DESIGN AND FABRICATION OF MANUAL PADDY SAPLING TRANSPLANTING MACHINE

RAJESH KUMBARA S K¹, PRAVEENKUMARA B M², BHANU PRAKASH M J³, MUTHURAJU N P⁴,
MAMATHA Y P⁵

^{1,2,3,4,5}Vidyavardhaka College of Engineering, Mysuru, India

ABSTRACT

India is an agricultural nation and paddy is its primary crop. A paddy Trans planting machine is an equipped device which is used to transplant paddy seedlings in the paddy field during transplantation. This project is mainly concentrated on developing a simple manually operated paddy Transplanting machine for small and mid-range farmers in India. This helps the farmers in avoiding the cost of labour for transplantation and they can do paddy transplantation by using this machine in a less amount of time. In India more than 80% of the farmers having less than 2 hectares of land, this creates an urgent need to develop a machine which is simple to operate and available for every sector of farmers for highly labour intensive farm activities specially where the country is growing more paddy in the agriculture land. Also in the present era the labour availability is declining rapidly and labour cost is also increasing every year. In the early 1960's Paddy Transplanting machines were first developed in Japan. Since then technology has been contributing very much in this field by providing improved mechanism. The main purpose of this project is to design manually operated seedling transplantation mechanism to plant paddy seedlings. Many advanced transplanting machines are available but it is available at the higher cost which is not affordable by the small scale farmers. Hence this project aims at sustainable machine and marginal farmers in the country. It consists of simple mechanical linkages to plant the seedling, a tray to hold the seedlings, a gear which drives the links and a mechanical pedal to drive the gear. It can plant four rows of seedlings at a time and at a constant distance.

KEYWORDS: Agriculture Equipment, Paddy Saplings, Marginal Farmers, Transplanting Machine, Four Bar Mechanism, Sustainable Method

Received: Jun 08, 2020; **Accepted:** Jun 28, 2020; **Published:** Sep 16, 2020; **Paper Id.:** IJMPERDJUN20201274

INTRODUCTION

Agriculture is considered as the art and science of crop and domestic production. In a broad sense, agriculture consists of the huge range of technologies which are associated with the producing useful products from the plants and animals, including soil cultivation, crop and domestic management, activities of processing and marketing. The kind of agriculture practiced in a particular area is influenced by so many factors. Among these are climate, soil, and water availability, topography, transportation facilities, land costs, and general economic level. Agriculture is also considered as the back bone of many countries and also economic status of the countries. Hence there is a need to develop machineries for farming sector. This is one such a step towards finding solution for paddy transplantation which is manual in many of the countries especially in India. Agriculture sector produces many primary products which consist of crops and vegetables as food for human and also to animal feed and many livestock products. Paddy is cultivated in more than 100 countries and it is the main food for more than 50 percent of the population in the whole world. And about 90% paddy farming exists in Asia (2012). India holds the highest

area for the rice crop and is the 2nd largest producer of rice in the world after China. The average rice cultivation in India is only 2.09 Ton/ha, as compared to the world average of 3.91 T/ha (2007) which is very less also. Due to the lack of invention in the agricultural equipment. There are chances of less yielding also compared to other countries. If it is possible to manufacture such equipment which helps all the kind of farmers then it is possible to increase the yield rate. In India rice is the major crop and major food because of the fertile land and rice is cultivated in most of the states in India and are concentrated majorly in the river valleys, deltas of rivers.

SCOPE

In India agriculture is the main sector which gives major economy to the country's GDP rate. Paddy is one of the main crops in India. Rice production in India is an important part of the national economy. Paddy can be planted by two methods one is by Manual (hand) and another is by machine.

- This seedling transplanter is specialized and sustainable equipment.
- In order to make it cost effective and easy to use.
- To maintain optimum spacing and uniform planting direction in manual planting.
- This manual operated paddy transplanter is suitable for the small-hold farmers which is sustainable also.
- The manual operated paddy transplanter is designed by comparing both the manual seedling and automated machine seedling system.
- The cost of the project is 15000/-

OBJECTIVES

- To design and fabricate the seedling transplanter (four rows).
- To make it simple in construction and operation.
- To reduce the labor cost.
- To reduce the initial investment compared to other machine.
- To make it easy handling & portable.

LITERATURE REVIEW

Manually Operated Transplanters

Manually operated transplanting machines are powered by human power. The operator has to move along with the transplanter and pull the machine by hand itself. These machines are small enough to operate manually. There are various types of transplanting machines existing in the world with different mechanisms. In Sri Lanka, these types of machines are mainly designed by FMRC (Farm Mechanization Research Center at Mahalluppallama) and FMTC (Farm Mechanization Training Centre at Anuradhapura) which are targeting small scale farmers in the country.

Figure 1: Manually Operated Transplanter.

The main components of the machine are seedling tray, forks, handle and skids. When the handle is pressed, forks will pick-up the seedlings and plant them in 3 rows separated by a predefined space. For every stroke of the handle the seedling tray moves side wards for uniform picking of seedlings by the forks. The operator has to drive the machine while punching the handle continuously at the desired spacing. The spacing between one row to another row is usually 200 mm and the machine looks as shown in the figure 2.1.

Hand Cranked Rice Transplanter

This is a backward walking type of transplanting machine. It can plant 2 rows of seedling at a time simultaneously. The space between the rows is usually 250mm, and planting distance can be adjustable to any required spacing distance. This transplanting machine is designed in such a way that transplanting can be done for a bare plant without mud. The seedlings from the nursery should be cleaned for any soil or mud. During the operation the machine is operated by one hand and pulled by another hand. It has got light and compact structure for easy operation and maintenance. This machine is presently used in china by small scale farmers.

Figure 2: Cranked Rice Transplanter.

Limitations of Manually Operated Transplanters

- Transplanter can be operated continuously only for 4-5 hours.

- Healthy persons can only be able to pull the transplanter.
- It uses mat type nursery seedling so cost is high.

Self-Propel Rice Transplanters (Riding Type)

This type of transplanters is capable to carry operator on the machine. A single wheel driven transplanter is shown in the Figure 2.3. It is fitted with diesel engine. The machine transplants seedlings from mat type nursery in eight rows in a single pass. The drive wheel receives power from the engine through V-belt, cone clutch and gearbox. A propeller shaft from the gear box provides power to the transplanting mechanism mounted over the float. The float facilitates the transplanter to slide over the puddled surface.

Figure 3: Propell Rice Transplanters.

The tray containing mat type nursery for 8 rows is moved sideways by a scroll shaft mechanism, which converts rotary motion received from the engine through belt-pulley, gear and universal joint shaft into linear motion of a rod connected to the seedling tray having provision to reverse the direction of movement of tray after it reaches the extreme positions at ends. Fixed fork with knock out lever type planting fingers (cranking type) are moved by a four bar linkage to give the designed locus to the tip of the planting finger.

Four Wheel, Riding Type Transplanter

It is a six-row rice transplanter using mat type seedlings. The double acting transplanting mechanism is run with, one sun and four planetary gears. The machine has provision for adjustments of number of seedlings per hill, depth of transplanting and hill-to-hill distance. The depth of transplanting is maintained constant, automatically during transplanting. The row-to-row spacing is 300 mm and five setting of hill-to-hill distance from 120 to 220 mm can be fixed depending on desired plant population. The machine is powered with six spare seedling racks for filling of trays intermittently. The machine is powered with a 12 hp air cool petrol engine and it is provided with power steering. Depth of transplanting can be set from 15 to 45 mm

Figure 4: Wheel, Riding Type Transplanter.

Limitations of Engine Operated Transplanters

- The cost of the transplanter is high.
- It not suitable of small hold formers.
- It required large area of space to transplant not suitable for small area.
- It uses mat type nursery seedling so cost is high.

METHODOLOGY

The surveying of planting the seedling into the field is difficult, time consuming and labour availability is less. The machine transplantation costs higher by its process of plantation and this can't be done small house hold farmers. so manual transplantation is method which can used by the small house hold formers because it is the multigrain Seedling transplanter.

Working Principle

The seedling transplanter will plant seedlings on the field by the 4 bar mechanism where it is connected to the wheel and the fork where power is given by the wheel with square blades. As the transplanter drags the fork plants the seedling on the field.

The seedling transplanter consist of main parts seedling tray, fork(4 bar mechanism), wheel with square blades and base frame. The transplanter can poweredby dragging the transplanter with the help of handle to plant the seedling into the field. The wheel rotates with square blades in a field connected with four bar mechanism which converts circular motion into reciprocating motion. The fork in the circular motion where it takes the seedling from the seedling tray and plant it into the field with vertical support given to the seedling tray. The seedling will plated by the seedling tray to the field by the fork.

Components

1. Handel
2. Seedling tray
3. Wheel
4. Fork
5. Frame

Figure 5: Manual Multigrain Seedling Transplanter.

Seedling Tray

Seedling tray is component where the paddy seedlings are kept in the horizontal position and it is made up of Galvanized Steel sheet. This component is fabricated using cutting and welding technologies. Initially the thin sheet Galvanised Steel is taken and marked the measurement according to the design calculation. Then cut trim the sheet as per the dimension and then weld the parts to fabricate the seedling tray. Similarly 4 seedling trays are fabricated as shown in the fig 3.2. The seedling tray is like a shed roof. When the transplanting machine is brought in the field, the seedlings need to be kept on seedling tray. The seedlings have to be placed one above the other in the seedling tray in horizontal position as and when the lifting fork picks the seedling, the seedling comes to picking position continuously.

Figure 6: Seedling Tray.

Table 1: Seedling Tray Specifications

Description	Specification
Length	140mm
Width	200mm
Seedling tray material	Galvanised steel sheet

Wheel with Square Blade

The wheels for this machine are designed in such a way that they can easily move in the wet land during seedling transplanting process. The wheels are fabricated using the mild steel through electric arc welding and cutting process. The outer surface of the wheel having small square blade like shape was given for proper grip as shown in the figure 3.3. The large wheel rotates with square blades in a field which is connected to small pulley by V-belt drive the large wheel rotates and it powered the small wheel where it is attached with four bar mechanism at its end. Four bar mechanism which converts circular motion into reciprocating motion.

Figure 7: Wheel.

Table 2: Wheel With Square Blade Specification

Description	Specification
Diameter	300mm
Thickness	8mm
Seedling tray material	Mild steel

Frame with Handle

It is the supporting structure that carries all the load of the transplanting machine which is as shown in the figure 3.4. It is made up of stainless steel which gives better strength to the transplanting machine and also reduces weight. Four bar mechanism to transfer the motion is also supported on the frame with a bearing. The handle is provided to move the transplanting machine in the wet paddy field. The frame is fabricated by using the cutting and electric arc welding technology.

Figure 8: Frame with a Four Bar Mechanism.

Fork

The Fork is one of the very important components in the transplanting machine, which picks up a seedling from the seedling tray and put the seedlings into the wet ground. Machine transplanting using transplanter requires considerably less time and labour than manual transplanting. In the manual transplanting the seedling were planted with the help of human workers. In fork the reciprocating motion takes place, where it takes the seedlings from the seedling tray and plants it into the wet field with vertical support given to the seedling tray.

Ball Bearing

A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least two races to contain the balls and transmit the loads through the balls. In most applications, one race is stationary and the other is attached to the rotating assembly (e.g., a hub or shaft). As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were sliding against each other.

Table 3: Ball Bearing Specifications

Description	Specification
Inner Diameter (d)	10mm
Outer diameter (D)	30mm
Maximum Speed (N)	20000 RPM
Bearing Material	SAE 52100 Chrome Steel

Shaft

A shaft is a rotating element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it. Transmission shafts are used to transmit power between the source and the machine absorbing power; e.g. counter shafts and line shafts. Machine shafts are the integral part of the machine itself; e.g. crankshaft.

Table 4: Shaft Specifications

Description	Specification
Diameter	10mm
Length	850mm
Shaft material	High strength Alloy Steel

Fabricated Model

The final fabricated model after assembling the all the other components will look as shown in the figure 3.5. The assembly of the components are done thorough permanent as well temporary joining process. Electric arc welding is used where permanent joining is required for example in frame and seedling tray. Temporary joints are used in assembly of bearing to the frame and links are used for the four bar mechanism.

Figure 9: Frame with a Four Bar Mechanism.

Design Calculation

Design of Shaft

Shaft is the rotating element which is used to transmit power. Shaft has to be designed in such a way that it can sustain all forces acting on it and it is made up of mild steel.

Calculation of shaft and it is placed in between two bearing like simply supported.

Yield strength is $\sigma_y = 310\text{Mpa}$ and its Dia. is 30mm, Material = SAE1045steel, Density=7870 kg/m³,

thickness = 5mm. $\phi = 20^\circ$ and speed is 30rpm.

Weight of wheel = $m \times g = \rho \times v \times g$

$$W_w = 7870 \times \pi/4 \times 0.3^2 \times 0.05 \times 9.81$$

$$W_w = 272.86 \text{ N}$$

Weight of fork = $m \times g = \rho \times v \times g$

$$W_s = 7870 \times 25 \times 15 \times 0.005 \times 9.81$$

$$W_s = 14.47 \text{ N}$$

Considering Vertical Load Diagram (VLD)

Figure 10

Taking moment about A

$$R_A + R_F = 272.56 + 14.47 + 14.47 + 14.47 + 14.47 + 272.56$$

$$R_A + R_H = 603 \text{ N}$$

$$14.47 \times 75 + 14.47 \times 225 + 14.47 \times 375 + 14.47 \times 525 + 272.86 \times 675 - 272.86 \times 75 - R_B \times 600 = 0$$

$$R_H = 301.46 \text{ N}$$

$$R_A = 603 - 301.46$$

$$R_A = 301.54 \text{ N}$$

Vertical bending diagram (VBMD)

$$M_{bBV} = M_{bGV} = 0 \text{ N}$$

$$M_{bAV} = -272.86 \times 75 = -20464.5 \text{ N-mm}$$

$$M_{bCV} = -272.86 \times 600 + 301.54 \times 525 - 14.47 \times 450 - 14.47 \times 300 - 14.47 \times 150 \\ = -18430.5 \text{ N-mm}$$

$$M_{bDV} = -272.86 \times 450 + 301.54 \times 375 - 14.47 \times 300 - 14.47 \times 150 = -16221 \text{ N-mm}$$

$$M_{bEV} = -272.86 \times 300 + 301.54 \times 225 - 14.47 \times 150 = -16182 \text{ N-mm}$$

$$M_{bFV} = -272.86 \times 150 + 301.54 \times 75 = -18313.5 \text{ N-mm}$$

$$M_{bHV} = -272.86 \times 75 = -20464.5 \text{ N-mm}$$

Resultant bending moment diagram (RBMD)

$$\text{General formulae of RBMD is } M_{bD} = (M_{bDH}^2 + M_{bDV}^2)^{1/2}$$

$$M_{bD} = (0)^2 + (-20464.5)^2)^{1/2}$$

$$M_{bD} = 20464.5 \text{ N-mm}$$

$$\text{Maximum bending moment} = M_{bmax} = 20464.5 \text{ N-mm}$$

$$\text{Maximum twisting moment} = M_{tmax} = 348.96 \text{ N-mm}$$

$$\tau_y = 0.5\sigma_y = 0.5 \times 310 = 155 \text{ N-mm}^2$$

From DDHB for the state and gradually applied load

$$K_b \text{ is shock factor} = 1.5, K_t \text{ is Endurance factor (DDHB vol.1, Pg.no.14.13)} = 1.0$$

$$D = [16/\pi\tau_y ((K_b M_b)^2 + (K_t M_t)^2)^{1/2}]^{1/3}$$

$$D = 10.02 \text{ mm}$$

$$\text{Standard diameter from (DDHB table no. 14.6 Pg.no.14.13)} D = 10 \text{ mm}$$

Design of Bearing

Bearing is designed for 10mm shaft. It is designed to operate 6hrs/day, 7days/week for 10 yrs. It is designed to carry stationary load of 78.48 N at 30rpm.

$$\text{Required rated dynamic load, } C_r = F_e \left[\left(\frac{L_d}{L_r} \right) \left(\frac{n_d}{n_r} \right) \right]^{1/m}$$

Where,

$$F_e = \text{Equivalent load ie. } F_e = V \times F_r \times K_a \times K_t$$

V = Rotation factor is 1

K_a = Load application factor is 1.5(light shock)

K_t = Temperature factor is 1

$$F_e = 1 \times 78.48 \times 1.5 \times 1$$

$$F_e = 117.72\text{N}$$

L_d = Design life

$$= 6 \times 7 \times 52 \times 10$$

$$L_d = 21840\text{hrs}$$

$$L_r = 500\text{hrs (constant)}$$

n_d = Design speed is 124.8rpm

n_r = Rated speed is $33\frac{1}{3}$ rpm

M = Exponent = 5 ball bearings

$$C_r = 117.72 \left[\left(\frac{21840}{500} \right) \left(\frac{84.6}{33\frac{1}{3}} \right) \right]^{1/5}$$

$$C_r = 376.79\text{N}$$

Standard Bearing from Balveer Reddy DDHB page 340 from table no 16.9a

ISI NO: 10BC02

SKF NO: 6200

Inner Diameter, $d = 10\text{mm}$

Outer Diameter, $D = 30\text{mm}$

Bore = 9mm

Max Speed = 20000 RPM

RESULTS AND DISCUSSIONS

- Comparing with all transplanter, this manual transplanter is cost effective of 10200.00/-.

- The seedling transplanter achieves four row planting.
- Labour cost also reduces for small scale farmers.
- Comparing with the manual method and manual transplanter, it is time consuming and because it achieves the plantation of four row. It can be easily handled by single person.
- In this machine, ground wheel supplies the power to operate transplanting fork and mechanism. Pulling the machine will rotate the ground wheel. Increasing the size and number of lugs (fins) around ground wheels will increase contact area of the ground wheel with the field and make it easy to operate.
- This suggests that transplanting machine requires distinct soil characteristics that prevent the sedimentation of soil. Under puddled conditions, soil cannot make a strong grip on the seedlings. If excess water (more than 1 cm) is there above the ground at the time of transplanting then it will lose the soil grip on the seedlings.

CONCLUSIONS

- Design and fabrication of manual operated paddy seedling transplanter is successful for four row planting and this machine finds very helpful in small hold formers cost effective.
- The process remains safe and one operator is required to operate this machine. The transplanter is easy to handle and less effort is required when compared with other transplanter. This transplanter reduces the labour cost compared to other process of plantation.
- The farm land with average size in area, this mechanized paddy transplanter would highly aid in the transplantation.

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