POTATO PLANTING MACHINE: FEASIBLE SOLUTION OF FARMING

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Abstract: Potato has an important role in human food. It was the sixth alimentary product in the world after sugar cane, maze, rice, wheat and milk in 2011 year. Any attempt in the improvement of potato harvester will be valuable. In this study, a new semi-mounted one-row potato digger with rotary blade was designed. It can be connected to rotary potato graders. Transmission system was mechanical from tractor to blade by belt, pulley, gearbox, chain and sprocket. More than sixty percent of Indians is depended on agriculture and State Government for development of agricultural sector has accorded high priority to elevate and boost rural economy. Potato seed being vital input to agriculture, endless efforts are being made to assure 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 is 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 suitable processing methods through development 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 outlook and prediction of high growth of crop of cultivators are very high because intensive soil cultivation requires consistency and reliability. In the meanwhile, cultivators are also expected to work smoothly and cultivate large areas. Our design competes with all these expectations to aid cultivators. They intensively tilt the soil while destroying annoying clods. The soil thus becomes loose and can be used for crease forming and create the basis for a harvest with a higher yield. Furthermore, our prototype 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.

Key Words: Rotary Potato Digger, Potato plantation, potato seed, transmission system, conveyor, hopper.

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1. **Introduction:** The paper is designed based on the principles of farmers view and the system is automatic type. By using automation the productivity of the product can be increase. In view of above, our project has been formulated with the objective to produce quality potato, with minimum cost. 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 project has been formulated with the objective to produce quality potato of paddy through scientific approach and adopting suitable processing through development of potato planting machine.

1.1 Arrangement of seed potato's:

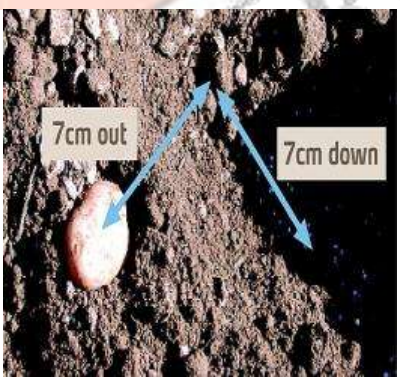
The manual method of potato cultivation is too lengthy and time consuming process . And it contains the following methods. First thing is the farmer has to buy the potatoes containing number of eyes then it has to be stored in cold condition. Proper kind of seed potatoes are shown in figure 1. Then next 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 .

1.2 Physical cultivation of potato:

Potatoes are generally grown from seed potatoes – these are tubers specifically grown to be disease free and provide consistent and healthy plants. To be disease free, the areas where seed potatoes are grown are selected with care. Potato growth has been divided into five phases. During the first phase, sprouts emerge from the seed potatoes and root growth begins. During the second, photosynthesis begins as the plant develops leaves and branches. In the third phase runner develop from lower leaf axils on the stem and grow downwards into the ground and on these runners new tubers develop as swellings of the runner. This phase is often (but not always) associated with flowering. Tuber formation halts when soil temperatures reach 27 °C (81 °F); hence potatoes are considered a cool-season crop. Tuber bulking occurs during the fourth phase, when the plant begins investing the majority of its resources in its newly formed tubers. At this stage, several factors are critical to yield: optimal soil moisture and temperature, soil nutrient availability and balance, and resistance to pest attacks. The final phase is maturation: The plant canopy dies back, the tuber skins harden, and their sugars convert to starches.

1.3 Implementation 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.



1.4 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 appropriate method 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.

Overlapping soil :

Once pre-planting tillage operations are completed, various methods are used for potato planting in different parts of the country. Crease formation (Ridge) and furrow (Channel formation) method is the most widely used method carried out either manually or mechanically. In manual approach of furrow method, the Channels are made with the help of curved/narrow-blade spade followed by fertilizer mixture application to cover it with soil and finally making of ridges. The tubes carrying seed are dibbled on each ridge formed. In mechanical approach, furrows can be formed with the help of tractor drawn rows marker cum fertilizer driller so that fertilizer can be applied in one sequence. This can be achieved by planting of tubers with the help of row planters cum ridger. If fertilizer drill and automatic planter not present, then ridges are made with tractor drawn ridger after application of fertilizers and tubers are dibbled manually 5-7cm deep on each 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.

Figure- **Overlapping soil**

Figure-**Tiller**

2. Concept of potato seed planter:

In 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: Potato Planting Machine

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.

4. Objectives and Scope of the Work:

- Reduce the labor work.
- High productive seeds plantation.
- Losses are minimum.
- Huge production.
- Low cost.
- Less time.
- Faster work.
- Good growth.
- High margin.
- High profitability.

5. Methodology:

5.1 Potato seed container:

Potato container is fabricated with the size shown in the figure and it has a capacity of around 18 kg of Potato. Production of potatoes with natural potato is simple and much more effective if it is 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 potato and the dimension is around 520mm Height x 500mm Width x 200mm.

$$\text{Volume of Container} = 520*500*200 \text{ mm}^3$$

Container can made up of mild steel so that weight might be less and high ductility materials helps to overcome the friction and thrust issues

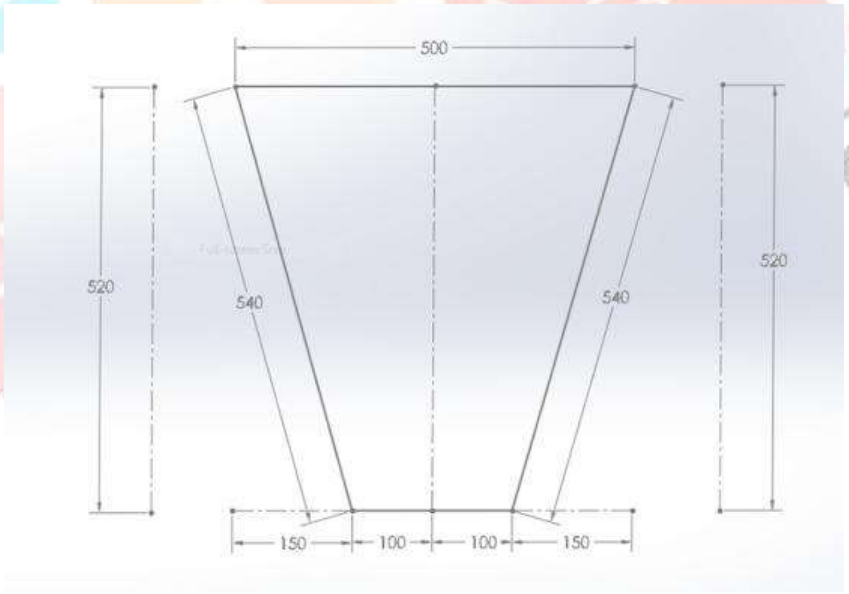


Figure 5.1- Potato seed container

5.2 Fertilizer container:

Fertilizer container is fabricated with the size shown in the figure and it has a capacity of around 10 kg of Fertilizer. Production of potatoes with natural fertilizers is simple and much more effective if it is 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 600mm Height x 400mm Width x 400mm.

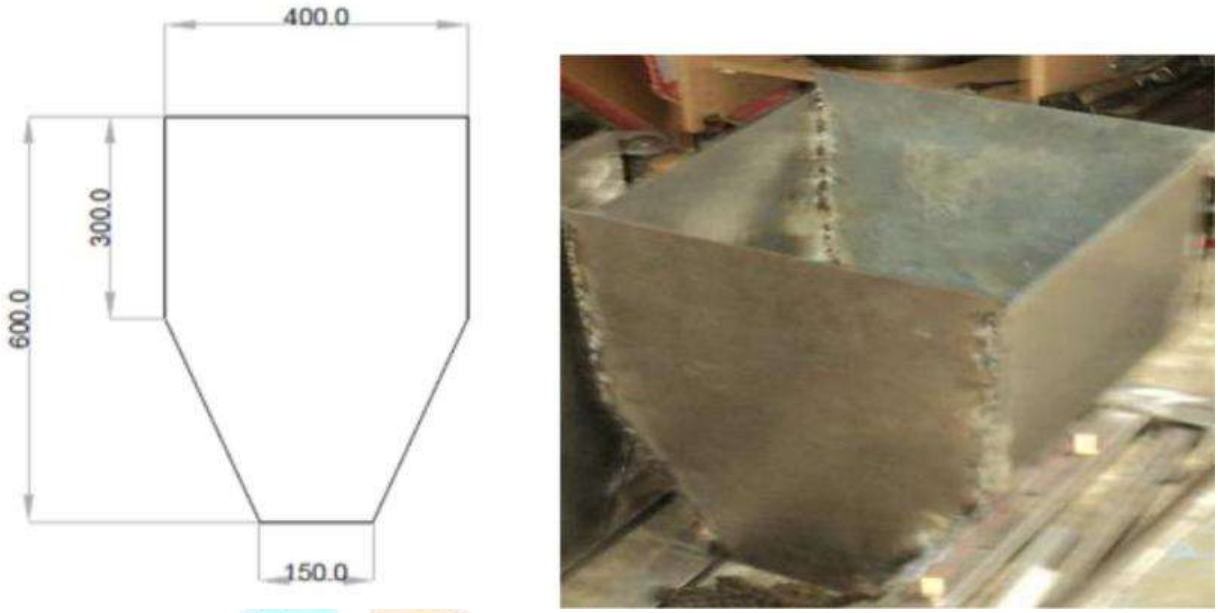


Figure 5.2-Fertilizer container

5.3 Selection of Tiller:

A narrow tiller is a type of motorized cultivating equipment that breaks the soil with the help of rotating blades. Narrow tillers are available with advanced technologies and state of the art designs to provide greater 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 which are often used for breaking or working on the soil in lawns, gardens, narrow tillers are used for the plantation.

5.4 Design of Tiller :

The design of a 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. M.S. Steel used for fabricating the unit and the design is given below.

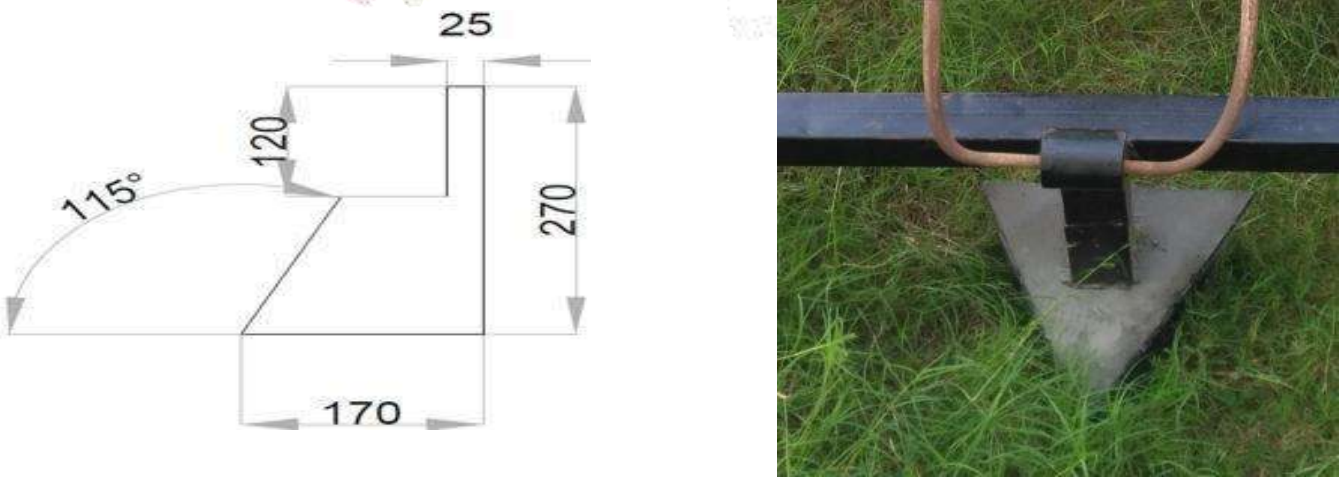


Fig: Tiller Design

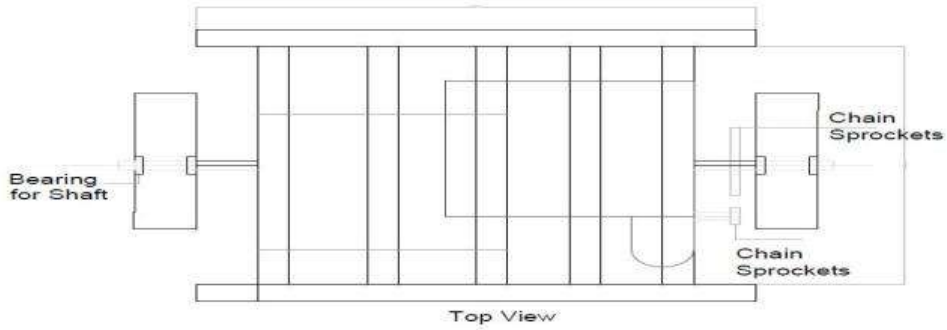
5.5 Selection of Chain and Chain Sprockets:

Chain drive are used for transmitting mechanical power from one place to another having large distance between sprockets. Sometime, they are also used to transfer power to the wheels of a vehicle, especially in bicycles and motorcycles. But widely used in a variety of machines besides vehicles.

Particularly when the power is conveyed by a roller chain, the drive is known as the chain drive or transmission chain. While passing over a sprocket gear with the help of 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.

5.6 Base/Chassis:

A chassis consists of an internal framework that supports a man-made object in its construction and use. It is similar 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.



5.7 Selection of Wheels:

A wheel is a circular element is meant to rotate on an axial bearing. 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 : Wheel Overview

5.8 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.

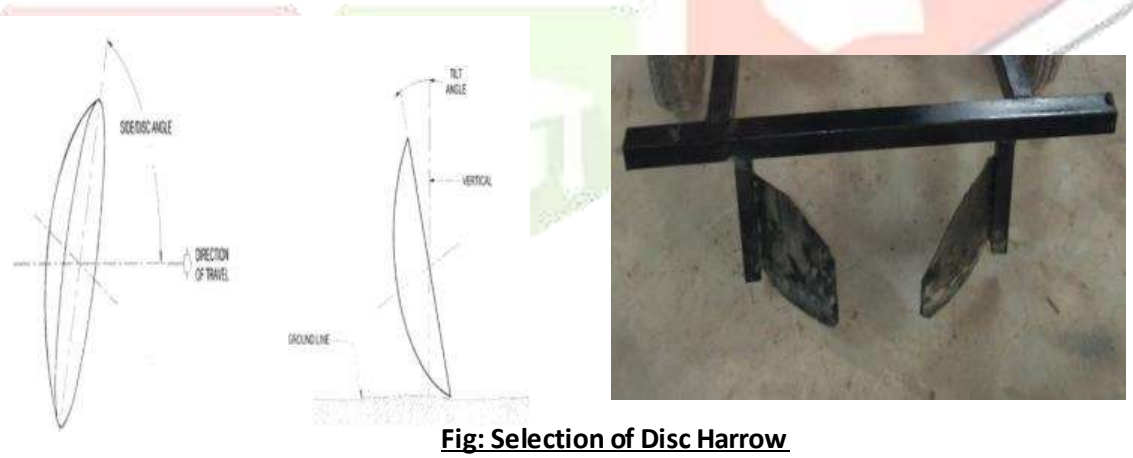


Fig: Selection of Disc Harrow

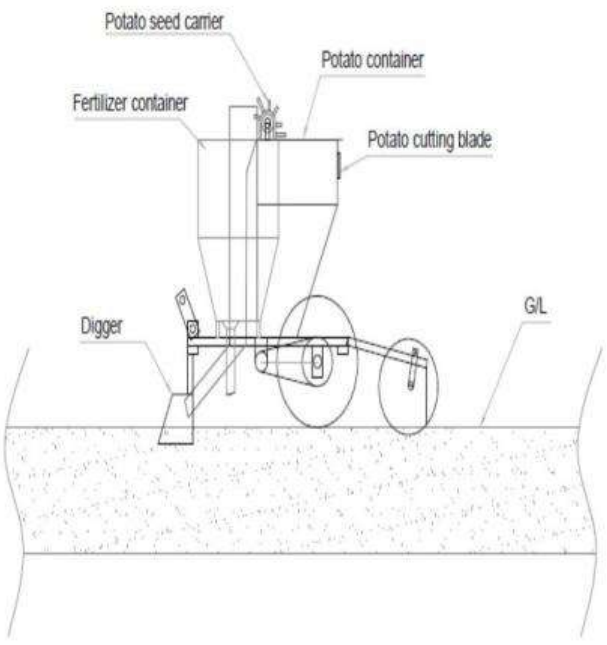
The first animal powered ploughs were used to be pulled by oxen, and later in many areas by horses (generally draught horses) and mules were used, although various other animals have been used for this purpose. In industrialized countries, the first mechanical means of pulling a plough was steam-powered (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 favor 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°.

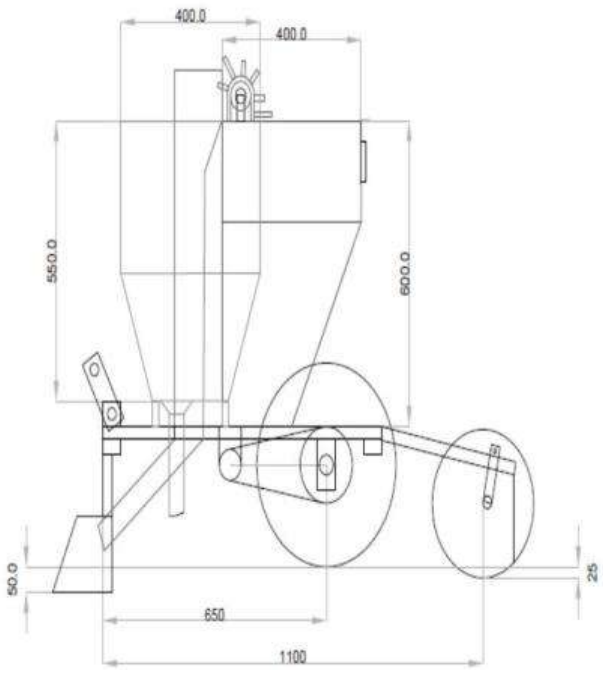
6. POTATO PLANTING MACHINE:

6.1 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.





6.2.1 Potato Seed Container:

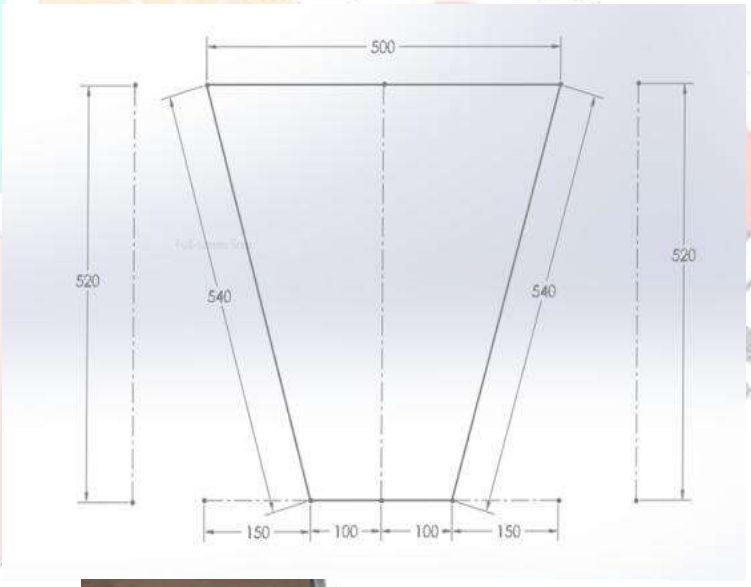
- Volume of container = volume of rectangle + volume of trapezium
- Volume of rectangle = Length × Breadth × Height

Length=500mm, Breadth=500mm, Height=520mm Volume of rectangle =500×500×520 =130000000mm^3

- Volume of trapezium = $(L_1+L_2)0.5 \times$ Width × depth × 7.48

From the fig., L_1=200mm, L_2=500mm, Depth=540mm, Width=500mm Volume of the trapezium = (200+500)0.5 × 500 × 520 × 7.48 = 680680000mm^3 Volume of the container = 130000000 + 680680000 = 810680000mm^3 per 18Kg

For 18Kg = 0.81068m^3 and For 1Kg = 0.081068m^3



6.2.2 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 = $(L_1+L_2)0.5 \times$ Width × Depth × 7.48

  From the fig. 8, L_1 = 150mm, L_2 = 400mm, Depth = 400mm, Width = 280mm

  Volume of the trapezium = $(150+400)0.5 \times 280 \times 400 \times 7.48 = 230384000mm^3$

  Volume of container = 48000000 + 230384000 = 278384000mm^3 per 20Kg

  For 20Kg = 0.278384m^3 and For 1Kg = 0.13919m^3

6.2.3 Design Procedure for Roller 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. $\frac{N_1}{N_2} = \frac{Z_2}{Z_1}$ $\quad 20/N_2 = 38/15, \quad N_2 = 8rpm$
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.

6.2.3 Design of Conveyor Chain Drive:

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

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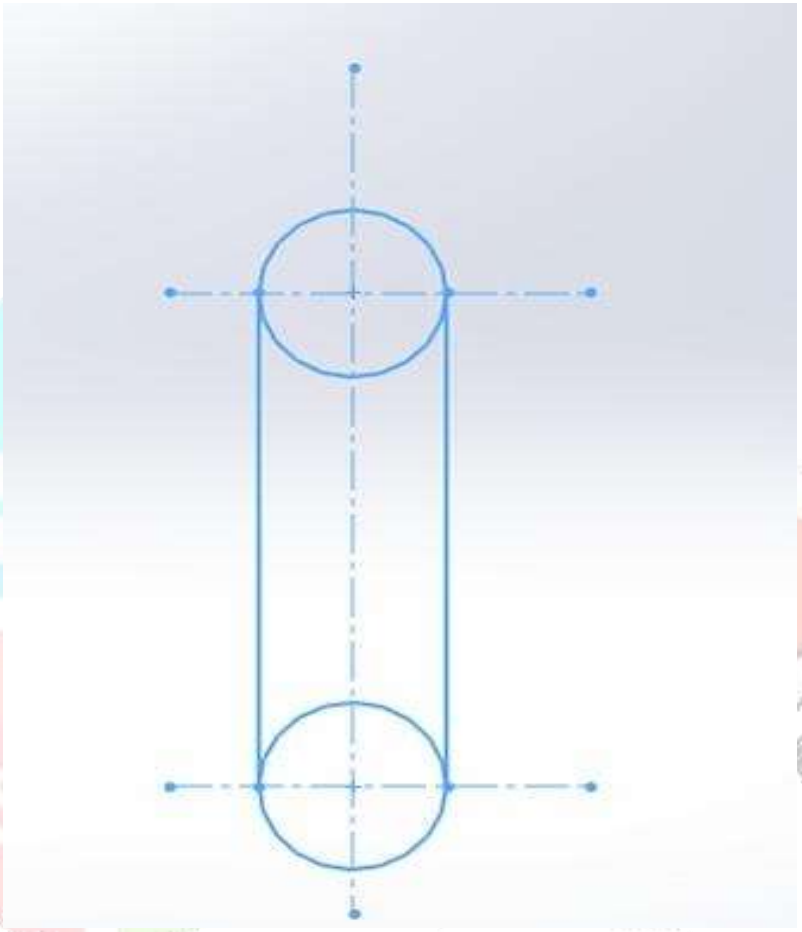
$$= 2(940) + 1.57(60+60) + \frac{(60-60)^2}{4(940)} = 2068\text{mm}.$$

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



8. RESULTS AND DISCUSSION:

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

8.1. Ploughing the Land:

The ploughing is done by the tiller provided at the front of machine as shown in figure 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.

8.2. 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.

8.3. Fertilizing:

Production of potatoes with natural fertilizers is much simpler and 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.

8.4. 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 seeds 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.




CONCLUSION: The paper presents theoretical aspects of the kinematics and dynamics of the potato planting machine. In this work, 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 outlook and prediction of high growth of crop of cultivators are very high because intensive soil cultivation requires consistency and reliability. In the meanwhile, cultivators are also 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 crease forming and create the basis for a harvest with a higher yield. Furthermore, our prototype 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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