

#### **Design Overview of Vegetable transplanter**







#### **Flow diagram - Operations in Transplanter**







# Focus on the term tractor mounted



Mastering the Basics: Three – Point Linkages



Understanding hitch categories



How to make our implement compatible with both hitch categories?

https://youtu.be/okclgUJ764Y?si=AHSc69ap\_fjdFwiD

#### Hitch System Specification

- ✓ Compatibility CAT I/CAT II: Yes/No
- ✓ Pin hole diameter for CAT I:
- ✓ Pin hole diameter for CAT II:

The prime mover for tractor pulling the attachment would be in the range of 35-50 HP. Tractor will be provided by SAE TIFAN committee. Students need to make sure that the implement is compatible with 35-50 HP and 3-point linkage driven tractors.

- I. The attachment should be compatible with both ISO-730 CATI and CAT II hitch geometry.
  - a. CAT I:
    - i. Mast height 460+/-1.5mm,
    - ii. Lower Hitch distance: 683 +/-1.5 mm,
    - iii. Diameter of Top hitch pin 19mm,
    - iv. Dimeter of lower hitch pin 22mm,
    - v. Clevis 65mm
  - b. CAT II:
    - vi. Mast height 610+/-1.5mm,
    - vii. Lower Hitch distance: 825 +/-1.5 mm,
    - viii. Diameter of Top hitch pin 25.5mm,
    - ix. Dimeter of lower hitch pin 28mm,
    - x. Clevis 65mm
- II. Tractor wheels reactions: 20%:80 % (Front: Rear) by mass
- III. Turning radius: < 2m
- IV. Attachment should be transported through tractor 3-point linkage.
- V. The sapling planting can be driven through ground wheel drive or PTO drive shaft.



### Source: Adapted from ASAE Standards, 2001





## Understanding Pickup-System



How can you pick a sapling from the tray?



From which direction can you approach the sapling to pick it?



Will it damage the sapling?



Is it accurate?



Is it fast?

#### Picking system

The main function of this system is to pick up sapling cups from tray or buckets without any manual intervention. The pickup systems can be one or multiple depending upon the machine row configuration. Every team has its freedom to design and use any system that performs the intended function.

#### Sapling Tray Dimension:

Sapling cup diameter- 3.5cm Tray Length- 52.5 cm Tray Width – 27 cm Tray Depth- 4 cm Total Sapling in a tray – 7\*14 = 98



Fig. 2- Sapling Tray

#### **Sapling Size Considerations**

- Teams are provided with Sapling (Chili, Brinjal or Tomato) that can range from 15cm to 25 cm in height.
- Compatible with specified crops?
  - Tomato, Chili, Brinjal\*
- How many sapling trays can the implement hold?
- ✓ How are trays held on implement?
- ✓ Design of Mechanism for Sapling pick-up?
- ✓ Power source? Is it Hydraulic, Mechanical, Motors?



Source: MDPI Article: Design and Experiment of an Integrated Automatic Transplanting Mechanism for Picking and Planting Pepper Hole Tray Seedlings





#### Types of picking Mechanism

- 1. Pin type pickup
- Pins will pick the sapling from the cup and drop that into the planting mechanism.

#### 2. Push mechanism

- Pushing mechanism push the sapling from the back side of the cup.
- The dropped plant goes into the planting mechanism.

#### 3. Gripper mechanism

 Gripper mechanism plug out the plant with stem and the drop it into the planting mechanism.



Source: precision Agricultural science and technology: Automatic picking mechanisms





- ✓ How saplings are being conveyed from Sapling trays to ground?
- Conveying maximum number of saplings, with no or minimum damage.
- Proper picking of saplings from tray/bucket and thus ensuring smooth transfer.
- Channelize the pickup saplings towards digging system.
- Choose an appropriate type of conveyor belt like a slat type belt, flat belt, metal rod with chains etc.
- Proper angle of the system to enable material movement.
- Speed of conveyor and liner speed of travel of material
- Saplings flow rate
- Power consumption for conveying unit
- Diameter and spacing of conveyer belts.





### Hold and Conveying and planting system

 The main function of conveyor is to convey the saplings picked from trays/buckets to digging system. Conveyor unit/system is used. The system should be designed that it holds the saplings at predetermined spacing and then passes to the other end of digging unit.

- Wheel type
- Rotary Hopper Type
- Linkage Type





#### 1. Wheel type transplanting mechanism



2. Rotory type transplanting mechanism



• The wheel method is a method in which a number of planting openers are installed on the wheel to formally match the wheel speed. And it is characterized by a uniform structure and simple structure even when the speed changes.

• The rotary method is the planting device that is most often used for planting vegetables by drawing power through the crankshaft and drawing the oval-shaped stop trajectory of the planting machine while the gear cases and planting machine rotate.

Source: research article: Analysis of mixed ratio of waste cooking-oils in biodiesel production process using near-infrared





# Digging a hole in soil

- $\checkmark$  We need a sharp surface to dig a hole
- $\checkmark$  Think about objects which have sharp tips.
- ✓ Can we make a mechanism which digs and puts the sapling in the hole ?
- $\checkmark$  Can we think of a shape like a cone?
- ✓ What if we make the cone hollow from inside?
- Blade depth should be adjustable ( can be done by using top link of tractor also)
- ✓ Hole depth should be in range of 5-7cm.



**Source :** https://tse1.mm.bing.net/th/id/OIP.x1nVCySpbD\_i8kAt-MNWRgAAAA?rs=1&pid=ImgDetMain

#### 3. Linkage type transplanting mechanism



• The both crank arms rotate counterclockwise with similar rotational speed around the fixed point respectively, as the result the seedling were picked by the duckbill planter at predetermined position and move downward to plant the seedling into the soil.



Source: MDPI Article: Optimization of Main Link Lengths of Transplanting Device of Semi-Automatic Vegetable Transplanter





#### Design of Digging and Covering of Soil

- ✓ Blade Shape and Geometry:
- ✓ Blade Material:
- ✓ Rack Angle, Throat clearance, Draft calculations:
- ✓ Blade depth adjustment:
- ✓ Soil Closing Mechanism:

Dig a hole in soil:

- Proper selection of blade shape and geometry
- Selection of appropriate blade material.
- Selection of proper rack angle.
- Throat clearance calculations
- Draft force calculations for the given soil
- Provision of depth change to adjust draft variation requirements.
- Choosing optimum machine travel speed to make best use of machine power and efficiency of system







#### **Digging forces calculations**

#### 2.4.1 Digging Force:-

- 1. Cutting Blade shape: Conical
- 2. Blade Material: EN8
- 3. Rake Angle: 20<sup>0</sup>
- 4. Throat Clearance Calculation: 90 mm

Digging force is calculated by

$$P = 0.0082\{(V2yw)\left(\frac{C + \check{C}a}{V2y}\right) * 0.84\left(\frac{d}{w}\right) * 1.4(sin\alpha)\}$$
(1)

#### Where,

V= Velocity of tractor/blade, (mm) y= Soil bulk density, (KN/m<sup>3</sup>) w= Tool width, (m)  $\alpha = Rake angle, (degree)$ d= Tool depth, (m) C= Cohesion (kPa) Ca= Adhesion (kPa) **Draft Calculations**  $P = (y * Z_1 * 2N_y) + (C * Z_1 * N_c)$ (2)For black cotton soil,  $N_y = 1.55$  for  $\delta = 0$  = Angle of shearing resistance of soil  $N_v = 1.75$  for  $\delta = \varphi \delta$  = Angle of metal friction  $N_c = 1.65$  for  $\delta = 0$  $N_c = 1.6$  for  $\delta = \phi$ y= 17.68 kN/m<sup>3</sup>  $C = 30.18 \text{ kN/m}^2$  $Z_1$  = Depth of operation = 10cm = 0.1m  $P = (17.68 \times 10^3 \times 0.1 \times 2 \times 1.75) + (30.18 \times 10^3 \times 0.1 \times 1.65)$ P= 5289.1 N For Black soil

Digging Force Calculations Draft Calculations P



Source: MDPI Article: Optimization of Main Link Lengths of Transplanting Device of Semi-Automatic Vegetable Transplanter





#### Rack angle, throat clearance and Draft calculations

- D = k0 x w x d (2) D (kgf) = draft force,w (cm) = width of opener,
- d (cm) = depth of opener,
- k0 () = Specific soil resistance = 0.25 Taking,
- w = 45 mm,
- d = 40 mm and
- k0 = 1 considering factor of safety Total draft force for four furrow openers was obtained as kgf.



Source: MDPI Article: Optimization of Main Link Lengths of Transplanting Device of Semi-Automatic Vegetable Transplanter









1-guide rod 2-lower crank 3-fixed plate 4-driving sprocket 5-upper crank 6-connecting rod 7-duckbill Figure 1. Structural diagram of planting mechanism



Source: IOP Conference Series: Materials Science and Engineering article: Design and Analysis of Vegetable Transplanter Based on Five-bar Mechanism





## Covering mechanism

What is it?

Is it already being used in some other machinery?

Which kind of machines are similar to transplanter?

Can we use the similar mechanisms present in those machines?





### Soil Covering Mechanism



Key mechanisms of the transplanter. 1. Transmission case; 2. Power transmission shaft; 3. Trim shell of rotary tillage device; 4. Transmission housing;

5. Rotary blade shaft; 6. Rotary blade; 7. soil-covered plate; 8. Auger cover roller; 9. The shelf of film and soil covering device; 10. Film-pressure wheel;

11. Film roller suspension rack; 12. Film; 13. Film roller; 14. Installation support; 15. Soil-retaining plate; 16. The shell of auger cover roller; 17. Soil guide plate;

18. Seedlings cup; 19. Turntable plate; 20. Seedlings cup bracket; 21. Duckbilled transplanting apparatus; 22. Coupler-1; 23. Crank-1; 24. Gear-1;

25. Crank-2; 26. Connection plate; 27. Coupler-2; 28. Gear-2; 29. Gear-3.

Source: ResearchGate: Design and Experiment of Dry-Farming Cantaloupe Transplanter under Water





Specifications of other essential parts of the FVS transplanter.



Fig. 3. Different views of the furrow opener vegetable seedling (FVS) transplanter: (a) top view; (b) perspective view; (c) front view; and (d) side view. All dimensions are in mm.

Source: ResearchGate: Article :Design and evaluation of a power tiller vegetable seedling transplanter with dibbler and furrow type





180.00

(d)

Side view









#### Design of Planting System

- ✓ Row spacing (mm) Min/Max:
- ✓ Plant spacing (mm) Min/Max:
- ✓ Planting Speed Min/Max:
- ✓ Supporting Calculation/Working principle:







Source: SAE TIFAN Rulebook







Source: Int.J.Curr.Microbiol.App.Sci (2021) 10(01): 497-508:Design, Development and Evaluation of Manual Vegetable Transplanter







**Figure 1.** Structure of the pepper transplanter under development: (**a**) seedling picking manipulator, (**b**) seedling (**c**) conveying unit, (**d**) dibbling mechanism, (**e**) mathematical model of dibbling operations, and (**f**) soil-compacting

Source: article MPDI: Working Speed Analysis of the Gear-Driven Dibbling Mechanism of a 2.6 kW Walking-Type Automatic Pepper Transplanter







Source: ScienceDirect: Development of embedded automatic transplanting system in seedling transplanters for precision agriculture





#### Performance parameter from Existing transplanter

#### • Kubota Transplanter

| Model                 |                                      |          | KUBOTA SPV-6MD                                     | Model     |               |                |  |
|-----------------------|--------------------------------------|----------|--|-----------|---------------|----------------|--|
| Drive Type            |                                      |          | 4-wheel drive                                      |           | Steering      | y Sy           |  |
|                       | Overall length                       | mm       | 3050   | Travalina | Wheel -       | Ţ              |  |
| Dimonolono            | Overall width                        | mm       | 2220   | portion   |               |                |  |
| Dimensions            | Overall height                       | mm       | 2600   |           |               | 0              |  |
|                       | Minimum groung clearand              | ce mm    | 500  |           |               | 0              |  |
| Weight                |                                      |          | 805 kgs  | ]         | Shifting      | Shifting sys   |  |
| Engine                | Engine Model                         |          | GA620-Diesel Engine                                |           | No. of S      | No. of Shifti  |  |
|                       | Engine Type                          |          | Water-cooled, 4-cycle,<br>3 cylinder diesel engine |           | Planting      | SVS            |  |
|                       | Total Displacement (L {cc})          |          | 778  |           | No. of plant  |                |  |
|                       | Output Revolution Speed (KW{PS}/rpm) |          | 14.4 KW (19.6 PS) @ 3200 rpm                       |           | Distance be   |                |  |
|                       | Applicable Fuel                      |          | Diesel   | Planting  | Hill space (d |                |  |
|                       | Fuel Tank Capacity                   | (L)      | 34 litres  | FULIOI    | Planting De   |                |  |
|                       | Starting System                      |          | Starter motor                                      | No. of    |               | ille           |  |
| Seedling<br>Condition | Seedling type                        |          | Seedling mat                                       | ]         | NO. OF N      | io. of hills ( |  |
|                       | Seedling height                      | (cm)     | 8 to 25  | ]         | No. of social |                |  |
|                       | Number of leaves                     | (leaves) | 2.0 to 4.5   | No. of s  |               | eeali          |  |
| Operation speed (m/s) |                                      | 0-1.65   |  | P.01 1111 |               |                |  |

|                           |          |                          | KUBOTA SPV-6MD   |  |  |
|---------------------------|----------|--------------------------|--|--|--|
| Steering System           |          |                          | Power  |  |  |
| Wheel                     | Туре     | Front wheel              | No-punctur tire  |  |  |
|                           |          | Rear wheel               | Rubber lug wheel   |  |  |
|                           | OD       | Front wheel (mm)         | 650  |  |  |
|                           | OD       | Rear wheel (mm)          | 950  |  |  |
| Shifting                  | system   |                          | Hydrostatic Transmission                                   |  |  |
| No. of Shifting positions |          |                          | HST:Main shift, Variable speeds for<br>Forward and Reverse |  |  |
| Planting                  | system   |                          | Rotary, forced planting                                    |  |  |
| No. of pl                 | anting r | OWS                      | 6  |  |  |
| Distance                  | betwee   | n rows (cm)              | 30   |  |  |
| Hill spac                 | e (cm)   |                          | 10, 12, 14, 16, 18, 21, 24                                 |  |  |
| Planting                  | Depth (  | cm)                      | 1-5.5 (7 positions)  |  |  |
| No. of hills (mm)         |          |                          | 110, 90, 80, 70, 60, 50, 45<br>(Seedling 3.3 sqm)          |  |  |
| No. of se<br>per hill     | edlings  | Crossfeed distance       | *11/26, 14/20, 18/16 [3 positions]                         |  |  |
|                           |          | Vertical taking quantity | *8 to 18   |  |  |



Source: https://www.tractorjunction.com/implement/kubota/nsd8/





#### YANMAR Full Automatic Vegetable Transplanter

| Model name |                                 |                 | YANMAR Full Automatic Vegetable Transplanter                             |                           |  |
|------------|---------------------------------|-----------------|--|---------------------------|--|
|            | Model number                    | PW20R           |  |                           |  |
|            | Туре                            |                 | -  | RS                        |  |
|            | Driving                         | g system        | Four-wheel drive   |                           |  |
| Dimension  | Lengt                           | h (mm)          | 3160   |                           |  |
|            | Widt                            | h (mm)          | 1725   |                           |  |
|            | Height (mm)                     |                 | 1925   |                           |  |
| Fasias     | Weight (kg)                     | - madal         | 638  | 603                       |  |
| Engine     | Engine model                    |                 | GB400  |                           |  |
|            | Steerin                         | g system        | Front wheel steering (power steering)                                    |                           |  |
|            | Wheel                           | Front (mm)      | Blowout-free tire pE00ÁE0  |                           |  |
|            |                                 | Rear (mm)       | AG tire 8-18 pE50ÁE90  | Blowout-free tire ρΕ50ΑΈ0 |  |
|            | Tread                           | Front (mm)      | 1200, 1270   |                           |  |
| Driving    |                                 | Rear (mm)       | 1200, 1320   | 1200, 1270, 1320          |  |
|            | The number                      | of shift steps  | Forward 2, backward 1 (HMT)  |                           |  |
|            |                                 | Forward 1 (m/s) | 0 to 0.50  |                           |  |
|            | Speed                           | Forward 2 (m/s) | 0 to 2.50  |                           |  |
|            |                                 | Backward (m/s)  | 0 to 0.81  |                           |  |
|            |                                 | Up/down         | Oil pressuring automatic following                                       |                           |  |
|            | Body control                    | Horizontal      | -  |                           |  |
|            | The number of planting rows     |                 | 2  |                           |  |
|            | Row distance (mm)               |                 | 2 rows on 1 ridge: 450, 500, 550, 600, 650<br>1 row on 1 ridge: 600, 650 |                           |  |
|            | Planting di                     | stance (mm)     | 260 to 800   |                           |  |
| Planting   | Planting dep                    | th adjustment   | 10 steps x pin 2 steps (one-lever)                                       |                           |  |
| i ianung   | Ridgehe                         | eight (mm)      | 0 to 300   |                           |  |
|            | The number of cell trays        |                 | 16 (planting table 4 + tray table 12)                                    |                           |  |
|            | Operating efficiency (hour/10a) |                 | 0.6 to 0.9   |                           |  |
|            | Vege                            | tables          | Cabbage, Chinese cabbage, broccoli                                       |                           |  |
|            | Cell                            | trays           | 30 - 128 holes, 25 - 200 holes   |                           |  |



#### <u>Video link</u>

Source:https://japan-agritrading.com/products/yanmar-full-automatic-vegetable-transplanter-pw20r





## How to transmit power to our implement?

### By using ground



• By using PTO



Source : https://i.ytimg.com/vi/qosqMIn3Wwg/maxresdefault.jpg

https://compactoperator.com/wp-content/uploads/2022/01/What-Is-PTO-On-A-Tractor-1.jpg





## How ground wheel can be used?



Source : <a href="https://youtu.be/qosqMIn3Wwg?si=9d87VOhuhYJeVhkv">https://youtu.be/qosqMIn3Wwg?si=9d87VOhuhYJeVhkv</a>





Let's explore the advantages and drawbacks of ground wheel and PTO Shaft



Source : https://chinaschooling.com/wp-content/uploads/2017/12/gettyimages-483149360.jpg

# Thank you



