# Design and Fabrication of Cost Effective Potato Planting Machine to Increase Quality of Potato

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## ABSTRACT

Sixty percent of Indian population is depended on agriculture and State Government has accorded high priority to the upliftment of rural economy through the development of agricultural sector. Potato Seed being vital input to agriculture, continuous efforts are being made to ensure availability of quality foods grains to farmers in order to sustain the agricultural development and best vegetables to consumer end. In the present situation the demand of quality potatoes are very high and our proposed potato planting machine will be more helpful to this industry. In view of above, our work has been formulated with the objective to produce quality potato of paddy through scientific methods and adopting appropriate processing through establishment of potato planting machine. The paper presents theoretical aspects regarding the kinematics and dynamics of the potato planting machine and features we have implemented all that is required to sowing and planting of potato seed, which includes tilling, planting, fertilizing and ditching of soil all process in a single operation. The expectations of cultivators are very high, as their intensive soil cultivation requires consistency and reliability. At the same time, they are expected to work smoothly and cultivate large areas. Our design competes with all these benefits. They intensively cultivate the soil while destroying annoying clods. The soil thus becomes loose and can be used for ridge forming and makes up the basis for a harvest with a higher yield. Furthermore, our proto type model can be converted to full width cultivators with a few manual actions to planting. The machine which we have invented is working properly and the design and fabrication is matched the requirement. The future scope of this work; we have implemented all the process for single row. Whereas, our machine can only support for one single operation and this can be expanded by placing two different tillers, so that, we can sow the seeds in two rows and four rows at a time by increasing the tiller in the same machine. By using the springs it can make it as a flexible.

## 1. INTRODUCTION

Sixty percent of Indian population is depended on agriculture and State Government has accorded high priority to the upliftment of rural economy through the development of agricultural sector. Potato Seed being vital input to agriculture, continuous efforts are being made to ensure availability of quality foods grains to farmers in order to sustain the agricultural development and best vegetables to consumer end. In the present situation the demand of quality potatoes are very high and our potato planting machine will be more helpful to this industry [1].

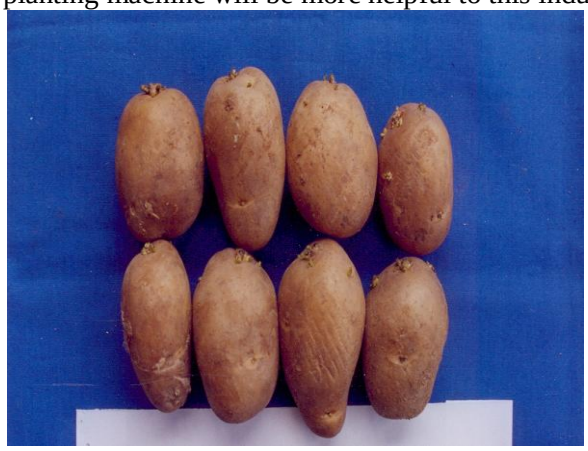


**Fig. 1 Seed potato**

**Fig. 2 Seed Potato slices**

In view of above, our project has been formulated with the objective to produce quality potato of paddy through scientific methods and adopting appropriate processing through establishment of potato planting machine.

### 1.1 Preparations of Seed Potatoes

The manual method of potato cultivation is too lengthy and time consuming process [5, 6]. And it contains the following methods. First thing is the farmer has to buy the potatoes containing number of eyes then it has to be stored in cold condition. Proper kind of seed potatoes are shown in figure 1. Then next procedure is to cut the seed potato into 4 pieces in such a way that each piece consists of at least one single eye. Cut pieces of potato are shown in figure 2. Then these pieces will be dried for two days [2, 4].

### 1.2 Manual Cultivation of Potato

#### 1.2.1 Placement of Seed Potato

Next procedure is to cultivation of land or preparation of land for plantation which is common both for manual procedure and potato planting machine. Then the next procedure is placement of seed potato into the cultivated land that too in a particular row prepared, to a certain depth. This procedure needs more labor and it is time consuming too. In this procedure they have to place the potato nearly to a distance of 20 -25cm, i.e. distance between each seed should be nearly 20 -25cm. Row to row distance should be equal to 60cm.

**Fig. 3 Placement of Seed Potato**

**Fig. 4 Fertilizer placement**

#### 1.2.2 Fertilizer Placement

Phosphorus and potassium are the other two essential elements in potato production. Phosphorus increases tuber yield by increasing the yield and number of medium size tubers whereas potassium increases the number of large size tubers. The application of P and K in furrows in full dose at the time of planting gives the best results. Water-soluble phosphate fertilizers like superphosphate and DAP are most suitable for potato. Similarly potassium sulphate is a better source of K than muriate of potash. The residual phosphorus and potash are generally adequate and nitrogen requirement is reduced by half in succeeding cereal crop. Farmyard manure has been found to be useful in potato production and its application at 30 tonnes/ha has been found to meet entire P and K needs of potato and succeeding cereal crop besides meeting micro-nutrient needs. Beside the row of potato placed fertilizer like phosphorus and potassium in gap of 3-4 inch from seed potato. Finally it covers by disc.

### 1.2.3 Over Lapping Soil

After pre-planting tillage operations, different methods are used for potato planting in various parts of the country. Ridge and furrow method is the most popular method carried out manually or mechanically. In manual method, the furrows are made with the help of curved/narrow-blade spade followed by fertilizer mixture application, covering it with soil and finally making of ridges. The seed tubers are dibbled on each ridge whereas in mechanical method, furrows are made with the help of tractor drawn 2-4 row marker cum fertilizer drills so as to apply fertilizer in one sequence. This is followed by planting of tubers with the help of 2-4 row planters cum ridger. In absence of fertilizer drill and automatic planter, ridges are made with tractor drawn ridger after application of fertilizers and tubers are dibbled manually 5-7cm deep on the ridges. In another method, the field is marked with the help of rope or marker and fertilizer is placed on the marked lines. Tubers are placed to the side of these lines and then ridges are made either with bullock-drawn implements or with narrow-blade spade manually. In the hills, after placement of fertilizer in shallow furrows drawn with hand tools (*Khilna* or *Kudal*) tubers are placed and covered with soil to make ridges. In all these methods care is taken that seed tubers do not come in direct contact of fertilizers.

**Fig. 5 over lapping soil**

**Fig. 6 Tiller**

### 1.3. Problem Definition

There is a need to develop potato planting machine which is enough to perform the following works.

- Seed bed preparation by manually is very risk full.
- Lack of workers at a right time at right place.
- Manual potato cultivation is time consumption.
- High skilled labors are required for cultivation by manual.

The presented task will help the farmers to significantly lower their operating cost, reduce their need for labor, and increase their efficiency and yield [18].

### 1.4. Objectives and Scope of the Work

- Wide ridge two rows potato planting machine.
- Row space and plant space all adjustable.
- One time can finish the drill fertilization, ditch, ditch spray pesticides, sow, Hiller.
- Dismountable, without plastic foil function.

- Raises the land-use capability and the yield rate.
- Improve soil moisture, suppress many weeds, and avoid saline-alkali soil.

Scope of this work is help the farmers for making use of Potato Planting Machine to carry out the process like ploughing, seeding etc., to increase their productivity [8].

## 2. LITERATURE SURVEY

In this section, a detailed literature review on potato planting machine used in agriculture is carried to know its current status, which is more relevant for fabrication of POTATO PLANTING MACHINE.

Jackson, Michigan et al. [1] Have first mechanical potato planter has been attributed to the Aspin wall Manufacturing Co. in 1878. Because of the invention's success, the company devoted itself solely to creating and building potato equipment in 1883 in. The Aspin wall Co. later built another plant in Ontario, Canada, in keeping with the demand for its products.

Fred Bateman et al. [2] Have owner of the Iron Age Co. in Glenoch, New Jersey, developed an assisted-feed planter solving the problem of missed hills. This assistive device placed the seeds on a rotating plate, much like a lazy Susan, before dropping them into the hole. This device ensured that a piece of potato was ready to be fed into the furrow. It also allowed the driver to manually deposit a potato seed into position if necessary.

Wisconsin et al. [3] Although Aspin wall made a complete line of potato equipment including a two-row, gasoline-powered planter, the company went out of business in the early 1920s. The McKenzie Manufacturing Co. of La Crosse bought the Aspin wall potato machinery patent and continued producing potato planters. The basic design of this machinery is still in use today although horsepower has given way to tractor power and several rows are planted at a time.

Jack H. Wigham et al. [4] A tractor mounted three point hitch potato planter that drops the seed close the bottom of the furrow to prevent its rolling, and which planter is closely hitched with hydraulic lift and can thereby be raised off the ground for tight turns and backing.

It is observed from the literature the potato planting machine have been successfully used for cultivating the potato process. This gives an idea to develop a potato planting machine in agriculture for land ploughing, seed placement, fertilizer placement, soil over lapping [11].

## 3. METHODOLOGY

### 3.1 Selection of Potato Seed Container:

The potato seed container is designed and fabricated in the size given in the figure above and it is completely made of M.S. Steel with the gauge of 1.5mm thick. This container has a capacity of around 10 Kgs of potato seed containing. It contains sliced potatoes for planting and carried by using chain sprockets for rotation and bowls are attached to the chain sprockets to and fro motion or carrying the potatoes. The dimension of this container is 500mm Height x 400mm x 400mm.

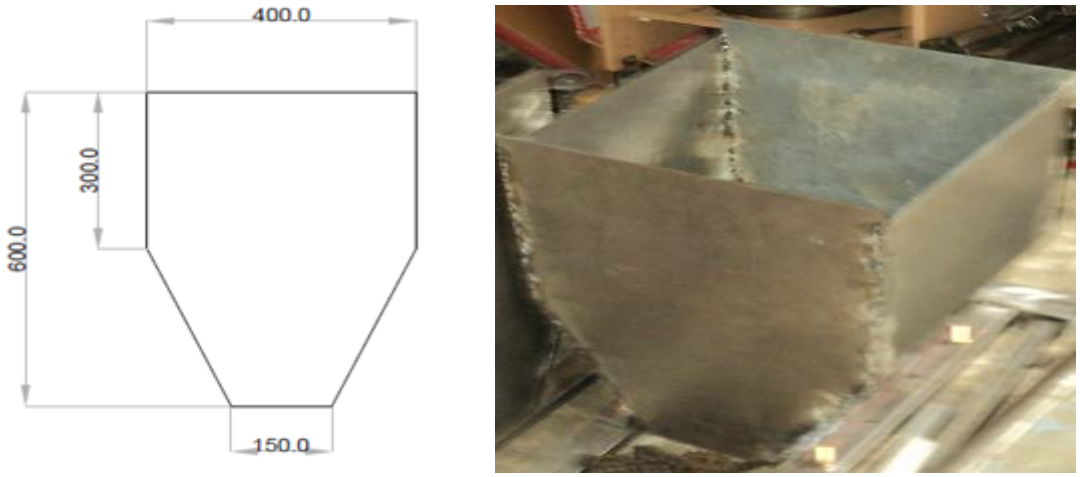



Fig. 7 Potato Seed Container

### 3.2 Selection of Fertilizer Container:

Fertilizer container is fabricated with the size shown in the figure and it has a capacity of around 10 kgs of Fertilizer can be feeder.

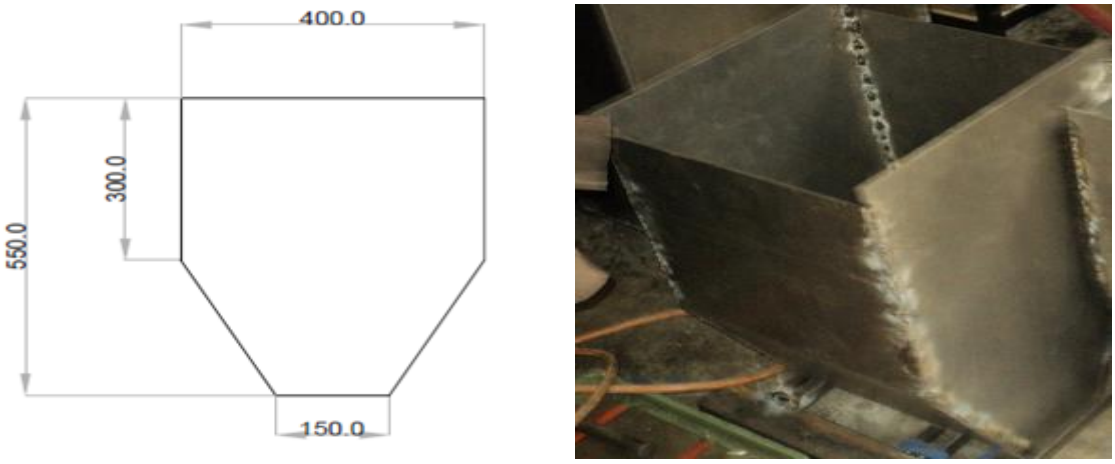



**Fig. 8 Fertilizer Container**

Growing potatoes with natural fertilizers is easier and much more effective if done before the crop is planted. Growing a healthy and hassle free crop of potatoes is best achieved by sheet composting your garden in the autumn-fall. This is a separate chamber built on the machine for containing the Fertilizer and the dimension is around 500mm Height x 400mm Width x 400mm.

### 3.3 Selection of Tiller:

A narrow tiller is a type of motorized cultivating equipment that breaks or works the soil with the aid of rotating blades. Narrow tillers are available with advanced technologies and innovative designs which provide great performance. The narrow tiller can be self-propelled and driven forward on wheels. Featuring a gearbox, the narrow tiller enables one to increase the rotation speed of the blades more than the forward speed of the equipment. Narrow tillers have become world famous for preparation of seedbed in fields. These equipments are often used for breaking or working the soil in lawns, gardens, narrow tillers are used for the plantation.

### 3.4. Design of Tiller:

The design of a tiller in a such a way that, the tiller will penetrate the soil and allowing the seed to be planted in the way it has formed. M.S. Steel used for fabricating the unit and the design is given below.

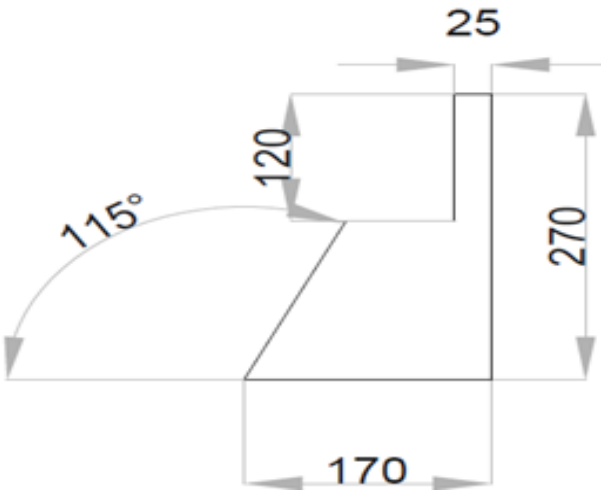



Fig. 9 Design of tiller (all dimensions in mm)

### 3.4 Selection of Chain and Chain Sprockets:

Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles.

**Fig. 10 Chain Sprocket**

**Fig. 11 Chains**

Most often, the power is conveyed by a roller chain, known as the drive chain or transmission chain, passing over a sprocket gear, with the teeth of the gear meshing with the holes in the links of the chain. The gear is turned, and this pulls the chain putting mechanical force into the system.

### 3.5 Selection of Pulleys

A pulley is a wheel on an axle that is designed to support movement of a cable or belt along its circumference. Pulleys are used in a variety of ways to lift loads, apply forces, and to transmit power. A pulley is also called a sheave or drum and may have a groove between two flanges around its

circumference. The drive element of a pulley system can be a rope, cable, belt, or chain that runs over the pulley inside the groove.

### 3.6 Base/Chassis

A chassis consists of an internal framework that supports a man-made object in its construction and use. It is analogous to an animal's skeleton. An example of a chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted) with the wheels and machinery.

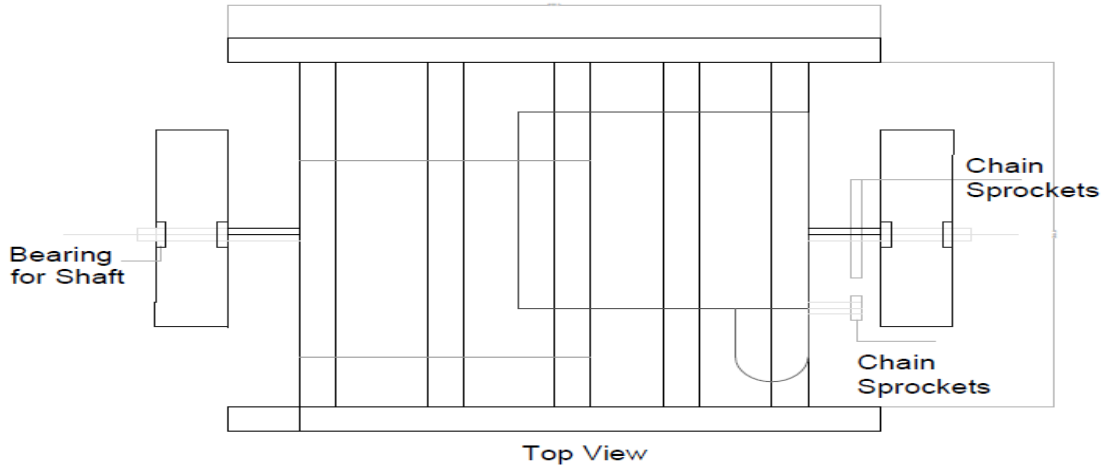



**Fig. 12 Base/Chassis**

### 3.7 Selection of Wheels:

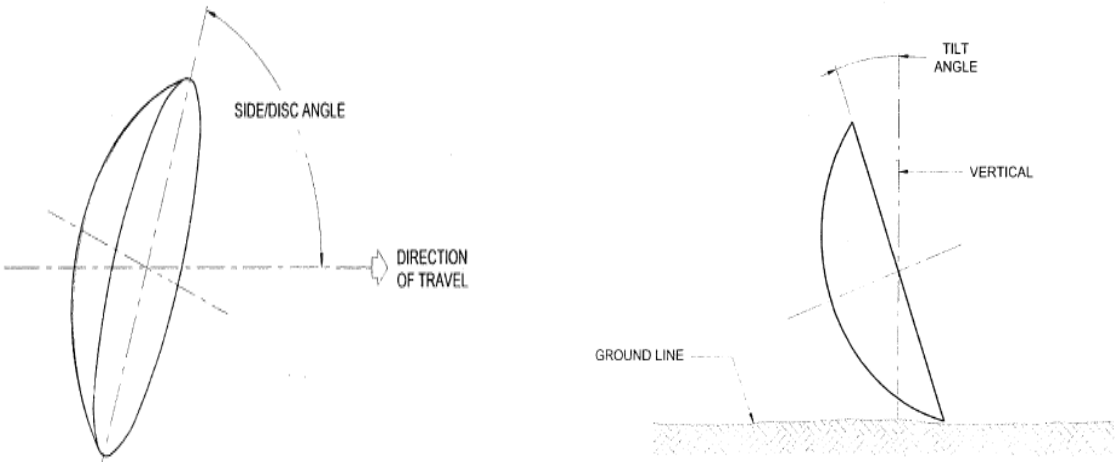
A wheel is a circular component that is intended to rotate on an axial bearing. The wheel is one of the main components of the wheel and axle which is one of the six simple machines. Wheels, in conjunction with axles, allow heavy objects to be moved easily facilitating movement or transportation while supporting a load, or performing labor in machines. Wheels are also used for other purposes, such as a ship's wheel, steering wheel, potter's wheel and flywheel. Common examples are found in transport applications. A wheel greatly reduces friction by facilitating motion by rolling together with the use of axles. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity, or by the application of another external force or torque.

**Fig. 13 Wheel**

**Fig. 14. Disc Harrow**

### 3.8 Selection of Disc Harrow:

The primary purpose of ploughing is to turn over the upper layer of the soil, bringing fresh nutrients to the surface, while burying weeds, the remains of previous crops, and both crop and weed seeds, allowing them to break down. It also aerates the soil, allows it to hold moisture better and provides a seed-free medium for planting an alternate crop. In modern use, a ploughed field is typically left to dry out, and is then harrowed before planting. Ploughs were initially human powered, but the process became considerably more efficient once animals were pressed into service.




**a. Top View of Disc** **b. Side View of Disc**

**Fig. 15 Different Views of Discs**

The first animal powered ploughs were undoubtedly pulled by oxen, and later in many areas by horses (generally draught horses) and mules, although various other animals have been used for this purpose. In industrialized countries, the first mechanical means of pulling a plough were steam-powered (ploughing engines or steam tractors), but these were gradually superseded by internal-combustion-powered tractors. In the past two decades plough use has decreased in some areas, often those significantly threatened by soil damage and erosion, in favour of shallower ploughing and other less invasive tillage techniques.

Disc plough implement in our project is fixed type and for measuring the width of cut, the tilt angle shall be set at 15 to 25°. For nonadjustable plow disc blades, the tilt angle shall be set at 18 to 20° and we have set up at 20°.

## 4. POTATO PLANTING MACHINE

### 4.1. Working of Potato Planting Machine

Our potato planting machine consists of mainly digger, potato seed container, fertilizer container, two sets of roller chain drive mechanisms then a set two discs. Firstly dried pieces of potatoes will be loaded into the potato seed container and fertilizer into fertilizer container. Here one roller chain drive mechanism will be provided for free moment of wheels, carrying heavy load. Another will be provided for carrying seed potatoes from the container and place it into the land.

This chain consists of set of cups attached to the chain. As the tractor pulls or drives the machine then the digger will make the row with required depth. Then chain drive with cup arrangement will also rotate along with wheels, which carry seed potatoes one by one and place it into the appropriate position made by the digger. Besides this only fertilizer container will be their consists of a passage

for fertilizer and to fall on ground. Behind this a set discs will be provided which overlap the soil on the placed potato seed.

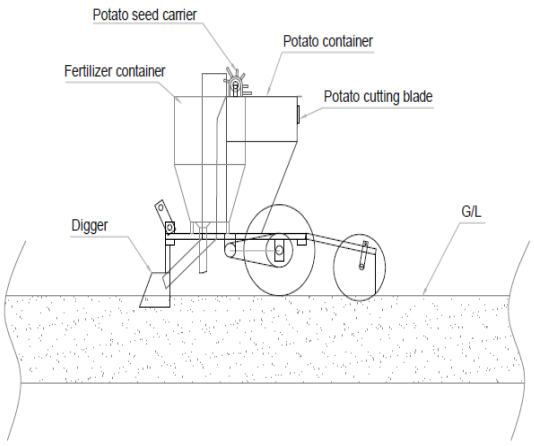



**Fig. 16 Line Diagram of Potato Planting Machine**

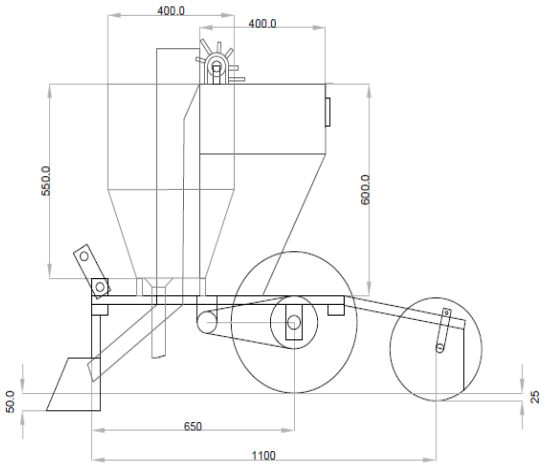



**Fig. 17 Potato Planting Equipment With Dimensions**

### 4.2.1 Potato Seed Container:

- Volume of container = volume of rectangle + volume of trapezium
- Volume of rectangle = Length × Breadth × Height
  From the above fig.7 Length=400mm, Breadth=400mm, Height=300mm
  Volume of rectangle =400×400×300 =48000000mm$^3$
- Volume of trapezium = $(L_1+L_2)0.5$ × Width × depth × 7.48
  From the fig.7, $L_1$=150mm, $L_2$=400mm, Depth=400mm, Width=325mm

Volume of the trapezium = (150+400)0.5 × 325 × 400 × 7.48 = 267410000mm$^3$
Volume of the container = 48000000 + 267410000 = 315410000mm$^3$ per 10Kg
For 10Kg = 0.3154m$^3$ and For 1Kg = 0.03154m$^3$

**Fig. 18 Potato Planting Machine**

**4.2.2 Fertilizer Container:**

- Volume of container = volume of rectangle + volume of trapezium
- Volume of rectangle = Length × Breadth × Height
  From the above fig. 8, Length = 400mm, Breadth = 400mm, Height = 300mm
  Volume of rectangle = 400 × 400 × 300 = 48000000mm$^3$
- Volume of trapezium = $(L_1+L_2)0.5$ × Width × Depth × 7.48
  From the fig. 8, $L_1$ = 150mm, $L_2$ = 400mm, Depth = 400mm, Width = 280mm
  Volume of the trapezium = (150+400)0.5 × 280 × 400 × 7.48 = 230384000mm$^3$
  Volume of container = 48000000 + 230384000 = 278384000mm$^3$ per 20Kg
  For 20Kg = 0.278384m$^3$ and For 1Kg = 0.13919m$^3$

**4.2.3. Design Procedure for Roller Chain Drive**

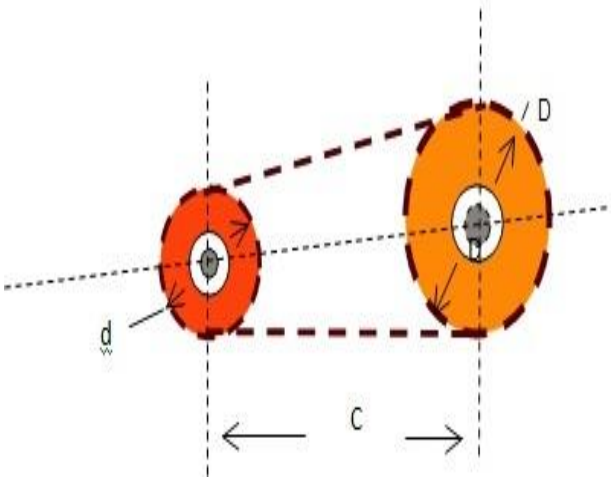



**Fig. 19 Roller Chain Drive**

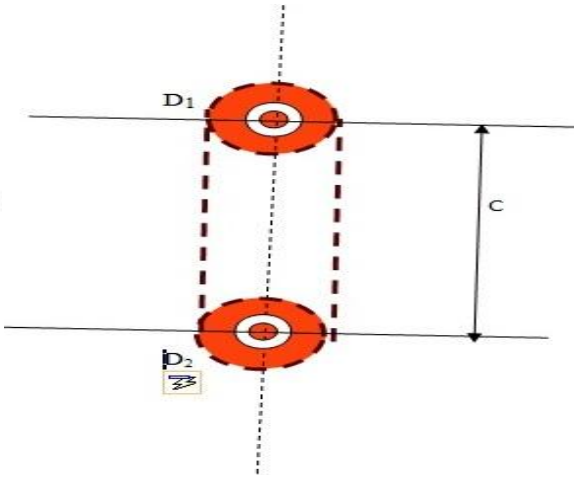



**Fig. 20 Conveyer Chain Drive**

Where, D –Dia of bigger sprocket = 140mm, d –Dia of smaller sprocket = 60mm, C –Center distance between two sprockets = 320mm, $Z_1$ – Number of teeth on smaller sprocket = 15teeths, $Z_2$ – Number of teeth on bigger sprocket = 38teeths, P –Pitch, L – Length of chain

1. Chain length: $L = 2C+1.57(D+d) + \frac{(D-d)^2}{4C} = 2(320) +1.57(140+60) + \frac{(140-60)^2}{4(320)} = 959mm$
2. Pitch: $P = d.\sin(180/z_1) = 60.\sin(180/15) = 12.47mm$
3. $\frac{N_1}{N_2} = \frac{Z_2}{Z_1}$ $20/N_2 = 38/15$, $N_2 = 8rpm$
4. Tractor Power = 50HP = 36.77 kw
   Power, $P=2\pi NT/60$ Where, N= 20 rpm
   Torque, $T= 36.77*60/2*\pi*20 = 17.55$ N-m
5. T = F*R
   Force, $F= T/R = 17.55/70*10^{-3}= 250N$
6. Velocity, $V = PZ_1N_1/60000 = 0.06235$ m/s
7. Required pull
   $P = F_\theta V/1000*k_l *k_s$
   $k_l$ = load factor = 1.3, $k_s$ = service factor = 1
   $F_\theta = 36.77*1000*1.3*1/0.06235 = 766.6$ K N.

### 4.2.4. Design of Conveyor Chain Drive

From the Figure 20, 1. Chain length: $L = 2C+1.57(D_1+D_2) + \frac{(D_1-D_2)^2}{4C}$

$= 2(940) +1.57(60+60)+ \frac{(60-60)^2}{4(940)}$ =2068mm.

2. Pitch: $P = d.\sin(180/z_1) = 60.\sin(180/15)$ =12.47mm.

## 5. RESULTS AND DISCUSSION

The potato planting machine is developed to perform the functions like ploughing the land, seeding, fertilizing and overlapping of soil.

### 5.1. Ploughing the Land

The ploughing is done by the tiller provided at the front of machine as shown in fig. 21. The designer of tiller in such a way that, the tiller will penetrate the soil and allowing the seed to be planted in the way it has formed. Here M.S. Steel is used for fabricating the unit.

### 5.2. Seed placement

Placement of seed involves the mechanism of fall of seed at a distance of 20-25 cm throughout the ploughed land as shown in figure 22. This mechanism consists of cup and chain drive arrangement in which cups are attached to chain drive in order to carry seed potatoes.

### 5.3. Fertilizing

Growing potatoes with natural fertilizers is easier and much more effective if done before the crop is planted. Growing a healthy and hassle free crop of potatoes is best achieved by sheet composting your garden in the autumn-fall. Fertilizer is made to fall down with the help of pipe provided with a valve just beside the seed placement.

**Fig. 21 ploughing the land**

**Fig. 22 Seed Placement**

Fig. 23 Fertilizing

Fig. 24 soil overlapping

### 5.4. Soil Overlapping

Soil lapping is done by disc harrows provided in the model. A disc harrow is a farm implement that is used to cultivate the soil where crops are to be planted. It is also used to chop up unwanted weeds or crop remainders. It consists of many iron or steel discs. From the above figure 24, it is concluded that our machine has performed successfully the functions like ploughing, seed placement, fertilizing and soil overlapping. Also it can be employed for larger agriculture area.

## 6. Conclusion

The paper presents theoretical aspects regarding the kinematics and dynamics of the potato planting machine. In this project we have implemented all that is required to sowing and planting of potato seed, which includes tilling, planting, fertilizing and ditching of soil all process in a single operation. The expectations of cultivators are very high, as their intensive soil cultivation requires consistency and reliability. At the same time, they are expected to work smoothly and cultivate large areas. Our design competes with all these benefits. They intensively cultivate the soil while destroying annoying clods. The soil thus becomes loose and can be used for ridge forming and makes up the basis for a harvest with a higher yield. Furthermore, our proto type model can be converted to full width cultivators with a few manual actions to planting. The machine which we have invented is working properly and the design and fabrication is matched the requirement. The present work is implemented all the process for single row and machine can only support for one single operation. This can be expanded by placing two, four different tillers, so that, we can sow the seeds in two rows and four rows at a time by increasing the tiller in the same machine. By using the springs it can be made as flexible.

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