

DESIGN AND FABRICATION OF MANUALLY OPERATED PAPER POT PLANT TRANSPLANTING MACHINE

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Abstract - The paper pot transplanter machine is an innovative, labour and time saving technology. It relies on using paper pot that is connected in a chain so that they feed themselves through the transplanter. The transplanter itself is hand-pulled manually operated machine. It can take around 264 plants in the tray and put in the ground in less than 5 minutes i.e., 33 seedlings in just 40 seconds. All this operation are carried out while walking upright (no kneeling, crawling or stopping) the transplanter opens a narrow furrow and the paper chain goes down into the furrow, and the plants are covered by soil by a pair of metal flanges (wings). At the start of a row, the lead cell of a paper pot chain are pulled down into the furrow, staked to hold it in place, and then pull the transplanter forward. The transplanter all will follow each other into the ground.



Fig.1: Plants in trays



Fig.2: Manual planting

Key Words: Paper pot, transplanter, Seedlings, furrow

1. INTRODUCTION

Agriculture is the backbone of Indian economy. Today, India ranks second worldwide in farm output. About 175 types of vegetables are grown in India, produce 14 of the vegetables crops like tomato, onion, chili, brinjal, cauliflower, cabbage etc. are transplanted.

Transplanting is practice which involves the placing of seedlings either on ridge or well prepared seedbed, such that they starts establishing their roots and survive as a separate plant.

Seedlings for transplanting purposes are raised on beds in which seeds are broadcasted or dibbled in lines. According to the requirement of the procedure followed for transplanting of a particular crop or method. Seedlings are then uprooted manually when they are about 4-10 weeks old and transplanted in fields, transplanting of seedling is a manual and labor-intensive operation.

Timely transplanting of vegetable crops is essential for higher yields. A survey conducted to access mechanization gaps in the seeding, planting and transplanting of vegetable crops indicated that Indian vegetable transplanter.

The average vegetable grower in India mainly belong to small and medium category of farmers. (146.55 million tons) of world's vegetables and have 15% (8.5 million hectares) of world's area under vegetables. Productivity of vegetables in India (17.3 tons/hectare) is less than the world average productivity (18.8 tons/hectare) in 2013-2014. Seeds of crops like cowpea, okra, carrot etc. are either drilled or planted directly however, most of the vegetables crops like tomato, onion, chili, brinjal, cauliflower, cabbage etc. are transplanted.

1.1 Paper Pot Transplanter

Paper pot is for seedling material and consisted of special paper, and each pot is in chain. Paper pot is made by paper only, so it can supply air and water quality to plant root. It is easily make healthy seeding.

When transplanting, seedling put in field with paper pot. It means that don't remove paper. So it protects a root and it help to be initial growing, especially for non-healthy seeding and young seeding. Transplanter is a machine. So very simple and easy to use, also no need maintenance. It will be easy working for transplanter, as well as good for body.

1.2 Working

The paper pot transplanter works on similarly to a direct seeder in design. There is a furrower in the front that makes a trough, the plants are fed through a channel to drop into trough, and there are two wings that push the soil back around the plants, two wheels at the tail end lightly compact the soil around the plants.

Instead of a seed hopper, there is a large tray space for tray of transplant to feed out of.

The key part, and namesake, of this design is paper pot tray that the seeds are planted into these little paper pots are actually loops attached into a chain that looks similar to a honeycomb. The paper pots unchain as you move the transplanter, feeding themselves through the transplanter.



Fig.3: Working of paper pot transplanting machine

2. Summary of Literature Survey

With reference to literature survey we came to know that plant transplanting machine works either manually operating or connected together with the tractor with provision provided in the machine. Transplanting of plant is actuated by various mechanisms like slider crank mechanism through chain and sprocket arrangement etc. By using this type of arrangement one can achieve transplanting of plant with good efficiency, consuming less time compared to traditional planting method and accurate in-row spacing is obtained.

3. Problem Definition

The average yield of vegetables in India is still lower than that in many Asian countries. Transplanting of plants in manual is labour-intensive operation. In peak seasons due unavailability of labours, timely transplanting is not possible. Cost of labours being increased day by day and therefore manual transplanting is becoming uneconomical. Proposed transplanter was designed on the basis of morphological parameters of seedlings, agronomical requirements and ergonomical consideration for transplanting plants at a time.

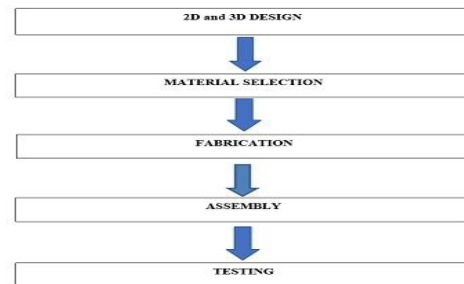
4. Objectives

- Design of paper pot for desired planting conditions.

- Design and fabrication of manually operated paper pot transplanting machine.

5. Methodology

The procedure mentioned in flow chart will be followed during design and fabrication of the product



5.1 Design calculation

Design of paper pot transplanter

Load due to weight of transplanter

- 1) Load due to digging of soil
- 2) Load to pull transplanter

Design of tray

Selection of material

Mild steel 20gauge, $\sigma_{yt1}=150\text{Mpa}$

Density=7891.093 Kg/m³

20 gauge=0.953 mm

Assume total 264 paper pot contains in tray

One paper pot mass=30 grams

Mass of total pots $F_0=264*30 =7920 \text{ grams} =7.92\text{kg}$
 $=77.6952 \text{ N}$

Area of tray containing paper pots, $A_0= L*B$

$$=24*12=288 \text{ sq inch}=185806.08 \text{ mm}$$

Compressive stress on frame = F_0/A_0

$$=77.6952/185806.08$$

$$= 4.1815*10^{-4} \text{ N/mm}^2$$

Therefore, yield stress is greater than induced stress tray design is safe.

- Force required to the pull the tray
 - a. Friction force in rolling

Force due to rolling tire in loose sand= 0.2-0.4

Lets radius of front tire=101.6mm

Total load = load of paper pot +load of tray

Load of tray = 1kg =9.81N

It is distributed on two front wheel = 9.81/2 = 4.905 N

Load of paper pot on each wheel = 77.6952/2 =38.8476N

Therefore, Total load $W_1= 4.905+38.8476 = 43.7526N$

Force required to overcoming the rolling friction of front wheel

$$F_1 = f \cdot W_1 / r_1 = 0.4 \cdot 43.7526 / 101.6 = 0.1722 N/mm$$

$$= 172.25 N/m$$

Total two front wheel required = 172.25 N/m force

Let radius of rear tire $r_2= 76.2mm$

Load due to tray and support on rear wheel $W_2 = 1kg =9.81N$

Force required to overcome the rolling friction by rear wheel

$$F_2 = f \cdot W_2 / r_2 = 0.4 \cdot 9.81 / 76.2 = 0.0514 N/mm = 51.49 N/m$$

- Load required to digging the soil
 - Design of soil anchor

Force required to pull the anchor = $F_3 = m \cdot a$

Where, $m =$ load of transplanter + load of paper pots

$$= 15kg + 8 kg = 23kg = 225.63 N$$

$a =$ average man walking speed

$$= 1.5km/hour = 0.416 m/s$$

$$F_3 = 225.63 \cdot 0.416 = 93.86 = 94 N$$

$F =$ Total horizontal force

$$\text{Therefore, } F = F_1 + F_2 + F_3 = 172.25 + 51.49 + 94 = 317.74 N$$

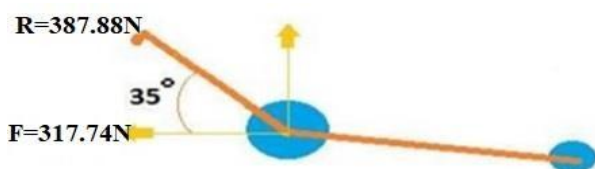


Fig -4: Resultant force acting on handle

Total resultant force on handle, $F = R \cdot \cos\theta$

$$R = 317.74 / \cos 35 = 387.88 N$$

- Design of handle

Handle is made up 1 inch round pipe

Handle length = 457.2 mm

Handle is pull by hand therefore pipe is subjected to tensile force.

Therefore, $\sigma = R / A_1$

Where, $A_1 =$ surface area of handle = $\pi D L_1 = \pi \cdot 0.0254 \cdot 0.4572 = 0.03648 m^2$

$$\sigma = 387.88 / 0.03648 = 10632.675 N/mm^2 = 10.63267 N/m^2$$

Handle is made up of material galvanized steel, $\sigma_{yl} = 55000 psi = 379.212 Mpa$

$$FOS = \sigma_{yl} / \sigma_{all}$$

Consider $FOS = 3$

Therefore,


$$\sigma_{all} = \sigma_{yl} / FOS = 379.212 / 3 = 126.404 N/mm^2$$

$$= 126.404 \cdot 10^6 N/m^2$$

$$\sigma_{all} > \sigma$$

- Design of paper pot for desire planting condition

Table.1: Design parameter of paper pots (Radish seedlings)

Parameters	Dimensions
In row Planting distance	 50mm
Pot diameter	30mm
Pot height	30mm
Pot length	14000mm
The number of pots per tray	264pots

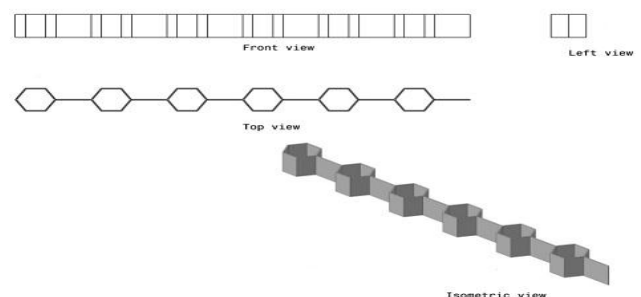


Fig.5: All views of paper pot

6. Fabrication Details

Fabrication involves a process of building machine, structures and other equipment's by deploying various process and operations like cutting, forming, setup, full welding and assembling components made from raw material. A brief description of selection of raw material is given below.



Fig.6: Fabrication



Fig.8: Tray and Ramp



Fig.9: Main body and Furrower

6.1 Material Details

In this project, a material for different parts are used in building of transplanter is mild steel. The selection of appropriate material for respective components was based on following mechanical properties such as,

- Tensile strength
- Bending strength
- Compressive strength
- Shear strength
- Yield strength
- Hardness

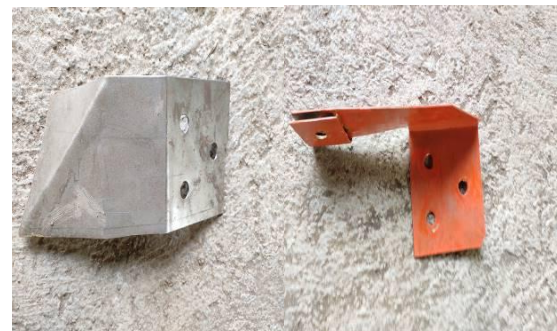


Fig.10: Wings and Support link

6.2 Components of the Planting Machine



Fig.7: Front wheel assembly and Pull handle



Fig.11: Rear wheel and Paper pot chain

6.3 Machine assembly

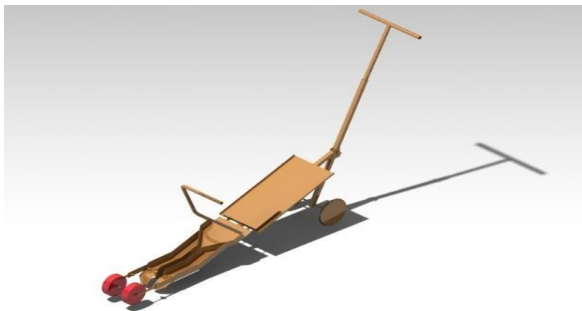


Fig.12: 3D rendered diagram of assembled transplanter

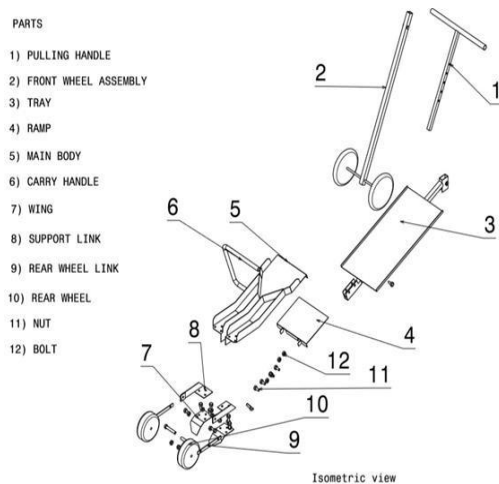


Fig.13: 3D diagram of exploded view of transplanter

After all the parts are fabricated according to the drawings, all the parts are assembled in the following sequence.

- A front wheel assembly carries tray and pull handle in which tray is slides on outer body for suitable depth of digging soil and is fixed using nut and bolt and pull handle slide in inner part of the body for adjusting suitable height and fixed at suitable height using nut and bolt.
- Once tray is fixed to front wheel assembly, then main body is joined to tray using nut and bolt of drilled hole provided in tray.
- A carry handle is fixed to lower part frame provided in main body part using nut and bolt.
- A ramp is simply place between tray and main body that connects between them for easy move of paper pot seedlings.
- A wing is fixed in main body at both sides for distributing the soil around the plants.

- A support link is placed and fixed at the same hole for connecting rear wheels.
- A rear wheel link is fixed to support link at the both side.
- A rear wheel is joined to rear wheel link at the both side using nut and bolt.

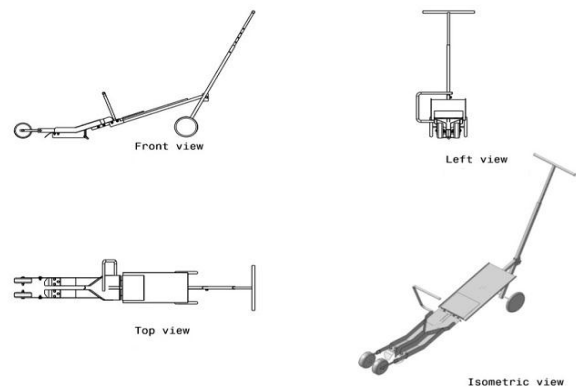


Fig.14: All views of transplanter

6.4 Preparing and seeding the paper pot tray



Fig.15: Preparation of paper pot with seedlings

- Readily made paper pot chain is taken and it is arranged properly in germination tray of dimension 60*30 cm.
- Paper pot containing cell which must filled with well mixed soil and cocopeat.
- Soil-cocopeat mixture is to be filled in the paper pot cell up to half volume of paper pot cell.
- Each seed must be sowed inside the paper pot cells, after its completion remaining volume of paper pot cell is to be filled with soil-cocopeat mixture.
- After completion of sowing, then it should be watered properly.
- After some time say 2-3 week of sowing, depending on the baby plant condition it is taken for transplanting.

7. Result and discussions



Fig.16: After transplanting 33 seedlings of radish



Fig.17: Accurate 2 inch in row spacing

- The paper pot plant transplanter works satisfactorily and paper chain is made with double layer of paper and it unchain properly without any damage and moves in path provided in main body and it is tested with radish baby plant and it is transplanted successfully as shown in the figure11 with maintaining the proper in row spacing.
- It took less than 40 seconds to transplant 33 paper pot seedlings in a single stretch.

Table.2: Result

SL No	Dimension	No. of plants		Time taken	
		Manual work	Planting machine	Manual work	Planting machine
1	33*33 feet	260	260	31min	6min
2	1 acre	8184	8184	16hr	4hr

7.1 Advantage

- The paper pot is that can use it for many different crops.

- Maintains the uniform spacing between rows while operation.
- The paper chain pots can be made in 2,4 or 6 inch in row spacing.
- Transplant about 264 seedings in less than a 5minute.
- The paper is organic, holds up well until transplanting, then decomposes once in ground.
- It can be operated by single person and avoids human errors.

7.2 Disadvantage

- The paper pot transplanter works best in loose soil that doesn't have too many rocks or detritus.
- Occasionally, if chain will break or detritus will have stuck under furrower and slow down the transplantation.
- Minor manual operational adjustments are required.

7.3 Application

- Paper pot transplanter can be used for both small scale farming and large agricultural fields.
- The paper pot transplanter can be used for radish, cabbage, cauliflower, onion, and herbs etc...

8. Conclusion

- The paper pot transplanting machine works satisfactorily with transplanting rate of 33 seedlings in just 40 seconds compared to 8 a 5 seedlings/min in case of manual transplanting for raised bed condition.
- Weight of transplanter is less than 25kg so that it can easily handled by single operator and it is simple, low cost and found suitable for transplanting of various vegetable , herbs and flower seedlings.

9. Future scope

- The machine is driven by man power but engine can be coupled to enhance the performances.
- Paper pot chain of different in row spacing can prepared for different seedlings.
- Machine can be developed to transplant several rows simultaneously.

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