Design and Development of Manual Rice Transplanter Machine

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Abstract - *Manual seed planting leads to lower efficiency, back pain for labors, low seed yields limits the amount of field that may be planted. The cost of imported seed transplanter machine has gone beyond the purchasing power of the majority of our farmers. Worker agriculturists can significantly increase grain production by reducing or eliminating the need for rigorous work during planting, To optimize seed transplanter machine performance, consider upgrading the machine's structure and determining the necessary parts to meet yield requirements. The need for rice transplanting machine is growing these days since it notably emphasizes planting in an appropriate manner and course of action. Using rice transplanter machine for seeding reduces the labor intensive work significantly, also the buyer of this machine is mainly small to medium scale farmers and they don't have much money to invest for imported machine or highly automated machine. Requirement is machine should be budget friendly which gives solution on labor intensive work. This paper provides highlights of advancements in rice farmers applied in India. Planting rice is exceptionally very old method that dates back many years and has long history since many years, and this decade has seen changes in their rice-planting tactics. Application the number of rice transplanter machine is growing, the present models are expensive. Thus, the main focus of this project is to develop feasible design, structure and lower that machine's cost.*

Key Words: *Rice Transplanter Machine, Farmers, Rigorous Work, Advancement, Feasible Design, Lower Cost.*

1. INTRODUCTION

India is known to be a cultivating nation. In India, almost 71% of the population depends on immediate or indirect cultivation. Farmers have been using comparable techniques and equipment for centuries. In order to advance the techniques and equipment, things must alter as the time does. In this way, the expanding efficiency of cultivation increases. Similarly, agribusiness plays a crucial role in India's economy. Its present GDP commitment is to increase one-sixth of the total. Additionally, the Indian government has made progress in organizing a number of initiatives to educate farmers about the unique cultivation techniques. A farmer simply needs to precisely complete five stages in order to increase production. The following describes these five stages: Harvesting, sifting, irrigation, planting seeds, and plowing. It has become evident that rice is a vital food source in India. Better generation, Good quality, Less work required, Saves time, Low expense.

Approximately one-fourth of the entire planted area is covered by rice, a significant food crop that feeds half of India's population. In India, 2.2 tons of rice is produced per hectare on average. Temperature and humidity are two key climate factors that affect rice production. It is thought that rice farming has potential in North Eastern India. Just 5.9% of India's total rice production is produced in North Eastern India, which possesses 7.8% of the country's total rice cultivation land. However, because of labor-intensive activity, rice output in this region is trailing. The following element is mostly responsible for rice cultivation: age of the variety, availability of moisture, climatic conditions, Availability of inputs and labors.

Among these factors, manpower and input availability are major determinants of rice production technique. Numerous efforts have been undertaken to automate the process of paddy transplantation through the introduction of different transplanters, and ongoing research aims to lower production costs while minimizing labor fatigue. While mechanical transplanters need energy to drag the transplanter through puddled fields, local transplanters must frequently bend over and straighten up throughout the transplantation procedure. A small-scale farmer is unable to purchase a non-subsidized automated paddy transplanter due to the high cost of such a machine. An affordable and efficient manual rice transplanter machine has been attempted to be constructed.

2. PROBLEM IDENTIFICATION

As we know in India, almost 71% of the population depends on immediate or indirect cultivation. In our nation, an area of 43.86 million hectares is used for rice cultivation. About 1.70 million hectares of land are used to grow rice in Maharashtra. Transplanting requires a greater labor requirement roughly 8 to 9 labors per acre are needed. Additionally, a labor scarcity frequently results in transplanting being delayed, which gradually lowers yield. In order to save labor and time when planting rice seedlings, a mechanical method for moving the seedlings from the nursery to the farm field should be used. Currently, rice seedlings are transplanted manually by hand in India, which is a labor intensive and time-consuming process.

When it comes to this technique, transplanting produces a considerably better rate of production than direct seeding.

For example, 1 acre of rice can produce about 2400 kg of rice by direct seeding, whereas 3360 kg can be produced by transplanting.

3. METHODS OF ESTABLISHMENT

3.1 Direct seeding/sowing Method

For germination and establishment, direct planting entails sowing seeds directly into the ground. Almost any combination of vegetation may be replicated manually or mechanically.

3.2 Transplanting of Seedlings Method

Transplanting of seedlings can be done by either use of Man power or by Transplanting by Machines.

3.2.1 Transplanting by Man power

This calls for a significant amount of labor, and therefore is only appropriate in locations with an adequate supply of labor. Relocating seedlings consistently in the field is a challenging task that is best suited for small and marginal farmers alone. This transplanting technique is challenging for both large scale cultivation in vast fields and large-scale manufacturing. So rather than by man power, transplanting by machine will become most feasible and suitable method.

3.2.2 Transplanting by Machine

As similar process like transplanting by man power but here is major difference is occur when seedlings are kept in transplanting machine and sown by this machine itself. It requires hardly 1 to 2 labours for operation of machine.

4. LITERATURE REVIEW

In order to get this project started, we looked for a variety of transplant-related information sources and reviewed the literature on several research papers. Our evaluation of the literature is broken down into several areas of investigation, such as the theoretical development of rice transplanting machines, the performance of self-propelled rice transplanters and their impact on crop output, and the ergonomic-economic analysis of various paddy transplanting operations. This study was carried out to provide the parameters, specifications, issues that have arisen with transplanters that are already in use, and the development and design technique of transplanters.

Rajvir Yadav et al. (2007)

He had been complemented by an ergonomic assessment of a manually operated rice planter with six rows. He carried out an ergonomic assessment of a manually operated rice transplanter with six rows. According to their research, the transplanters field capacity was greater than that of the conventional approach, and the average force needed to lift the It was determined that the transplanter was 130.32 N for male individuals and 145.12 N for female subjects. Japan was the first nation to create a unit termed rice planters, according to a research by Han et al. (1971), who's the patent, was acquired as early as 1898.In 1960, the first machine for transplanting paddy seedlings was unveiled. The device is made up of a seedling tray, forks, handle and skids.

Dinesh Patil et al. (2016)

The demand for rice transplanter machines is rising these days due to its special ability to seed rice in an organized and systematic manner. Using a rice transplanter to seed rice saves a lot of human labor. Farmers are the type of people who use this equipment, and they typically come from low-income backgrounds. Guidelines for advancements in rice transplanters used in India are provided in this document. Planting rice is very ancient technique that dates back a long way, as well as their techniques for cultivating rice are altered in the current decade. While using rice transplanter machines is a recent trend, the machines that are now in high cost of buying. Therefore, the primary goal of this project is to reduce that machine's cost.

A.K. Goel et al. (2008)

He had carried out an experiment on three rice transplanters: Yanji, CRRI, and OUAT. They came to the conclusion that, in line with the split plot design of the tests, sedimentation duration of 32 hours was appropriate for the manual transplanter and 56 hours for the Yanji transplanter. For optimal use of water, nutrients, and pest control, the SRI (System of Rice Intensification) transplanting method recommends planting one seedling per hill, spaced 25 cm apart.

G. Singh et al. (1985)

He had studied a mechanized manual rice transplanter at the farm and reported that the machine worked effectively there, with a field capacity of 0.034 hectares per hour at different water depths and with seedlings of varying ages.

5. BENEFITS OF RICE TRANSPLANTER COMPARED TO TRADITIONAL METHOD

When compared to more conventional techniques like direct seeding and hand planting, using a manual rice transplanter has a number of advantages. The following are the main benefits of utilizing a manual rice transplanter:

5.1 Enhanced Efficiency

The efficiency of the transplanting procedure is greatly enhanced by manual rice transplanters. When opposed to manual hand planting, farmers can cover bigger areas faster with a transplanter machine since it can transplant one seedling at once in two rows respectively. Timely planting results in improved crop establishment and synchronized growth.

5.2 Consistent Plant Spacing

Achieving consistent plant spacing is one of the main problems with older approaches. This problem is solved by manual rice transplanters, which have adjustable planting spacing settings. By keeping seedlings uniformly spaced apart, farmers may encourage even growth and maximize the use of available resources. Maintaining uniform plant spacing also makes it simpler to control weeds, water plants, and apply fertilizers and pesticides.

5.3 Cost and Time Savings

Manual rice transplanter decreases time and labor costs by simplifying the transplanting procedure. With fewer workers and greater efficiency, farmers can cover a greater area while transplanting seedlings. Labor spending costs are reduced as a result of this. Furthermore, by saving up time for other crucial farming tasks, farmers are able to increase total output.

5.4 Less Labor Dependency

Manual labor is a major component of traditional transplanting techniques, which can be problematic in light of labor shortages or the scarcity of competent workers. The labor-intensive nature of rice transplantation is reduced by the substantial reduction in labor intensive work by manual transplanters. This is especially helpful in areas where there is a manpower shortage since it enables farmers to get around labor limitations and guarantee timely transplanting.

5.5 Improved Precision and Productivity

Rice transplanter's mechanized design allows for more accurate and consistent planting, which improves crop uniformity. Farmers are able to administer inputs like fertilizer, irrigation, and pest control more evenly over the field because to this precision. Higher-quality rice crops and increased productivity are the end results.

6. DISCUSSIONS WITH FARMERS

As we discussed with farmers to know about the rice farming we are discussed with them about, what is the process of rice transplanting so they said that there are two methods of seeding that is direct seeding and rice transplanting.
The rate of productivity is much different in about two different methods considered direct seeding method gives you production around 2400 kg per acre wherever transplanting used you production around 3360 kg per acre but the case is initial cost and labor work required for transplanting is higher than direct seeding.
8 Labours are required with their 350/day wages for 1 acre transplanting and this process required complete one day with 8 labours.
If you can designed the machine which is able to transplant that Seedling 2 to 3 acres per day with maximum 2 to 3 labours and the cost of around 15000 it will be very beneficial for farmers and agricultural sector.

7. METHODOLOGY

- Seedlings are kept in the tray and allowed to flow down under gravity.
- The fork which is attached to shaft picks up the seedlings from the tray and keeps it in horizontal position on the skid.
- The motion for shafts is given by wheel itself using chain and sprocket arrangement.
- On the rotating wheels small plates are welded for achieving required height in skid and also it is helpful for easy working in skid.
- Long handle is provided for control and giving direction for machine.
- Arrangement consist sprocket, linkages, wheels & Bars.

8. MATERIAL SELECTION

COMPONENTS	MATERIAL
Wheels and Shafts	Mild Steel
Wheel Blade	Flat Steel Bars
Seed Tray	Galvanized Steel
Frame	Hollow Steel Pipes
Bolts and Nuts	Stainless Steel
Bearing	Deep groove Ball Bearing (Code-61804)
Base Paddy	Edge Wood

Table -1: Material Selection

9. KINEMATIC LINKAGES AND DRIVE MECHANISM

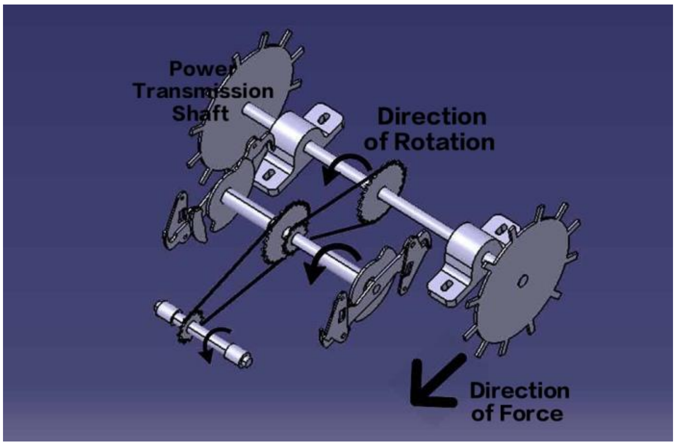

Figure-1: Kinematic Linkage and Drive

This figure show, kinematic linkage and drive mechanism of the machine as per that power transmission is to be carried out.

10. CALCULATIONS

10.1 Wheel Shaft

Axial Stress (σ) = F /A

Coned Shaft
Radius = 9.5 mm = 0.0095 m
Length = 0.52 m
Pulling force = 7 Kg = 68.6 N
Torque = FXR = 68.6 X 0.0095 = 0.6517 N-m
Bending moment = 68.6 X 6.733 X 10^{-7} m^3 /0.0095 m
= 4.861 X 10^{-3} Nm^2
Axial stress = Force/ Area
Area= π X $d^2/4$ = 283.5275
= 2.835 X 10^{-4}
Axial Stress = 68.6 N/ 2.835 X 10^{-4} = 241975.3086 N/m^2
= 24.19 KN/m^2 = 0.2419 N/mm^2
Bending Stress = MXC/I
M = Bending Moment
C= Distance from neutral axis to point of interest
I= moment of inertia
I = π X 0.019^4 /64= 6.39 X 10^{-9}
Bending Stress = MXC/I
=4.861 x 10-3 x 0.26/6.39 X 10^{-9}
Bending Stress = 0.000197787 N/mm^3

No Torsional stress because no twisting occur

10.2 Pick and Claw Shaft

R = 7.5 mm = 0.0075 mm
L = 0.3 m
Pulling force = 7kg = 68.6 N
Torque = F X R = 0.5145 Nm
Bending moment = 68.6 X 3.31 X 10^{-7}/ 0.0015
= 3.027 X 10^{-3}
Axial stress = Force /Area
Area = π X $d^2/4$ = 1.767 X 10^{-4}
Axial Stress = 68.6/ 1.767 X 10^{-4} = 388206.66 N/m^2
= 0.38 N/mm^2
Bending Stress = MXC/ I
I = π X d^4 /64 = 2.485 X 10^{-9}
Bending Stress = MXC/ I
= 3.27 x 10-3 x 0.15/2.485 X 10^{-9}
Bending Stress = 0.0001827 N/mm^3

10.3 Specifications

Mild steel is a common material that used for shafts due to its properties like strength, ductility, and affordability. Here are some typical material properties of mild steel:

Young's Modulus (E): 200 GPa (Gigapascals) or 29,000 ksi (kips per square inch)
Shear Modulus (G): 79.3 GPa or 11,500 ksi
Poisson's Ratio (v): 0.3 to 0.33
Yield Strength (σ_y): 250 to 350 MPa or 36 to 51 ksi Ultimate Tensile Strength (σ_u): 400 to 550 MPa or 58 to 80 ksi
Elongation at Break: 20% to 25%
Depending on the particular grade or specification of mild steel being utilized, these values may change. For accurate and current information on the exact mild steel grade you intend to use for your shaft application, it is essential that you examine applicable standards and references or refer to the material specifications.

10.4 Bearing Selection

Fr = 70 N
Shaft rotates at = n = 30 rpm
d = 20 mm
Step 1: Dynamic load capacity,
The bearing is subjected to pure radial load.
P = Fr = 70N
L10 = $60nL_{10h}/10^6 = 60(30)(10000)/10^6$
= 18 million rev.
C = P $(L10)^{1/3}$ = 70 x $(18)^{1/3}$ = 184 N
So, From Manufacturers Catalogue we have selected Deep Grove Ball Bearing and its designation is 61804
d = Bore dia. = 20mm
D = Outside dia. = 32mm
B = Width = 7mm

10.5 Area and Time Calculation of Rice Transplanter

A tachometer is used to measure the rotational speed of wheel shaft while it was being manually cranked. It was found that the wheel shaft revolutions averaged 30 rpm. The following outcomes were noted from the manually operated paddy transplanter that is now in use.
Hill to hill spacing = 0.15m
Row to row spacing = 0.25 m
Field capacity = 100 sq. m
During one revolution of the shaft, the transplanting operation occurred twice, i.e. covering a length of (0.15+0.15) = 0.30 m.
Hence the area covered in one revolution of the shaft was,
= 0.30 m x 0.25 m = 0.075 m^2
Therefore, to complete an area of 100 m^2, the total no. of revolutions required were,
100/0.075= 1334 Rev
1334/30= 45 min
So as per calculation 45 min are required for 100 sq. m rice transplanting field.
The shaft of the transplanting arm revolves at a speed ratio of 2:1 with the wheel shaft speed.
Hence the speed of the transplanting arm was taken to be 60 rpm.

11. DESIGN VIEWS OF MACHINE

11.1 Drafting Views

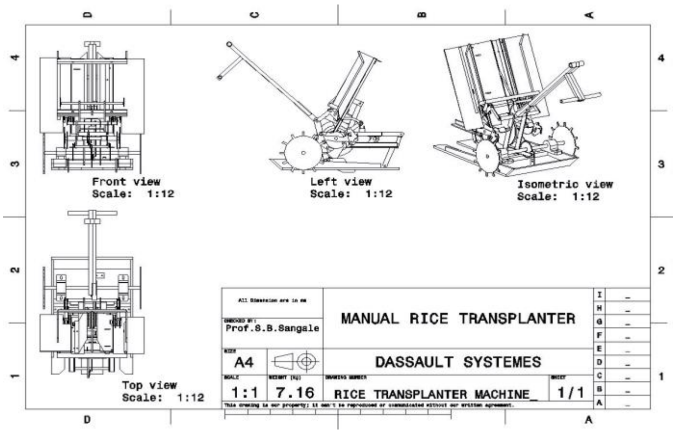

Figure-2: Design and Assembly Drafting

11.2 3D View

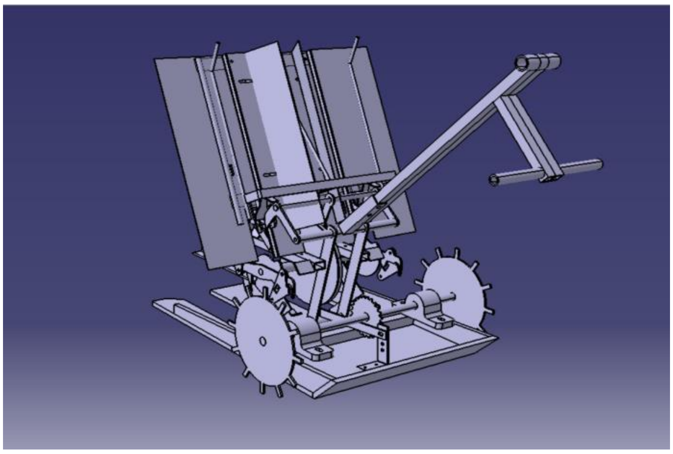

Figure-3: Design and Assembly 3D CATIA Model

11.3 Developed Machine View

Figure-4: Developed Machine

12. CONSTRUCTION

12.1 Ground Wheels

The wheels are in contact with the mud or skid. It mounted on driver shaft. It gives motion to the Four Bar Linkage through the chain drive.

12.2 Sprockets

The main function of sprockets is to transmit torque through chain. There are four sprockets –one on wheel shaft another two on picking shaft and one on deep down claw shaft

12.3 Chain

The function of chain is to transmit torque from driver to driven sprockets. The chain is simplex type.

12.4 Four Bar Linkage

In this four bar linkage one link is fixed and other three linkages are in motion. The links are connecting rod, crank and planting Pick & Sow mechanism. It is mounted on the driven shaft.

12.5 Tray

This is used to store the rice seedlings from where the planting fingers pick the seedlings and deep down in the skid. This tray has two vertical cut slots for guide purpose with spring locking arrangement.

12.6 Sowing Claw

The sowing claw is the main part which is responsible for the sowing of the nursery seedlings. It has the particular shape which picks the nursery seedlings and plant in skid. It oscillates at specific angle and it is known as fixed fork mechanism.

13. WORKING MECHANISM OF MANUAL RICE TRANSPLANTER

To effectively move rice seedlings from a nursery bed to sowing of all seedlings at field, a manual rice transplanter operates by following a set of procedures.
Here's a detailed explanation of how it typically functions:

13.1 Seedling Tray:

The rice seedlings are placed on a seedling tray or holder for transplantation as part of the transplanter. Usually, the transplanter's tray is situated at the front or top.

13.2 Seedling Release Mechanism:

As the operator advances, a mechanism on the transplanter releases the seedlings one by one. As per design of the transplanter, this mechanism is controlled mechanically.

13.3 Depth Adjustment:

To regulate how deeply the seedlings are planted in the ground, transplanter has a depth adjustment feature. By doing this, you can be confident that the seedlings are placed at the right depth for maximum growth.

13.4 Handle and Wheels:
A handle on the transplanter allows the user to grip and control the device. To make moving over the field easier, it also contains runners or wheels at the bottom.

13.5 Planting Motion:
The transplanter is pushed along the rows where the seedlings will be planted by the operator as they go forward in the paddy field. A single seedling is released and placed into the soil when the transplanter moves, activating the seedling release mechanism.

13.6 Spacing and Alignment:
To control the alignment and spacing of the seedlings, certain manual rice transplanters come equipped with extra capabilities. These characteristics guarantee that the seedlings are positioned according to the proper planting pattern and at the suitable distance from one another.

13.7 Continuous Operation:
Repeating the planting procedure, the operator walks forward until all of the seedlings in the tray have been transplanted. It is necessary to periodically refill the transplanter with seedlings from the nursery bed.

When utilizing a manual rice transplanter machine instead of a hand transplanting, the transplanting procedure becomes less labor-intensive and more efficient. Farmers can plant more quickly and uniformly, saving them time and labor. To guarantee correct and efficient functioning, it is required to adhere to the manufacturer's specific instructions for each model of transplanter.

14. FIELD TRIAL

Field trial is an important phase of project at which we get actual result of our research and development.
Also, we get some improvement points for sure as a future scope of development.

Figure-5 shows field is prepared for trial, as basic requirement of field should be plane to the surface with enough water absorbed by the mud for better crop.

Figure-6 shows arrangement of rice seedlings for trial, we made nursery at another place with better climate and other resources for better seedlings.

Figure-7 shows developed machine is loaded with rice seedlings and ready for trial.

Figure-8 shows commissioning of machine at field, as we see in the figure as a result proper working of machine with sowing of seeds with right space at right length.

Figure-5: Field Preparation for Trial

Figure-6: Seedlings Arrangement for Trial

Figure-7: Developed Machine with seedlings for Trial

Figure-8: Field Trial

15. CONCLUSIONS

The rice transplanter which we designed is found to be in Good working performance.
The cost is cheap than motor and hand cranked mechanical rice transplanter is added advantage.
After further improvement, this two row paddy transplanter can be transplant 2 to 3 acre/day while manual hand operated gives 1 to 2 acre/day by considering 8 hours per day of working.
Transplanter helps to acquire lesser cost of production with higher yield and production moreover the quality of produced rice is also good.
The total cost which include material and fabrication cost is Rs. 14500 and easy to operate. The cost will reduce to Rs. 12000 with mass production.

16. FUTURE SCOPE

There are other areas where the manual rice transplanter can be improved and expanded in the future. These are some possible directions for further study and development.

16.1 Design Optimization

To improve the transplanter's durability, efficiency, and ergonomics, more design optimization and refinement may be investigated. This entails enhancing the overall structural design, handle ergonomics, insertion mechanism, and seedling holder. To decrease weight, boost strength, and extend lifespan, research can also be done on the application of cutting-edge materials and production processes.

16.2 Precision and Automation

The precision and uniformity of rice planter placement can be increased by incorporating automation and precision technologies. This could entail using robotic devices, computer vision, or sensors to precisely locate and identify seedlings in the ground. Automation may improve consistency, lower the possibility of human error, and boost output even more.

16.3 Adaptability to Different Rice Varieties and Field Conditions

Different rice varieties and field conditions can be accommodated by designing manual rice transplanters. This could entail movable or modular parts that can be tailored to fit particular rice-growing techniques, including varying planting density or row spacing.

16.4 Economic Viability and Affordability

Prioritizing technology innovations should not overshadow the need to guarantee small-scale farmers' access to and affordability of manual rice transplanters. Research can be done to create affordable manufacturing processes, look at financial solutions, or investigate subsidy schemes to make the transplanter available to a variety of farmers.

By investigating these possibilities, the potential applications of manual rice transplanters in the future may result in enhanced production, decreased labor needs, enhanced efficiency, and sustainable rice farming methods.

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