N} / \text{mm}^2$. This strength is sufficient to withstand the working load that occur in the tapioca farm lands. By calculating the loads and the stresses developed in the working area, the required diameter and the other dimensions of the fasteners are found. From the design calculations it is found that the bolts and nuts having a diameter of 10 millimeters is sufficient to hold the parts together.

The blade is the cutting part of the weeder. The blade is mounted at the bottom of the machine with the help of a bent link. The blade is fixed in an angular position to enhance the correct shearing of the unwanted weed plants in the farm. The width of the blade is about 30 centimeters. This length of the blade is sufficient to row in the gap between the adjacent tapioca plants. The blade is made up of galvanized metal sheet. The sheet is made up of high carbon steel and it is case hardened to impart a sufficient strength to withstand the working load created in the weeding surface of the tapioca farms.

The thickness of the sheet is about 2 millimeters and this is sufficient to cut the weed plants and till the upper soil surface of the farm. The blade will be subjected to high compressive and bending loads and it should to have a sufficient strength to withstand the stresses created in the working environment. The yield strength of the stainless steel is about 270 MPa. This strength is enough to withstand the working loads in the tapioca farms. The stainless steel comprises of high amounts of ferrite in its overall composition which is favorable for its strength.

7. DESCRIPTION OF THE EQUIPMENT

The weeder is designed and fabricated in such a way that it is easy to handle and operate. It can be transported easily from one place to another. The process of carrying out of the weeding task is also easier when compared to the other methods. The weeder is fabricated by using the available material to make it affordable and cost effective the parts and components that are used to make the weeder can be easily assembled and disassembled in case of any wear or breakage. The weeder has a handle of length about one meter. The handle should be of enough length for easy handling and to give the required stability during the operation as it is operated in the farmlands where the working surface is uneven.

For mobility, the normally available bicycle wheel is used in the weeder. The bicycle wheel is chosen because it is light weighted as well as it can also withstand heavy loads. As the diameter of the bicycle wheel is large about 650 mm, very low effort will be sufficient to move the equipment. Also, the wheel has spokes arrangement. Spokes are the number of the rods that run radially from the hub to the outer rim of the wheel. The spokes wheel is chosen because it will offer greater flexibility to the shock loads, it can be easily replaced with new one. Also, the wheels are made up of stainless steel which are high durability, strength and easy to maintain.

For mounting the blade in the weeder, a mild steel frame of length about 65 centimeters is used and it is rigidly fixed with the wheel and handle using two other links. The blade is fixed at an appropriate distance. Such that during the working time, there will be no interaction between the wheel and blade. This frame also made up of mild steel. The provision for mounting the blade is a square rod made up of mild steel. The length of the rod is about 30 cm. the breadth of the rod is ten mm and the thickness is also about 10 mm. For connecting the handle and the frame, two links made up of mild steel are used. They have a length of about 20 cm. when the links are jointed together, a triangular shape is obtained the frame is designed in the triangular shape is more stable as it has a rigid shape.

The virtual model of the weeder created using modelling software is shown in the Figure 2.

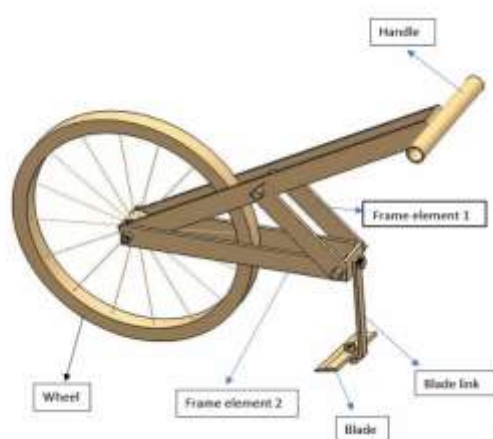


Figure 2. Virtual model of the weeder

8. DESIGN CALCULATIONS

8.1. Design of Wheel

The standard diameter of the wheel, $D_w = 650$ mm

The material used for the fabrication of the wheel is

C35 Mn75.

The yield strength of the material, $\sigma_y = 700 \text{ N / mm}^2$

Calculation of design safety for the wheel: Thickness of the wheel rim = 3 mm

Width of the wheel rim = 50 mm

Cross sectional area of the wheel rim = 150 mm^2

Pushing force given by the worker = 550 N (approximately)

Reaction force from the working surface = 500 N

Consider Factor of safety as 2

The load acting on the wheel = Pushing force + reaction force

Stress induced in the wheel during the working time is,

Stress = Total load / Area of cross section

$$\sigma_{\text{wheel}} = P_{\text{Total}} / A_w$$

$$= (1100 + 1000) / 150 = 14 \text{ N / mm}^2$$

The stress developed in the wheel is less than the yield stress of the wheel material. Hence, the chosen wheel is safe to use in the weeder.

8.2. Design of Frame and Blade

For making the frame and the blade mild steel is chosen and used.

The material chosen is designated as C25.

The ultimate tensile strength of the material, $\sigma_y = 560 \text{ N / mm}^2$

Pushing force given by the worker = 550 N (approximately)

Reaction force from the working surface = 500 N Consider Factor of safety as 2

The thickness of the frame is 5 mm.

Since the blade and frame will shear the soil they should break the compressive strength of the soil.

The compressive strength of clay soil = 200 k Pa

The load created due to the soil = 100 kN To calculate the breadth of the frame, Stress = Load / area

$$560 = (1000 + 100 \times 10^3) / (b \times 5)$$

$$b = 36 \text{ mm}$$

As the breadth of the frame is 36 mm, the 1.5'' width mild steel plate is chosen for making frame. For blade:

Thickness of the blade = 3 mm

Length of blade = 30 mm

$$\begin{aligned} \text{Stress in the blade} &= (1100 + 1000) / (3 \times 30) \\ &= 23.33 \text{ N / mm}^2 \end{aligned}$$

The stress developed in the blade is less than the ultimate shear strength of the material. Hence, the design is safe.

8.3. Design of Bolt and Nut

The material for fasteners is mild steel.

The bolt should withstand the compressive and the shear loads.

Shear strength, $\tau = 0.5 \times \text{compressive strength}$

$$= 0.5 \times 280 = 140 \text{ N / mm}^2$$

Take safety factor as 2

Then, $\tau = 70 \text{ N / mm}^2$

To find the diameter of the bolt, Area = load / stress

$$\pi \times d^2 / 4 = (1100 + 100 \times 10^3) / 70$$

$$d = 42 \text{ mm}$$

The standard diameter of the bolt available is 5 mm. Considering safety factors 10 mm bolt is chosen.

9. BILL OF MATERIALS

This chapter explores and describes the components required for the fabrication of the weeder and the material used for making the components.

Table 2 Bill of Materials

S. No.	Components	Material	No. of components
1	Bicycle	Stainless steel	1
2	Handle	Mild steel	1
3	Frame element	Mild steel	2
4	Frame element	Mild steel	1
5	Blade link	Mild steel	1
6	Blade	Mild steel	1
7	Blot (M10)	Mild steel	8
8	Nut (M10)	Mild steel	10

Based on the survey from the literatures collected the materials are selected to fabricate the weeder. The materials are chosen in such a way that they are able to withstand the working loads that act on the weeder during the working time and also cost effective. The bill of materials used for the fabrication of the weeder are described in the Table 2.

10. FABRICATED MODEL AND WORKING PROCEDURE

The purpose of the project is to fabricate a weeder for the tapioca farms that will reduce the efforts in the weeding process of the farm. The weeder is fabricated using the available materials to reduce the cost. The fabrication and the assembly of the weeding tool does not require any special tools or any other skills. The fabricated model of the weeder is shown in the Figure 3. The weeder is initially positioned in the farm as shown in the figure and the input force is given by the worker to carry out the weeding process. The working procedure is as follows,

- For carrying out the weeding operation, the weeder is positioned in the farm as shown in the Figure 3.
- To move the equipment, some amount of pushing force is to be given by the equipment will be according to the walking speed of the operator.
- According to the studies the normal pushing force of an adult human being will be 550N.
- This force will be sufficient for pushing the weeding equipment.
- The direction of the weeder can also be controlled with the handle.
- When the weeder is moved in the farm, the blade touches the soil surface.
- When sufficient force is given in the downward direction, the blade gets into the ground.
- When forward motion is given to the weeder, it removes the weeds by slicing them.
- The weeder also act as a tiller. It ploughs the top surface of the soil by doing so, the top soil get loser.
- This improves the porosity of the soil, due to the increase in the porosity of the soil.



Figure 3 Fabricated model

11. RESULTS AND DISCUSSION

The weeder was fabricated and tested in a tapioca farm for estimating its efficiency and the advantages over the traditional methods. The weeder showed a greater performance results than the conventional methods and attained the design scope. The following results were obtained from the evaluation.

- The fabricated model of the weeder was tested in the tapioca farms and the effectiveness and the advantages of the weeder were studied. The weeder considerably reduced the time involved in the weeding process. The time taken to carry out the work per unit area of the farm by the weeder was very less than the manual weeding processes that were carried out traditionally.
- The weeder also does not create any damage to the crops and achieved the primary aim of the project. As expected, the weeder loosened the upper soil surface of the farm and it helped in the better water percolation also. The labor and operating costs of the task are also minimized.

11.1. Advantages of the weeder

- The weeder is low cost and affordable.
- The labour costs in the tapioca farm are reduced.

- It does not cause any damage to the crops.
- It reduces the time consumption in the weeding process.
- The equipment is light weighted and portable.
- The materials used are easily available and can be purchased easily.

11.2. Other uses of the weeder

- The weeder can be used for cleaning the irrigation channels constructed in the farms.
- The shape of the blade used in the weeder helps to use it as an equipment to heap grains.

12. CONCLUSION

The project has been started with a high vision to reduce the efforts and the investments in the Tapioca farms by implementing the engineering solutions. The following conclusions are arrived from the present project.

- The equipment can be used to remove the unwanted weed plants in the farm lands and can be used as a tool to loosen the soil in the farm. The equipment reduces the time and the labour costs involved in the cultivation of the tapioca crops.
- The equipment can also be used for other purposes such as cleaning of irrigation channel in the farm. The equipment is more efficient than traditional tools used in the weeding process and it is user friendly. The cost of the weeder is less and it is affordable at all economic levels.

FUTURE SCOPE

- The weeder can be equipped with a power source such as an electric motor to eliminate the input power that is to be given by the worker.
- The equipment can be converted as a small seed sower by attaching suitable mechanisms.

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