Design and Fabrication of Paddy Transplanter

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Abstract—**Agriculture is themost important sector of Indian economy. Rice being the major crop cultivated in India, a huge amount of workforce is engaged in rice production. The common practice of rice cultivation is manual transplanting of seedlings. Besides being costly, cumbersome and time consuming it is very labour intensive task. To mechanize the transplanting system several attempts have been made to design and fabricate transplanting machines. Due to the high price of an automated paddy transplanter it becomes impossible for a small scale farmer to purchase a non-subsidized automated paddy transplanter. An attempt has been made to fabricate a manual paddy transplanter which is effective as well as cheap. Selection of an efficient power transmission system and a suitable mechanism to drive the planting claw is given due consideration in its design. The objective of this project is to design a paddy transplanting mechanism to transplant rice seedlings by small scale farmers in the country.**

Keywords-***Rice Cultivation; Transplanter; Design mechanism.***

I. INTRODUCTION

Rice being the important food crop covers about one fourth of the total cropped area and cater food to half of the Indian population. In India, average rice production per hectare is 2.2 tonne [1]. Climatic condition such as temperature and humidity plays a vital role in rice production. Rice production mainly involves the following three steps: (i) Pre-Planting (ii) Postproduction (iii) Growth. North Eastern India is considered to be potential region for rice production. North Eastern India covers 7.8 percent of the total area of rice cultivated in India and in terms of rice production, accounts to only 5.9 percent of the total national rice production [2]. However, this region is lagging in terms of rice production because of labour intensive work. Rice cultivation mainly depends on the following factor (i) age of the variety(ii)availability of moisture (iii) climatic conditions (iv) availability of inputs and labour. Among these reasons, availability of inputs and labour play a huge role on deciding the method of production of rice. Several attempts has been made to mechanize paddy transplanting operation by introducing various transplanters and research is under progress to reduce the cost of production with less fatigue.Local transplanting requires frequent bending down and straighten up for transplanting process whereas mechanical transplanter requires energy for pulling the transplanter in puddled field. Due to the high price of an automated paddy transplanter, it becomes impossible for a small scale farmer to buy a non-subsidized automated paddy transplanter. An attempt has been made to fabricate a manual operated paddy transplanter which is effective as well as cheap.Murumkar R. P. et al. [3] during an experiment on performance testing of a four row self-propelled paddy transplanter, observed that the machine saved 30 man days of labour per hectare.Singh et al. [4] developed 6-row and 10- row paddy transplanter using mat type seedlings for operating with a 25 HP tractor and observed that transplanting quality is very poor due to depression caused by tractor wheels. Muthamil Selvan M., et al. [5] designed and developed a three row improved pull type rice transplanter for small farmers and found that the time saving of 91.3% compared to hand transplanting.

II. WORKING MECHANISM

The power transmitting mechanism of the paddy transplanter is achieved by means of simple four bar chain, also known as quadric cycle chain. A four bar chain has four links and four pairs which are turning in nature. The links are of different lengths. One of the rotating link is known as the crank or driver and the other link as follower or rocker. The member connecting the crank and the follower is known as connecting rod and fixed link is the frame. The crank is the shortest link and makes complete revolution. To obtain a mechanism from a chain its one of the links has to be fixed.

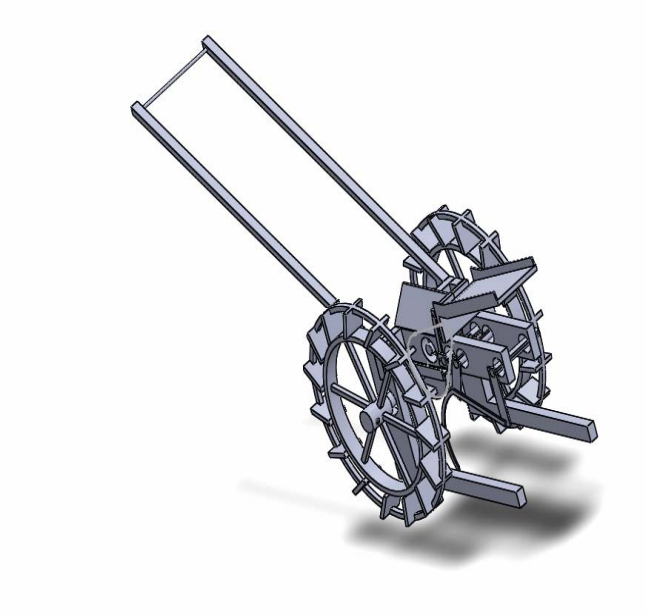

Fig. 1: CAD model of paddy transplanter

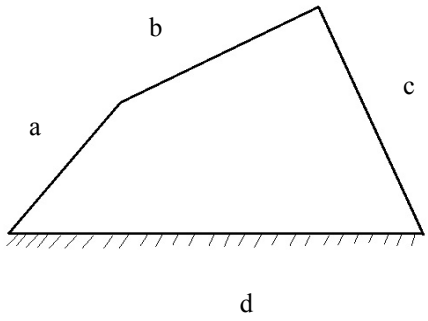

Fig. 2: A simple four bar mechanism

A. Calculations of Speed of driving sprocket N_1

Angular velocity is given by

$$\omega = \frac{v_{avg}}{r} \quad (1)$$

where

v_{avg} is the average walking speed of a man, m/s

r is the radius of the wheel, mm

Speed of driving sprocket is given by

$$N_1 = \frac{(\omega \times 60)}{2\pi} \quad (2)$$

where

ω is the angular velocity, rad/s

B. Calculation of Spacing between successive sapling

Speed of driven shaft (N_2) is given by,

$$N_1 S_1 = N_2 S_2 \quad (3)$$

where

N_1 is the speed of the driving sprocket, rpm

N_2 is the speed of the driven sprocket, rpm

S_1 is the number of teeth on the driving sprocket.

S_2 is the number of teeth on the driven sprocket.

C. Linear distance travelled by the transplanter in one complete rotation of wheel or circumference of the wheel is given by,

$$C = \pi \times D_w \quad (4)$$

where

C is the circumference of the wheel

D_w is the diameter of the wheel, m

D. Sprocket velocity ratio is given by

$$SR = \frac{S_1}{S_2} \quad (5)$$

where

S_1 is the number of teeth on the driving sprocket.

S_2 is the number of teeth on the driven sprocket.

E. Gear velocity ratio is given by

$$GR = \frac{Z_1}{Z_2} \quad (6)$$

where

Z_1 is the number of teeth on the gear.

Z_2 is the number of teeth on the pinion.

F. Overall velocity ratio is given by

$$TR = SR \times GR \quad (7)$$

where

SR is the sprocket velocity ratio.

GR is the gear velocity ratio.

G. Distance betweeen two saplings is given by

$$D_s = \frac{C}{TR} \quad (8)$$

where

C is the circumference of the wheel, m.

TR is the overall velocity ratio.

H. Calculation of number of plantings per minute

Speed of claw is given by

$$N_c = N_1 \times TR \quad (9)$$

where

N_1 is the speed of the driving sprocket, rpm

TR is the overall velocity ratio.

I. Design of gear drive

Module of the gear is given by

$$m = \frac{D}{Z} \quad (10)$$

where

Z is the number of teeth;

D is the pitch circle diameter, mm.

J. Calulation of diameter of shaft

According to maximum shear stress theory or Guest's theory,

$$d = \left[\frac{16}{\pi \tau_{max}} \left\{\sqrt{(K_m \times M)^2 + (K_t \times T)^2}\right\}\right]^{\frac{1}{3}} \quad (11)$$

According to maximum normal stress theory or Rankine's theory,

$$d = \left[\frac{16}{\pi \sigma_{max}} \left\{\sqrt{(K_m \times M)^2 + (K_t \times T)^2}\right\}\right]^{\frac{1}{3}} \quad (12)$$

where

d is the diameter of the shaft, mm.

$(_1max$ is the maximum shear stress, N/mm^2 .

$(_1max$ is the maximum normal stress, N/mm^2 .

K_m is combined shock and fatigue factor for bending.

K_t is combined shock and fatigue factor for torsion.

M is the maximum bending moment, *Nmm.*

T is the maximum torsional moment, *Nmm.*

K. Selection of bearing

Bearing is used for supporting the shaft. Once the diameter of the shaft is calculated using standard formula, selection of bearing can be done.

L. Calculation of chain drive

The chains are mostly used to transmit motion and power from one shaft to another. Here chain drive is used to transmit human effort to drive the claw mechanism. Total length of the chain is calculated by

$$L = 2x + \pi r_1 + \pi r_2 \quad (13)$$

where r_1 is the radius of one sprocket, mm and r_2 is the radius of the other sprocket, mm and *x* is the centre distance between two sprockets, mm.

Velocity of the chain is given by,

$$v = \frac{s^1 p n^1}{60 \times 10^3} \quad (14)$$

where,

s^1 is the number of teeth of driving sprocket

p is the pitch, mm

n^1 is the speed of driving sprocket, rps.

III. RESULTS AND DISCUSSION

The paddy transplanter is design and fabricated using locally available materials in order to reduce the cost. The purpose of fabricating the paddy transplanter is to minimise the

manufacturing cost that can be used by small scale farmers. The knowledge of design such as diameter of the shaft, length of shafts, bearing used and diameter of various drives are calculated using standard formulas.Calculations involving the working mechanism of paddy transplanter are tabulated below.

Parameters	Units	Values
Angular velocity of the driving sprocket	rad/s	2.5
Speed of driving sprocket	rpm	24
Speed of driven shaft	rpm	72
Linear distance travelled in one rotation of wheel	m	1.26
Sprocket velocity ratio		3
Gear velocity ratio		2.5
Overall velocity ratio		7.5
Distance between two saplings	m	0.17
Speed of claw	rpm	180
Length of the chain	mm	700
Velocity of the chain	m/s	0.18
Shaft diameter	mm	6
Gear shaft diameter	mm	6

The designed model of the paddy transplanter involves test run on the field and found the following results as shown

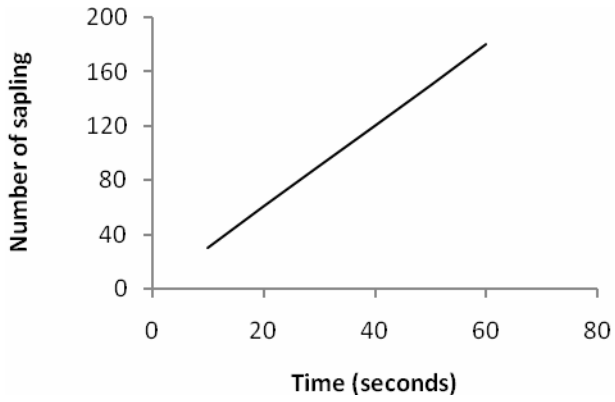

Fig.3: Number of saplings vs time chart

Time (min)	1
Number of saplings planted	180

Trial run for the prototype paddy transplanter is conducted and it is seen that the time taken for transplanting per square metre of paddy field is 49 seconds and 147 number of saplings is transplanted per square metre.

IV. CONCLUSION

The working of the paddy transplanter is found to be satisfactory. The selection of four bar mechanism turns out to be effective and simple to fabricate. The cost of fabricating the paddy transplanter is way cheaper than that of an automated paddy transplanter. It is seen that by using a two row paddy transplanter 0.04 ha/day can be transplanted while on the other hand manual transplanting can achieve only 0.2 ha/day, considering 8 working hours a day. The estimated cost of paddy transplanter is Rs 7000 and it is easy to operate.

V. REFERENCES

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